HangerON : A Belt-Type Human Walking Controller Using the Hanger Reflex Haptic Illusion

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Figure 1: *Left: Hanger Reflex. A wire hanger placed on the head causes head rotation to the left via the Hanger Reflex. Right: Walking Controller. The person in the black coat is manipulating the walking movement of the person in white.*

ABSTRACT

While walking with a navigation device, visual and auditory navigation information can require interpretation, and may distract the user from potential hazards. As a novel way to provide navigation information without distraction, we propose a method whereby the Hanger Reflex, which is an illusory phenomenon caused by haptic stimulus, influences walking. We have developed a way to stimulate the Hanger Reflex at the user's waist, thus eliciting rotation towards the left or right. In this paper, we describe three different uses of our system: 1) Normal walking navigation, in which the device automatically navigates the user to the destination; 2) remote control of one user by another user; and 3) self-control of walking.

CCS CONCEPTS

• **Human-centered computing → Haptic devices;**

KEYWORDS

Hanger Reflex, Walking Navigation, Pseudo-Force

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1 INTRODUCTION

We use walking navigation tools on a daily basis. Many of these tools involve the presentation of visual and audio navigation information by mobile devices equipped with GPS. However, interpretation of such information can be distracting. To reduce potential distraction caused by visual information, systems that present navigation information via vibration have been developed. However, visual, auditory, and tactile navigation information must be interpreted by the user and may consume their attention, thereby impairing safety.

To address this problem, a walking navigation method has been proposed in which the user's movement is directly generated and controlled based on navigation information [Fizpatrick et al. 1999; William et al. 2001; Frey et al. 2005; Pfeiffer et al. 2015; Ishii et al. 2016]. Although the system has been successful in reducing the necessity of interpretation of navigation information, practical issues remain. These include characterizing the appropriate amount of time spent using the device, appropriate settings for usage, potential risk of falling, degree of difficulty in resisting the presented force, and appearance.

Here, we propose a new method to address a number of issues concerning the walking navigation system. Our method utilizes the Hanger Reflex, which is an illusionary phenomenon caused by a tactile stimulus (Figure 1) accompanied by rotation of the body.

2 HARDWARE

2.1 Hanger Reflex

The Hanger Reflex is a phenomenon in which unintentional head rotation, i.e., clear rotation force and motion, occurs when a wire hanger is placed on the head (Figure 1) [Sato et al. 2009]. This phenomenon is typically caused by compression of two points on the head, but has also been observed in the wrist, waist, and ankle. After investigating the effects of the different

Hanger Reflex types on walking, the waist-type Hanger Reflex was found to most strongly affect walking [Kon et al. 2016].
While the hanger reflex causes clear sensations of force and movement, it is easy to resist the presented forces. Therefore, it is considered to be suitable for the application of walking navigation. Clear sensation of force enables the presentation of well-defined navigation information, and the ease of resisting the presented forces contributes to the safety of the device for use in navigation.

2.2 Hanger Reflex Control Device

We developed a device that produces and controls the Hanger Reflex. This device consists of an aluminum frame and four pneumatic driven balloons, four air pumps (SC3701PML, Shenzhen Skoocom Electronic), four solenoid valves (SC415GF, Shenzhen Skoocom Electronic), four atmospheric pressure sensors (MIS-2503-015G, Metrodyne Microsystems) and a microcomputer (mbed1768, NXP).

The pressure necessary to generate the Hanger Reflex is realized by independently inflating the four air-driven balloons, and the Hanger Reflex is produced (Figure 2).

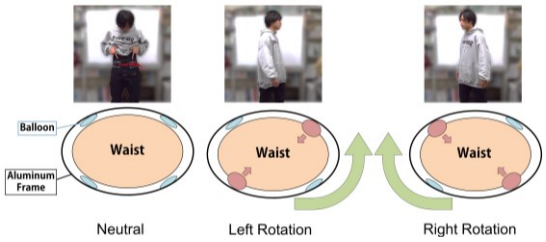

Figure 2: *Mechanism of the waist-type Hanger Reflex device.*

In the previous paper, we described walking experiments conducted using a hanger reflex control device in which we verified the navigation effect [Kon et al. 2016]. We confirmed that it was easy for users to follow or resist navigation information. When users were instructed to walk naturally and ignore the sensations produced by the device, their walking path was still affected.

2.3 Wearable Hanger Reflex Control Device

For demonstration purposes, we made a wireless battery-powered version of our proposed device (Figure 3), consisting of a belt section and a body unit, housed in a waist pouch. The device is lightweight (870g) and can be integrated into daily life by wearing it as a belt or under a shirt. By communicating with a smartphone via Bluetooth, the device can receive feedback from various sensors such as GPS and map applications.

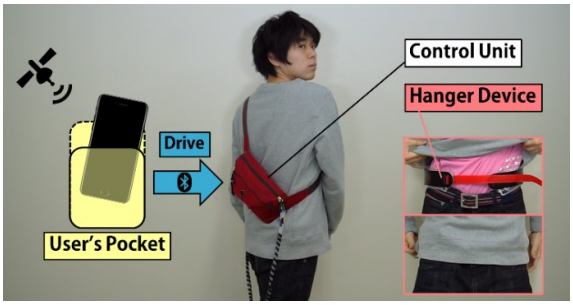

Figure 3: *Wearable Hanger Reflex control device.*

3 DEMONSTRATION

We conducted demonstrations of the device under three different conditions: Auto Navigation, Walking Controller, and Self Controller. Auto Navigation: A user wearing the device automatically navigates to a destination via a dedicated smartphone application. This is the usual navigation application. Walking Controller: The device is controlled by an operator. The wearer acts as a sort of "vehicle" of the operator, and teleoperation or telepresence is realized. Self Controller: A user has a controller that operates the device, and is thus able to manipulate his/her own walking. This may have future medical applications for treatment of people with movement disorders.

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