Hanger Drive: Driver Manipulation System for Self-balancing Transporter Using the Hanger Reflex Haptic Illusion

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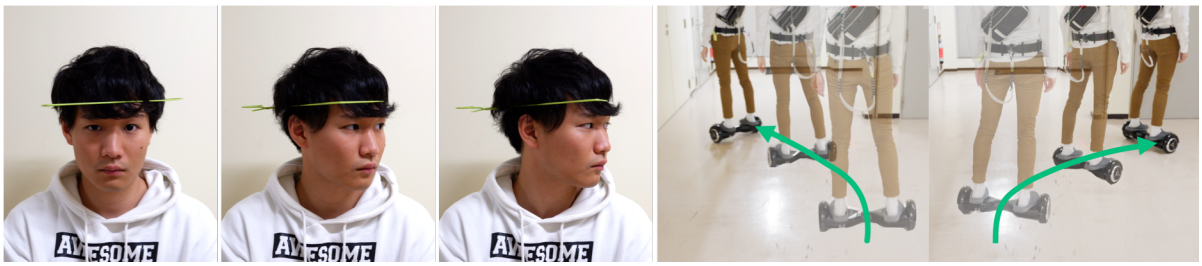

Figure 1: Hanger Reflex: wearing a wire hanger on the head causes involuntary head rotation. This phenomenon also applies to the waist can be used to control the turning direction of the self-balancing transporter.

ABSTRACT

In recent years, self-balancing transporters have become popular for medium-distance transportation such as police patrols and sightseeing tours, and are expected to further gain prevalence. Therefore, it is important to develop danger avoidance and automated driving systems for self-balancing transporters. However, automated control of a self-balancing transporter is challenging because the user balances on the vehicle while riding. In this study, we control the driving direction of a self-balancing transporter indirectly by controlling the motion of the user who is riding the vehicles. We develop a system to controlling the turning direction of self-balancing transporter using Hanger Reflex and its application.

CCS CONCEPTS

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

KEYWORDS

Automated Driving, Haptic Illusion, Self-balancing Transporter, Hanger Reflex

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1 INTRODUCTION

In recent years, self-balancing transporter are becoming popular as medium-distance transportation means such as police patrols and sightseeing tours. Therefore, development of the danger avoidance system and automated driving system for self-balancing transporter is desirable in the future. However, it is difficult to directly control the vehicle similar to automated driving system of car. When the user rides a self-balancing transporter, they balance on the body of vehicle. Therefore, if the vehicle suddenly changes direction or brakes against the user's intention, there is a high risk of losing balance and falling from the vehicle in reaction to the unexpected change in motion.

To address this issue, we propose a method to control the rotation of a self-balancing transporter indirectly by directly manipulating the user's body while he/she is riding the vehicle. Several methods were proposed for direct manipulation of the human body for walk navigation, including GVS, EMS and Vection. We use a haptic illusion called the Hanger Reflex [Sato et al. 2009] because it is compatible with the principles of the self-balancing transporter. The Hanger Reflex is originally known as a phenomenon in which wearing a wire hanger on the head in a specific direction causes

involuntary head rotation. Kon et al. confirmed the same phenomenon at the waist, and proposed a walking navigation method using this phenomenon[Kon et al. 2017].
We applied this technique to developed a method to control the turning direction of the self-balancing transporter by controlling the user's posture (Figure1).

2 SYSTEM

2.1 Hanger Reflex Control Device

In a previous study, Kon et al. developed a device that causes the Hanger Reflex at waist [Kon et al. 2017]. We used the same setup, consisting of an aluminum frame and four pneumatic balloons, four air pumps (SC3701PML, Shenzhen Skoocom Electronic), four solenoid valves (C415GF, henzhen Skoocom Electronic), four atmospheric pressure sensors (MIS-2503-015G, NXP) and a microprocessor (ESP32-DevKitC, Espressif Systems Pte. Ltd.). Air is supplied from an air pump and controlled by an atmospheric pressure sensor and solenoid valves. The pressure caused by the inflated balloons results in a skin deformation, thereby inducing the Hanger Reflex, which controls the user's rotation(Figure 2).

