HangerOVER : HMD-Embedded Haptics Display With Hanger Reflex

Yuki Kon
The University of Electro-Communications
1-5-1 Chofu-ga-oka Chofu-city Tokyo
kon@kaji-lab.jp

Takuto Nakamura
The University of Electro-Communications
1-5-1 Chofu-ga-oka Chofu-city Tokyo
JSPS Research Fellow
n.takuto@kaji-lab.jp

Hiroyuki Kajimoto
The University of Electro-Communications
1-5-1 Chofu-ga-oka Chofu-city Tokyo
kajimoto@kaji-lab.jp

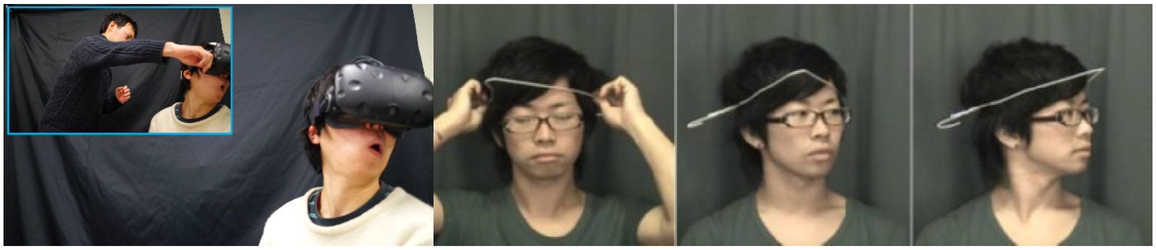

Figure 1: *Left: Concept image of HangerOVER, which can present motion and force associated with VR contents. Right: Hanger Reflex.ABSTRACT*

As a simple method to experience VR content with high immersion, we propose HangerOVER, an HMD-embedded haptics display that can provide both tactile and force senses using the Hanger Reflex (Figure 1). The Hanger Reflex is a phenomenon in which the head rotates unintentionally when appropriate pressure distribution is applied to the head. As it accompanies illusory external force and motion, it can be used to express haptics event in VR environment, such as being pushed and punched by a game character. The developed device is composed of air-driven balloons that can express four types of haptics senses such as touch, pressure, motion & force, and vibration. It can not only improve the immersion of the user's VR experience, but also extends the degree of freedom of expression by game creators.

CCS CONCEPTS

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

KEYWORDS

Hanger Reflex, Haptics HMD, Virtual Reality

ACM Reference format:

Yuki Kon, Takuto Nakamura and Hiroyuki Kajimoto. 2017. HangerOVER : HMD-Embedded Haptics Display With Hanger Reflex. In *Proceedings of SIGGRAPH Emerging Technologies, Los Angeles, CA, USA, August 2017 (SIGGRAPH '17 Emerging Technologies), 3 pages.*
DOI: 10.1145/3084822.3084842

1 INTRODUCTION

Virtual Reality (VR) contents is spreading rapidly along with commercialization of low coast head mounted displays (HMD). This prevalence highlights the importance of touch in VR experience, and there are many trials to improve the sense of immersion by giving haptics presentation. Many of them acquire the position of the user's hands with a handheld device, reflect it into the VR space, and present vibrotactile sensation by the vibrator embedded in the device [Jonatandsiucles et al. 2014; Pabon et al. 2007]. However, although these devices are suitable for vibrotactile presentation, they cannot present a force sense such as being pushed or punched, which is another aspect of haptics cues.

Many force displays were developed, but they are basically large and high cost for daily use [Massie et al. 1994]. Furthermore, both vibrotactile and force devices commonly target hand or fingertip, and they might not be suitable for representing the whole-body haptics events. There are some proposals for the whole-body haptics [Lemmens et al. 2009], but presentation is limited to vibrotactile cue, and wearing a device other than the HMD is cumbersome.

