Developing a Game-Based Proprioception Reconstruction System for Patients with Ankle Sprain

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The Asian Conference on Society, Education and Technology 2014
Official Conference Proceedings

Abstract
Research results have revealed that ankle sprain is the top one cause for sport injury, indicating the relatively high demand of rehabilitation programme due to ankle sprain. For patients with ankle sprain, apart from providing treatment for joint and muscle tone, in order to maintain body balance and stability, proprioception reconstruction should also be considered to be one of the treatment required. Proprioception is defined as receptors which is located at areas like muscles, tendons and joint, that upon external stimulants, providing the body with sensory action and location. Proprioception reconstruction allows defeated sensory receptors to regain its sensory action and location, balance and stability through means of rehabilitative exercises. Conventional rehabilitation is done by monotonous, repeatitive exercises, which generally lower patients' long term treatment compliance. In this study, we will be formulating a proprioception reconstruction system that is suitable for patients with ankle sprain. Kinect device and Unity 3D game engine are used in this system, incorporating entertainment into proprioception reconstruction requirements. It is expected that Kincet device provide communication between patients and machinery without the need of weaving and sensory device, which alleviate patients' physical burden. Non-conventional rehabilitation model not only provides a break through from the daunting exercises, but also enhances ankle-sprained patients' compliance and adherence to therapy. While catering treatment through entertainment, it also keeps the record of patients' activities as data base for further rehabilitation evaluation.

Keywords: ankle sprain, Kinect device, Unity 3D game engine, proprioception reconstruction

INTRODUCTION

In general, after patients experienced treatment of acute phase, they can normally walk and take the load without feeling pain. Then, they enter the phase of active rehabilitation. In this phase, we put emphasis on the recovery of joint activity, muscle tone and flexibility, especially proprioception[1] training, in order to maintain body balance and stability.

Proprioception training concentrate on balance. In addition to using the complete rehabilitation equipment, patients can train by himself with standing on one foot to achieve the goal of balance training. Like any other rehabilitation, maintaining the same position for a long time is such boring. Therefore, patients are hard to keep interest and lack of sustained treatment motivation and then give up treating and affect the rehabilitation effect. In view of this, we aim on satisfying the demand of footproprioception, develop rehabilitation aids to overcome the difficulty of proprioception rehabilitation.

In this study, Microsoft Kinect[2] is the main interactive media, detecting user's body movement and constructing natural and instant human-computer interaction mode. Kinect[3] equipped with three lenses, including color image camera, infrared emitters and CMOS infrared camera. The infrared grating received by CMOS camera consists a good 3D depth-sensing system.

In this study, we will develop a proprioception reconstruction system that is suitable for patients with ankle sprain. Its operation is quite intuitive and simple. The system triggers photographic system on Kinect device when it starts. The camera captures user’s skeleton information and in-depth information, analysis whether or not their body movement sin three-dimensional space correspond with rehabilitation movements by means of action algorithm. It records the data of rehabilitation process and evaluates them. Then, it provides instant feedback for the users as a basic of improvement. Finally, collect and organize the specific information needed into a report , which allows therapists to set up following treatment programs.

EXPERIMENT

The developing environment of system is constructed on the PC. Two main works are writing a program and simulating it. In terms of writing a program, we adopt C # as the main programming language and use built-in MonoDevelop [4] of Unity 3D to integrate development environment and standardize the library. On the other hand, it matches with the OpenNI[5] library that is for free to drive the associated functions and develop interface. In program simulating, development environment of the built-in MonoDevelop provides not only a complete compilation environment, but also a very perfect simulation tool that the program can be simulated directly on the PC without extra software.

The system can be divided into four main modules. Driving and controlling the Kinect device, capturing and analyzing the motion , effectiveness evaluation, and data integration. Their relationships are shown in Figure 1. First, the core program of the system uses Sensor Kinect class in OpenNI. The relevant function directly drives the imaging device equipped in Kinect and use User Generator, Depth Generator class . It

Catches user`s deep information and information from the skeleton images. Second, put emphasis on the "foot joints" , do a comprehensive analysis on user`s skeleton information and deep information. Find out the user`s location in 3D space, the direction and the motion trail of foot movement. General speaking, we can detect the speed, the included angle and the angle of rotation of skeleton joint to calculate its move mode and time consumption in 3D space. Then, we compare them with the movement in system to determine whether or not that fits the need of proprioception rebuild. During the process, we should record the relative data including the times of moving, swing angle, movement accuracy, and the time required for evaluation of rehabilitation results.

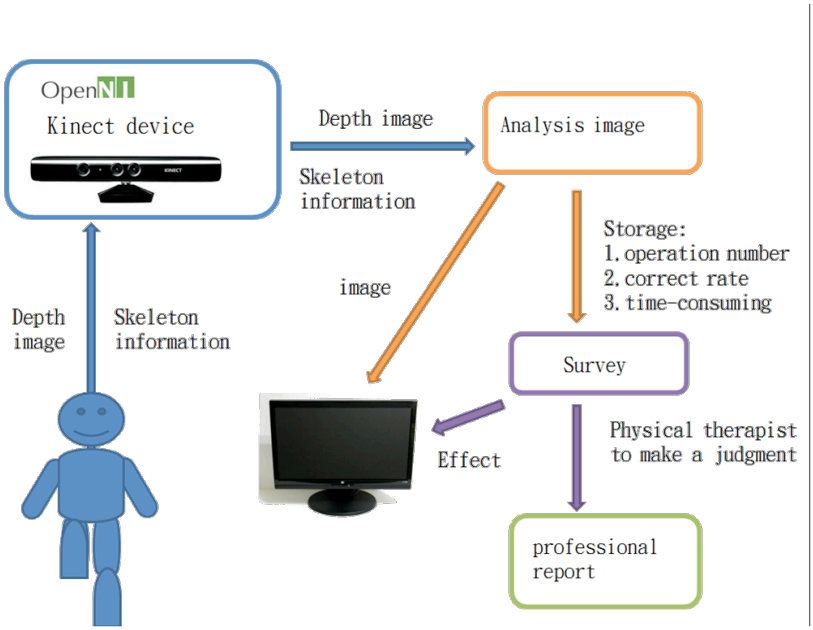

Figure 1: System Architecture

FEATURES OF THE GAME

- Operating system is simple, and users can operate independently without the assistance of others.
- During system operation without the need of weaving and sensory device, operating with body movements is fairly intuitive and simple.
- With precise detection, identification and analysis capabilities, can effectively judge the correctness of the action.
- Without a dedicated training space and rehabilitation props, can be set up in most of the grounds, at any time rehabilitation.
- Equipment is simple, low cost, just PC and Kinect body sensor that is able to set up the system.
- Unlike traditional rehabilitation model, to achieve the effect of human-computer interaction through somato sensory device.
- Has specifically designed for patients with ankle sprain story scenes and rehabilitation actions into one, through the game progresses, while achieving entertainment and therapeutic function.

- Complete evaluation mechanism, can be the results immediate feedback on the screen, providing users improved as a reference.

CONCLUSION

The results show that in the past, the highest ankle sprain injury in the first place, because of relatively high mean ankle sprain rehabilitation needs demand, however, tedious rehabilitation process often leads to the wishes of the patient receiving treatment to reduce, thus unable to achieve good rehabilitation results, the proportion of the affected area again wounded up to 80%, therefore, by the development of this system to effectively improve the patient's willingness to accept treatment, with considerable clinical significance and necessity.

Our system interface is in Figure 2. There are four buttons in the start screen, including "Start", " Instruction", " Introduction", and "Exit". When you meet enemy, the character stops moving, weaving right hand to attack, and weaving left hand to defense. These two movements could help patients fully engaged in the game, and gain body mobility. When you encounter a large amount of enemies, perform a single-knee raise to wipe out them. This process is called proprioception reconstruction. The instruction screen shows the introduction. The introduction screen shows control of the game.

Figure 2：System Interface

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