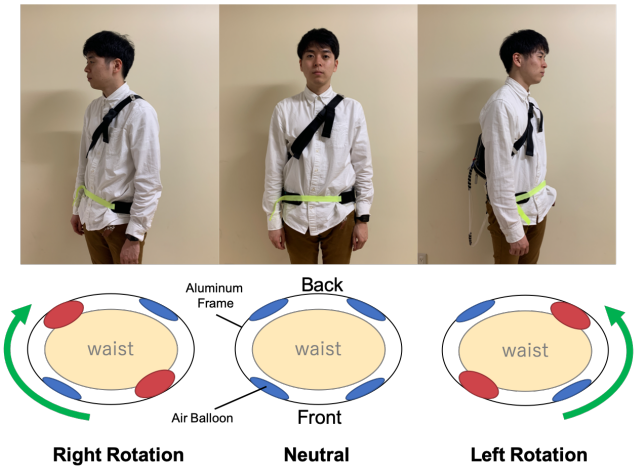
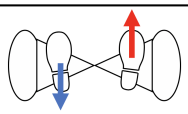
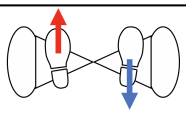
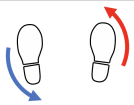
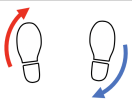


Figure 2: Hanger Reflex device for the waist. We can induce the user's waist rotation to the left and right by using a set of inflated balloons.

2.2 Rotation Control of Self-balancing Transporter

The self-balancing transporter (Kintone D01D, Kintone) used in this study is operated by altering the center of gravity (CoG) of each foot. The users move the CoG of each foot in the opposite direction to turn (Table1, middle row).
Using Hanger Reflex device causes an illusory perceived rotational force as shown in Figure2, which also influences the posture of each foot as shown in the bottom row of Table1. As a result, the rotation of the body caused by the Hanger Reflex also rotates the self-balancing transporter. Therefore, using this method enables the indirect control the self-balancing transporter by controlling the motion of the user.

Table 1: Movement of the center of gravity of each foot and driving mode of self-balancing transporter

Direction		
Self-balancing Transporter		
Hanger Reflex		

3 DEMONSTRATION

We assume the following demonstrations using our method to control the driving direction of a self-driving transporter using Hanger Reflex.
The radio-controlled self-balancing transporter refers to a self-balancing transporter ridden by user and controlled remotely like a radio-controlled car using controller (Figure 3 (a)).
The system uses automatic navigation by allowing a remote user to select the destination using a tablet interface. The user who is riding on the self-balancing transporter is then automatically transported to the destination by rotation direction control using the Hanger Reflex. In the experience, we reproduce the town as a demonstration space using AR technology, and a user drives within the AR-Town (Figure3 (b)).
For safety, the rider wears a helmet and uses walking frame with wheels. The Users engage in a short (a few minutes) training session before the main experiment to learn the control of the self-balancing transporter.

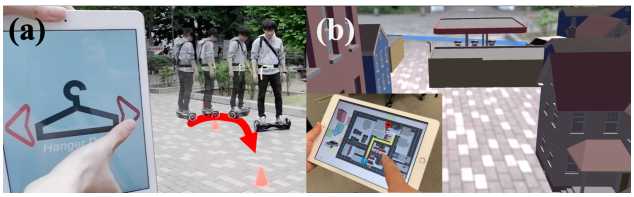


Figure 3: (a) Radio-Controlled Self-balancing Transporter: (b) Automatic Navigation.

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Michi Sato, Rika Matsue, Yuki Hashimoto, and Hiroyuki Kajimoto. 2009. Development of a head rotation interface by using hanger reflex. In *RO-MAN 2009-The 18th IEEE International Symposium on Robot and Human Interactive Communication*. IEEE, 534–538.