One way to present the whole-body haptics cue with minimal setup is to present via the HMD. Gugenheimer et al. presented a sense of force to the user's head using a gyroscope incorporated in the HMD [Gugenheimer et al. 2016]. It is compact because no additional wearing or holding devices is required, and it is possible to represent a sense that the characters in the VR contents feel with their whole bodies (e.g. impact when attacked) to some extent. However, in order to demonstrate the gyroscope effect, a large rotating mass is required, which leads to the problem of weight. The presented feeling is also limited to rotational force (torque), and continuous force representation is difficult.

We propose a new type of HMD-embedded haptic presentation device that can both generate vibrotactile and force sensations with lightweight setup. We use air-driven balloons that not only present compression and vibration, but also present illusory external force and torque by using psychophysical phenomenon called the Hanger Reflex.

2 Hanger Reflex

The Hanger Reflex is a phenomenon in which the head rotates unintentionally when a wire hanger is placed on the head, which accompanies clear rotation force and motion (Figure 1) [Sato et al. 2009]. This phenomenon is presumed to be induced by skin shear deformation caused by pressure on the skin. We have also confirmed that the Hanger Reflex can also express translational force, as well as rotational force, by appropriate pressure distributions [Kon et al. 2016].

This phenomenon is characterized by a clear feeling of "force and movement caused by external force". This feature is considered to be suitable for application of HMD-embedded haptic display, which is mainly used in passive context such as being pushed or punched by a game character.

2.1 HangerOVER

As an HMD with built-in Hanger Reflex control mechanism, we made a system named HangerOVER. HangerOVER consists of a HMD (HTC Vive, HTC), a Hanger Band consisting of a rubber band and four air driven balloons, and a control unit consisting of 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 microcontroller (mbed1768, NXP).

Air driven balloon has three states (Figure3); 1) Neutral, 2) Touch, and 3) Pressure. 1)Neutral is a state in which the air pressure of the balloon is equal to the atmospheric pressure. In this state, the balloon is in contact with the user's head, but no tactile information is presented. 2) Touch is a state in which the balloon has a pressure slightly larger than the atmospheric pressure. In this state, the balloon is in contact with the user's head, and touch information is presented. 3) Pressure is a state in which the balloon has greater pressure than Touch. In this state, the balloon presses the user's head and presents pressure sensation.

By independently driving the four air driven balloons, necessary pressure for Hanger Reflex is generated. The users wear the Hanger Band and put on the HMD thereon.

2.2 Haptic Presentation Functions

HangerOVER has the following four haptic functions (Figure 2); 1) Touch, 2) Pressure, 3) Motion & Force, and 4) Vibration. 1) Touch and 2) Pressure are simply achieved by setting an arbitrary balloon to the Touch or Pressure state, e.g. presents the sense of being touched or pressed by the characters in the VR content.

3) Motion & Force generates the Hanger Reflex by driving a specific combination of the balloons to the Pressure state. It can present a sense of rotational force by driving two opposite balloons (e.g. front-right balloon and back-left balloons generate right rotational force), as well as a sense of translational force by driving two neighboring balloons (e.g. front and back right balloons generate rightward force).

4) Vibration is presented by switching arbitrary balloons between the Pressure state and the Touch state.

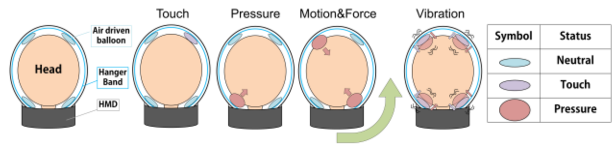

Figure 2: *State of each haptic presentation function.*

3 DEMO EXPERIENCE

Our demo provides VR content that the users can experience the four haptic presentation functions. When the avatar in the game screen interacts with other characters, the above-described four haptics senses are presented (Figure1). The required wearing and takeoff time is almost the same as the ordinary HMD.

ACKNOWLEDGMENTS

This research is supported by the JST-ACCEL Grant Number JPMJAC1404.

REFERENCES

M. J. Jonatandsiuclmes, A. Gracia, M. Oliver. 2014. Identifying 3D Geometric Shapes with a Vibrotactile Glove, IEEE Computer Graphics and Applications, Vol.36, pp.42-51.

S. Pabon, E. Sotgiu, R. Leonardi, C. Brancolini, O. Portillo-Rodriguez, M. