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# A HOME REHABILITATION SYSTEM COMBINED WITH SOMATOSENSORY GAMES FOR STROKE PATIENTS

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Abstract. *The rehabilitation is a long and boring process. In order to enhance the entertaining and efficiency to rehabilitation, we design a rehabilitation system for stroke patients at home. In this system, two somatosensory games are designed by using kinect. The stroke patients are assigned suitable rehabilitation games targeted at different limbic areas of them, and the system can also document the daily health status and rehabilitation efficiency of patients. Furthermore, by participating in games, patients would be more likely to participate in the tedious rehab process. This result illustrated that the designed system successfully provides a new mode of home rehabilitation for stroke patients.*
**Keywords:** Rehabilitation, Somatosensory game, Kinect, Stroke

1. **Introduction.** In Taiwan, strokes rank third among the 10 leading causes of mortality. Ordinarily, strokes occur in the elderly. However, the excessiveness and refinement of contemporary diets, coupled with inappropriate lifestyles, have resulted in a declining trend for the age of stroke onset. Recent advances in medical treatment have caused the mortality rate for stroke patients to lower gradually. For stroke patients, however, restoring lost bodily functions during stroke rehabilitation remains their most important task during the course of treatment.

In general, stroke patients are under instructions from physicians to receive rehabilitation therapy at rehabilitation centers or hospitals. Patients are separated into six levels based on their physical conditions. Patients who have suffered severe damages to their bodily functions are classified from the 1st to the 3rd levels. Such patients show symptoms such as rigid limbs, a lack of freedom in controlling body movements, decreased visual acuity, and a decline in comprehension. As a safety precaution, the presence of professional physiotherapists is required during rehab to assist with treatment therapy. Patients with only minor damages to their bodily functions (at the 4th to 6th levels) can usually walk freely. The goal of rehabilitation, in general, is to focus on the limbic regions that exhibit functional defects and repeatedly perform therapeutic actions to regain the lost bodily functions.

During the rehab therapy, the patient is required to execute similar actions persistently and repeatedly. Figure 1 [1] shows machinery used by patients during the rehab therapy. However, performing constantly repetitive motions during rehab causes patients to become bored or uninterested easily, thus losing their motivation for rehab. Furthermore, rehab equipment is cumbersome and expensive, making them unsuitable for use in the home setting. Therefore, patients must complete their rehab routines at a rehabilitation center,

thus straining their time and finances further. The extended rehab process also affects patients' willingness and generates heavy burden to the healthcare system.

FIGURE 1. Rehabilitation equipment targeting legs and arms [1]

Accompanied by the developments in information technology, the rehab therapy was supported by applying information technology [2-9]. Burke et al. designed gaming software for hand rehabilitation specific for stroke patients [2]. They designed a rehab game for grasping items by utilizing webcams and image analysis technology to locate the position of the palm. In using image analysis to locate hand positions, this technology was too easily influenced by differences in light condition and skin color, reducing the accuracy of identification. Betker et al. [3,4] designed a video game for balance rehabilitation specific for patients with spinal or cerebral damages. However, this equipment is more suitable for use in the rehabilitation center, and the light condition also influences the performance.

In 2010, Microsoft presented several somatosensory games combined with Kinect (Figure 2). In 2011, they further released the Kinect SDK for program developers. Kinect integrated functions such as color image information, skeleton tracking, depth information, and voice recognition. Being relatively cost-effective (USD 150), the Kinect has thus been extensively used in the context of various research topics in recent years. In this study, we use the Kinect and design two somatosensory games for rehabilitation. This rehab system provides suitable rehabilitation games targeted at different limbic areas of patients. Furthermore, through playing the games to rehabilitate, stroke patients may not exclude the boring rehabilitative process.


FIGURE 2. Kinect

2. **A Home Rehabilitation System Combined with Somatosensory Games.** The rehabilitation therapy is a lengthy process, and makes much burden to patients and medical resources. To improve this situation, we designed a rehab system suitable for home use and specific for patients with relatively minor functional damages (at the 4th to 6th levels).

In this system, the hardware equipment requires Kinect, a personal computer, and projector equipment or a television. Figure 3 depicts a schematic diagram of user scenarios.

We adopted the technology of augmented reality (AR), which uses the patients themselves and their residential environments to create the game scene for this somatosensory game. And then the system generated virtual objects on the project screen for touching, providing different users with varied gaming experiences in diverse environments. The game is presented via augmented reality to increase entertaining effect. Compared with other image-based rehabilitation games [2-4], using Kinect to track skeleton motion has following benefits:

(1) **Cheap:** The cost of kinect is not expensive (USD 150).
(2) **Speed:** The skeleton detection is fast, and the FPS is between the ranges of 20 to 30.
(3) **Robust:** The skeleton detection is not influenced by light condition, skin color, or environment background.
(4) **Easily Setup:** The device could be set up easily by general user.

