Chapter 9
The Use of Motion Tracking Technologies in Serious Games to Enhance Rehabilitation in Stroke Patients

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ABSTRACT

Stroke is the main cause of long term disability worldwide. Of those surviving, more than half will fail to regain functional usage of their impaired upper limb. Typically stroke upper limb rehabilitation exercises consist of repeated movements, which when tracked can form the basis of inputs to games. This paper discusses two systems utilizing Wii™ technology, and thermal and visual tracking respectively to capture motions. The captured motions are used as inputs to specially designed games, which encourage the users to perform repeated rehabilitation movements. This paper discusses the implementation of the two systems, the developed games, and their relative advantages and disadvantages. It also describes the upcoming testing phase of the project.

INTRODUCTION

Stroke is the main cause of long term disability (Mackay & Mensah, 2004). Of those surviving, more than half will fail to regain functional usage of their impaired upper limb (Feys et al., 1998). UK National Clinical Guidelines recommend participation focused rehabilitation - substituting medical rehabilitation services with suitable social and leisure activities (Royal College of Physicians, 2004).

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Community stroke rehabilitation can be expensive to provide due to therapy contact time and new ways are being explored to provide patients with alternative opportunities to practice upper limb tasks that will enhance recovery.

Typically stroke upper limb rehabilitation exercises consist of repeated movements, which when tracked can form the basis of inputs to games. In light of modern advances from the gaming industry of human motion tracking devices, such as the Nintendo™ Wii Remote, the Wii Balance Board (Clarka, Bryanta, Puab, Bennella, & Hunta, 2010), and optical cameras, the cost of accurate movement tracking systems has reached a level where systems could be deployed to the homes of patients. This increase in availability, combined with a suite of games that encourage participation could have a major impact on the successful rehabilitation of stroke patients.

In this paper, we introduce three 3D games which will encourage the sorts of repeated movements which have been considered effective in the reacquisition of post-stroke motor skills. We introduce two different motion tracking systems to enable stroke patients to control the games by hand and finger movements:

- The IRGlove system, uses Nintendo™'s Wiimote technology. Two Wiimotes mounted either side of a PC monitor track infra-red Light Emitting Diodes (LEDs) on the finger tips of a patient wearing a specially designed glove.
- The markerless motion capture (mocap) system uses dual cameras (both optical and thermal) to track hand movements and identify hand gestures, without any special deployment on the patients.

Both systems are able to capture grab/release motions, rolling motions of the wrist, as well as the 3D or 2D position of the hand in space.

This paper will outline the following: Section 2 introduces the three serious games specially developed for stroke rehabilitation. Section 3 introduces the IRGlove system. Section 4 introduces the markerless mocap system. Section 5 compares the two systems. And finally in Section 6 potential future work is discussed.

SERIOUS GAMES

Frequently stroke survivors are left with partial paralysis on one side of the body and movement can be severely restricted in the affected hand and arm. Effective rehabilitation must be early, intensive and repetitive, which leads to the challenge of how to maintain motivation for people undergoing therapy. Burke et al. (2009) and Brown et al. (2009) demonstrated that games may be an effective way of addressing the problem of engagement in therapy.

The Computing and Technology team at Nottingham Trent University have developed three serious games using C# and Microsoft XNA (Microsoft, 2010): The games are each designed to encourage particular hand exercises for stroke patients, and are described in the following section.

Slingshot Game

A screenshot of the Slingshot game is shown in Figure 1a. This was designed to encourage movement of the hand in the XY plane and pinching movements. The user moves their hand forward and then uses a pinching/hand-close action to load a ball. Force is applied to the arrow either by moving the hand backwards or via the period the pinch is held depending upon the user's ability. Once primed, the ball is aimed at the target via movement in the X and Y planes. The arrow is fired by releasing the pinch. Complexity is added to further levels of the game by introducing effects from both gravity and wind on the shots. The user fires three sets of three balls from an increasing distance away from the target. The score is calculated from their accuracy over the total nine shots.