Chapter 83

Unconstrained Walking Plane to Virtual Environment for Non-Visual Spatial Learning

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ABSTRACT

We have integrated the treadmill-style locomotion interface, called the unconstrained walking plane (UWP), with virtual environment (VE) to enhance spatial learning. This setting allows for a new type of experience, whereby participants with visual disability can explore VE for unattended non-visual spatial learning (NSL) and to develop cognitive maps of it. Although audio and haptic interface has been studied for NSL, nothing is known about the use of locomotion interface for supporting NSL. The structure and control mechanism of the device are presented. Discussion of advantages and limitations of the interface are given. Different types of locomotion interface to virtual environment with their constraints and benefits are discussed briefly. The purpose of the current study is to evaluate the efficacy of the UWP for VE exploration which leads to enhancement of unattended spatial learning and thereby enhancing the mobility skills of visually impaired people (VIP). We report an experiment that investigates the efficacy of UWP for VE exploration during turning and straight walking mode.

INTRODUCTION

Every year about hundred thousand new blind cases are added to an estimated 314 million visually impaired people in the world, 45 million of them are blind. It includes around 15 million from India. The inability to travel independently around and interact with the wider world is one of the most significant handicaps that can be caused by visual impairment or blindness, second only to the inability to communicate through reading and writing. The difficulties in the mobility of visually impaired people in new or unfamiliar locations are caused by the fact that spatial information is not

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fully available to them as against it being available to sighted people. Visually impaired people (VIP) are thus handicapped to gather this crucial information, which leads to great difficulties in generating efficient cognitive maps of spaces and, therefore, in navigating efficiently within new or unfamiliar spaces. Consequently, many blind people become passive, depending on others for assistance. More than 30% of the blind do not ambulate independently outdoors (Clark-Carter, D., Heyes, A., & Howarth, C., 1986; Lahav, O., & Mioduser, D., 2003).

This constraint can be overcome by providing some means to generate cognitive mapping of spaces and of the possible paths for navigating through these spaces virtually, which are essential for the development of efficient orientation and mobility skills. Reasonable number of repeated visits to the new space leads to formation of its cognitive map subconsciously. Thus, a good number of researchers focused on using technology to simulate visits to a new space for building cognitive maps. It need not be emphasized that the strength and efficiency of cognitive map building process is directly proportional to the closeness between the simulated and real-life environments. However, most of the simulated environments reported by earlier researchers don't fully represent reality. The challenge, therefore, is to enhance and enrich simulated environment so as to create a near real-life experience.

The fundamental goal of developing virtual environment for VIP is to complement or replace sight by another modality. The visual information therefore needs to be simplified and transformed so as to allow its rendition through alternate sensory channels, usually auditory, haptic, or auditory-haptic. One of the methods to enhance and enrich simulated environment is to use virtual reality along with advanced technologies such as computer haptics, brain-computer interface (BCI), speech processing and sonification. Such technologies can be used to provide learning environment to visually impaired people to create cognitive maps of unfamiliar areas. We present various research studies including ours for communicating spatial knowledge to VIP and evaluating it through virtual environment (VE), and thereby enhancing spatial behaviour in real environment. Different types of locomotion interface to virtual environment with their constraints and benefits are discussed briefly. Virtual environment provides for creation of simulated objects and events with which people can interact. Essentially, virtual environment allows users to interact with a computer-simulated environment. Users can interact with a virtual environment either through the use of standard input devices such as a keyboard, joystick and mouse, or through multi-modal devices such as a wired glove, the Polhemus boom arm, or else locomotion interfaces.

A locomotion interface is an input-output device to simulate walking interactions with virtual environments without restricting human mobility in a confined space such as a room. The locomotion interface is used to simulate walking from one location to another location. The locomotion interface can make a person participate actively in virtual environments and feel real spatial sense by generating appropriate unconstrained walking plane or ground surfaces.

The device is needed to be of a limited size, allow a user to walk on it and provide a sensation as if he is walking on an unconstrained walking plane. Locomotion interface with unidirectional as well as omni-directional treadmills create infinite surface by use of motion floors. But realization of the motion floors requires bulky or complex drive mechanism, thereby restricting practical use of locomotion interfaces. Secondly, it presents a problem of stability. As a result, such devices induce a kind of fear psychosis leading to difficulties in cognitive map formation. We have proposed a locomotion interface which reduces to a minimum these constraints. Our proposed design of a locomotion interface to the virtual environment for mobility learning is aimed at building improved cognitive map thereby enhancing mobility skills