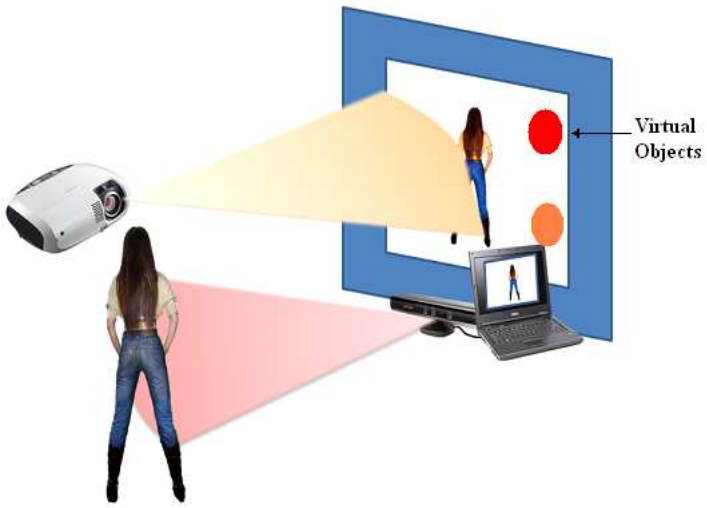


FIGURE 3. Schematic diagram of user scenarios

3. **Experimental Simulation.** When using this system, the user must stand approximately 2 meters in front of the Kinect to enable tracking and positioning of the limbs and torso. The two types of somatosensory game we designed can perform hand rehabilitation as well as torso balance rehabilitation. Up to two people can participate in the game simultaneously.

3.1. **Somatosensory game of hand rehabilitation.** Figure 4 depicts the actual rehabilitation situation in which the physiotherapist uses supportive devices to assist patients in hand rehabilitation. Designed by referring to this actual situation, this somatosensory game is designed to swat flies. Figure 5 depicts the actual operative situation. During game progression, virtual flies randomly appear in the projected screen. Patients are required to use the rehab hand to swat the flies. If patients successfully hit a fly, they then receive a sound response and a score. According to rehab levels, the system could adjust the position, the appearance rate, and the disappearance rate of the flies.

3.2. **Somatosensory game of torso balance rehabilitation.** Figure 6 depicts the actual situation of the physiotherapist to assist patients in controlling their torso and balancing their body. This somatosensory game was designed based on inferences to this situation. Figure 7 depicts the actual operative situation. During the progression of the game, there are two traffic lights located at the left and right sides of the patient. A red light is random lamp, and patients must use a preset hand to touch it. If patients successfully touch the target light, they then receive a sound response and a score. Depending

FIGURE 4. The rehabilitation situation for hand rehabilitation


FIGURE 5. The actual operative situation of somatosensory game for hand rehabilitation

FIGURE 6. The rehabilitation situation for controlling torso and balancing body


FIGURE 7. The actual operative situation of somatosensory game for torso balance rehabilitation

on the rehabilitation level, the system adjusts the appearance frequency of the red light and the position of two traffic lights.

3.3. **The advantages of the home rehabilitation system.** In this system, three main advantages of this system are summarized as below.

(1) To increase patient motivation for completing rehab treatment at home, we used the Kinect to redesign rehab movements into an entertaining somatosensory game. Through playing the game to rehabilitate, patients would be more likely to participate in the tedious rehab process.
(2) This somatosensory game was designed by referring to professional advice from physiotherapists. Two targeted areas for rehab are hand rehabilitation and torso balance rehabilitation. To promote patient's interest in rehab, a competition could be held between two people playing the somatosensory game simultaneously. The entertaining effects of rehab could be augmented by interactions with other people.
(3) The hardware equipment for this system is relatively cost-effective and does not require much space during use. Therefore, it is well suited for home use.

4. **Conclusion.** In this research, we have designed a home rehabilitation system specifically targeting the stroke population. The proposed system is cheap and easily set up. This proposed rehab system provides appropriate somatosensory games targeting different limbic areas of the patient, and can also document the daily health status and rehab efficiency of the patient. Furthermore, through playing the games to rehabilitate, stroke patients would like to accept the boring rehabilitative process. In the future works, more somatosensory games are designed for stroke population (e.g., leg rehabilitation).

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