

# Action Reproducer: Virtual Reality Rehabilitation System to Reduce Fear of Walking

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## ABSTRACT

Walking is a daily activity for most people. Lack of opportunities or inability to walk may cause both mental and physical health problems. However, in some circumstances, such as during a global pandemic, fear of heights, or withdrawal from society (*hikikomori*), people tend to walk less. To overcome such issues, we developed a walking rehabilitation system, Action Reproducer, to encourage people to walk in a virtual environment, e.g., around sightseeing spots, or to train walking on a high building. The proposed system comprised a motion seat to present vestibular sensation to the waist, slider-pedal devices to provide motion sensation to the lower limbs, wearable pseudo force devices to pull sensation to the fingers, and an avatar in the virtual environment to hold the user's hand during walking. This system can reduce user burden because the user simply sits on the motion seat and perceives multiple sensations that allow them to enjoy walking activities for long periods of time. During the virtual conference, we will conduct a live demonstration and present the details of our system with some interactive content, such as virtual traveling and walk rehabilitation between high buildings.

## CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; **Haptic devices**.

## KEYWORDS

Walk rehabilitation, virtual walk, holding hand, virtual travel, fear reduction.

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## 1 INTRODUCTION

The coronavirus pandemic has significantly affected many people's daily lives. For example, it has made many people unable or afraid to walk outside. Consequently, the number of people who have withdrawn from society (*hikikomori*) has increased. However, it is considered that virtual reality (VR) can overcome such issues by allowing people to walk safely inside virtual spaces.

Redirected walking is a well-known phenomenon that allows people to walk in a large virtual environment when, in fact, they are actually walking in narrow space [Steinicke et al. 2010]. Some studies have developed walking rehabilitation systems for lower-limb impaired patients (e.g., [Colombo et al. 2000]). These technologies allow people to walk freely in virtual spaces; however, users cannot sustain the experience for long period of time due to the burden of real walking. Moreover, multiple stimulations are required to encourage someone who is afraid of walking to start the activity.

In this study, we developed a prototype VR rehabilitation system to encourage people to walk outside around sightseeing spots as well as walking through two high buildings to reduce a fear sensation (Fig. 1). A user can experience the stimuli of vestibular at the waist, lower-limb motion sensation at the feet, and a pseudo pulling force at the fingers. In addition, the proposed prototype has an avatar in the virtual space that holds a user's hand to encourage and guide them.

## 2 SYSTEM

### 2.1 Vestibular at the waist and lower-limb motion sensation at the feet:

The stimuli in the proposed system generate walking-like sensations. A user sitting on the motion seat can perceive waist motions with four degrees of freedom (e.g., lift, yaw, pitch, and roll) (Fig. 2 (left)). The system has two pedals, each with three degrees of freedom, to move the heels up and down and move the feet forward and backward. In addition, the pedals move around the seat's axis to provide the sensation of turning while walking. These motions are not sufficient, but they are basic motions and are important to generate various walking activities.

