

Chapter 11

Interactivating Rehabilitation through Active Multimodal Feedback and Guidance

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ABSTRACT

This chapter outlines a Human-Computer Interaction inspired approach to rehabilitation of neurological damage (e.g. spinal cord injury) that employs novel, computer guided multimodal feedback in the form of video games or generation of musical content. The authors report an initial exploratory phase of a project aimed at gaining insight into the development of spinal cord injury (SCI) rehabilitation tools. This exploration included observation of a number of patient interactions in their current rehabilitation routines; the development of initial prototype proposals; and finally through to the development of rapid prototypes which can be used in rehabilitation settings. This initial phase has yielded an understanding of the issues surrounding the development of novel technologies for rehabilitation that will direct further research in the area of rehabilitation engineering. Through the integration of novel methods, in particular the use of interactive physical devices, to the rehabilitation of SCI patients, larger scale research into efficacy of the devices we are developing can be undertaken. These developments may eventually beneficially impact upon the instruments used, the training methods applied and the rehabilitation routines undertaken for individuals living with neurological damage.

INTRODUCTION

The process of rehabilitation involves many repeated and precisely prescribed movements to be carried out by the impaired patient in consultation with a therapist. It is important for the therapeutic

process to follow an established pattern of movements of individual limbs and body parts, and a guided development of these movements over time. The development of the rehabilitation intervention is determined by the range and type of movement dysfunction suffered by a patient and progression is only achieved after many repetitive movements.

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Two problems have been identified which potentially can be solved by using techniques of multimodal interaction with computer generated guidance and feedback. The first problem is boredom or lack of motivation to continue in rehabilitation due to the repetitive nature of the tasks. We propose that the repetitive nature of rehabilitation tasks can be addressed by making the tasks more fun and engaging by providing multimodal and multi-levelled feedback. The second problem is the need for continuous monitoring and guidance of progression by the therapist, which can be addressed by programming interactive algorithms which respond to the patient's progress with appropriate feedback and guidance (again using multiple modalities).

Our approach is to draw inspiration for designing such systems by looking at existing interactive systems that incorporate such rich (multimodal) feedback and behaviours such as found in video-games, virtual reality, and electronic musical instruments. Our approach is further supported and guided by theoretical insights developed in the scientific discipline that studies Human-Computer Interaction (HCI). Both these application domains (inspiration) and theoretical frameworks (support from HCI) are further described in the next section.

There are different types of rehabilitation therapies related to different causes of injury (such as neural damage resulting from stroke, spinal cord injury after an accident, traumatic brain injury or sporting-related injury). It is not always possible for the patient to regain all movement freedom and skills (restorative approach, see below), but in any case therapy is at least important for preventing further loss, and developing coping and alternate movements (compensatory approach, see below).

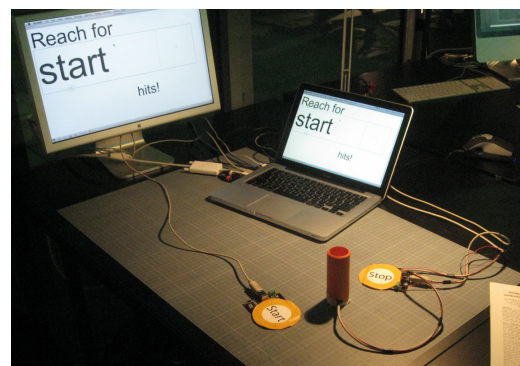
The aims of this chapter are to (a) give a brief overview of procedures in rehabilitation medicine such that designers and engineers can begin to understand the nature of the problems faced by rehabilitation therapists and patients, (b) describe some of the principals of human-computer interaction design that may be appropriate for applica-

tion to the domain of rehabilitation medicine and finally (c), to report an explorative project which aimed to gain further understanding of how augmented, multimodal feedback can be applied in a rehabilitation setting. The specific rehabilitation issue we explored concerned with the problem of upper body balance training in Spinal Cord Injury (SCI). The project took place between September and December 2009 and pursued three strands of investigation which worked towards development of novel technologies for training upper body and limb movements in spinal cord injury (e.g. Figure 1).

BACKGROUND AND INSPIRATION FOR THE WORK

In the past two decades there has been a significant transformation in our understanding of the extent to which functional recovery is possible following damage to central and peripheral nervous systems. In parallel with advances in the neuroscience of nervous system recovery, new technologies have become more easily available and applied in fields of research in interactive systems such as in virtual reality, and computer games, electronic musical instruments, and wireless sensor networks. The aim of the section of this chapter is provide an introduction to the process of rehabilitation and

Figure 1. An interactivated reaching task for rehabilitation purposes



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