Chapter 10

Effective Physical Rehabilitation System

Yee Mon Aung
University of Technology Sydney, Australia

Adel Al-Jumaily
University of Technology Sydney, Australia

ABSTRACT

Physical disability due to any neurological disorder such as Traumatic Brain Injury (TBI), Spinal Cord Injury (SCI) or Cerebrovascular Accident (CVA) leads to motor deficit which will result in loss of control over whole body or one side of the body depending on which part of the brain is affected. In this case, physical rehabilitation is required to perform for restoration of lost functions to promote the patient’s quality of life. However, traditional rehabilitation therapy requires one-to-one attention between patient and therapist. Furthermore, patients feel mundane after long term training with traditional exercises in repetitive manners. Therefore, this chapter presents the Effective Physical Rehabilitation System (EPRS) for upper limb rehabilitation by combination of augmented reality based rehabilitation exercises and biofeedback for fast recovery of motor deficit with motivational approach over traditional upper limb rehabilitation therapy which requires minimum supervision of physiotherapist. The main objective of EPRs is to restore the range of motions of upper limb and to prevent from muscle spasticity, muscle atrophy and osteoporosis in effective and motivated way. To meet this objective, augmented reality based pick and place rehabilitation exercises are developed for reaching movements. The effectiveness of the proposed system is evaluated by the experiments and questionnaires results.

1. INTRODUCTION

Augmented Reality (AR) defines as a combination of real world and virtual world where virtual objects lay on top of the real world. In other words, AR allows the overlay of digital information on the physical world that still “remain”. One of the first works on AR is created by Professor Tom Caudell for Aviation Company in 1990 and another work is invented in 1992 for US air force (Virtual Reality). In late 1990’s Hirokazu Kato released AR toolkit to develop AR systems and this is when researchers begun to...
Effective Physical Rehabilitation System

employ in various applications (Kato & Billinghurst, 1999). Although AR is still at the exploratory stage in many applications including rehabilitation field, it provides additional advantages such as user is able to view the real world and real objects can be employ as stimuli for the therapy. Since AR in rehabilitation applications is available as versatile modes, it can be used as a physical treatment mode via game approach and extrinsic feedback mode via motivational sensory cues. In physical treatment mode, the physical movements within AR environment are able to maintain the consistency of movement patterns and training protocol which surpass the traditional rehabilitation. In the context of feedback mode, the artificial stimuli such as visual cues, verbal cues, tactile cues and biofeedback provide additional motivation to the patients for fast recovery.

This chapter presents the Effective Physical Rehabilitation System (EPRS) for upper limb rehabilitation by combining AR based rehabilitation exercises and motivated biofeedback which requires minimum supervision by the physiotherapist. In section 2, the game attribute to EPRS is presented while section 3 discusses the therapeutic idea of all the developed games. Section 4 describes the extrinsic feedback that integrated in EPRS for fast recovery. The evaluations of the developments have quantitatively performed and experimental results are discussed in section 5. Finally, the conclusion and future work are presented in section 6.

2. GAME ATTRIBUTE TO EPRS

Game attribute is one of the important factors to consider during game development especially for rehabilitation purpose. This attribute consists of motivation, type of motion and cognitive challenge. The important aspect of the motivation is the availability of opportunities for treatment and re-training in longer term. The type of motion in rehabilitation therapy can either be focused on a simple motion with single muscle contraction or coordinated motion with multiple muscles contraction. In terms of cognitive challenge in rehabilitation exercise, it can be very simple game design to understand and play easily in starting point and then slowly increase the difficulty level to enhance the recovery after some period of rehabilitation therapy. The concept of developed therapeutic exercise attribute is depicted in Figure 1. From the figure, it is clearly shown the overall motivation pathway with type of motions and level of cognitive challenge for each therapeutic exercise which developed in EPRS. The lower left corner represents the movement of the exercise with basic motion and easy recognition while top right corner represents the exercise which required random movements of arm via advanced recognition. Basic motion in EPRS is defined as only 1 Degree of Freedom (DOF) is required to perform the exercise whereas random motion can be made up of several DOFs to complete the exercise. The types of upper limb movement in EPRS are developed in accordance with HOPE: The Stroke Recovery Guide by National STROKE Association guideline (Ahmad et al., 2010). In addition to the guideline, the exercises in EPRS are developed with customizable movement types, different level of challenges with motivational biofeedback. The detail developments of individual therapeutic exercise are explained in the following section.