

Chapter 8

A Mirror Visual Feedback Therapy System Applying Virtual Reality Technology

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ABSTRACT

A VR-MVF system was developed and used for the treatment of CRPS at the Okayama University Hospital. Preliminary results from applying this system in patients showed that VR-MVF therapy may be plausible for CRPS treatment. The effects of VR-MVF therapy, however, may be enhanced by increasing the frequency of treatments. Thus, a remote personal VR-MVF system was designed for future implementation, and a prototype personal VR-MVF system was developed. Patient evaluation of the prototype system by the PQ test shows the feasibility of our VR system for CRPS treatment.

1. INTRODUCTION

Complex regional pain syndrome (CRPS) is one type of chronic pain syndrome. It can be caused by nerve lacerations and severe injuries such as broken bones. Treatment of CRPS is difficult (Forouzanfar et al., 2002) because of the human body's resistance to pharmacologic treatment and therapeutic side effects. Moreover, CRPS

includes a variety of pain conditions with motor and autonomic symptoms (Veldman et al., 1993). Especially, CRPS patients are impaired in reaching and grasping objects at a distance (Maihofner et al., 2007). Its underlying pathogenesis is not fully understood, which makes it difficult to establish effective treatments.

Ramachandran et al. introduced a treatment (1998) for phantom limb pain, which is one kind of CRPS. They named the treatment Mirror Visual Feedback (MVF). In this treatment,

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an amputee moves his normal hand in a box. A mirror is placed vertically in the center of the box so that the patient can see the movement of this normal hand reflected in the mirror. A promising analgesic effect of the treatment in ten amputees treated with MVF was reported (Ramachandran, & Hirstein, 1998). MacCabe et al. also applied MVF to non-amputated CRPS patients and reported similar analgesic effects McCabe, Haigh, & Blake, 2008). Furthermore, pain reduction in CRPS patients through electrode stimulation of the motor cortex has been shown (Tsubokawa et al., 1993). Thus, functional recovery of the motor system may be one mechanism of MVF's therapeutic effects. The MVF has also an advantage such that it has fewer side effects compared with pharmacologic treatments. However, MVF limits the range of upper limb movements because the narrow mirror-containing box requires a fixed head position facing the mirror.

To solve these problems, a treatment called the Virtual Reality-based Mirror Visual Feedback (VR-MVF) therapy was introduced by applying virtual and augmented reality. VR technology has been popular in various medical treatments (Hoffman et al., 2007) because it gives the patient a sense of reality for an artificial space. VR is a flexible and cheap treatment environment that allows control of physical treatment task conditions. VR-MVF therapy applies artificial MVF in a virtual environment with sensors to measure hand and arm movements on the patient's normal side. A computer then produces virtual images according to these hand and arm movement measurements, and a virtual image is then displayed. VR-MVF has been applied in the treatment of CRPS in the Okayama University Hospital and the University of Manchester (Murray et al., 2007; Sato et al., 2010). Encouragingly, Sato et al. reported decreased pain attributable to VR-MVF therapy in four of five CRPS patients and continued pain reduction following the end of therapy (Sato et al., 2010).

This article presents the system configuration of the VR-MVF therapy system used at the Okayama University Hospital, preliminary results of the VR-MVF therapy, and system extensions for a remote personal VR-MVF system. The goal of the remote personal VR-MVF system is to allow patients to receive treatment at an increased frequency by conducting the therapy in the patient's home with guidance from a physician.

2. THE VR-MVF THERAPY SYSTEM AND VR-MVF APPLICATION AT THE OKAYAMA UNIVERSITY HOSPITAL

2.1 The VR-MVF Therapy System

A VR-MVF therapy system was developed at the Okayama University Hospital for the treatment of CRPS. The system consists of a personal computer (OS: Windows XP Professional SP2) for processing measured data and creating virtual images, data gloves (CyberGlove by Immersion Co.) for measuring finger movements on either hand, a real-time position and motion tracker (FASTRACK by Polhemus Co.), and a 20-inch liquid crystal display (EIZO FlexScan SX2761W by Nanao MS Corp.). The CyberGlove is a stretchable data glove with 18 embedded bend sensors that measure thumb and finger metacarpophalangeal and proximal interphalangeal joint angles, as well as finger abduction and wrist flexion. The FASTRACK is a magnetic sensor that detects alternating low frequency fields generated by a transmitter placed beside the personal computer.

The virtual environment (VE) was developed using the commercial software Autodesk 3DS Max. The original system, including the first version of the VE, was produced by Asahi Electronics Corp. The authors improved the realism of the VE by considering gravitational forces (such as including bounces of artificial objects on a table) and increasing the number of treatment tasks.

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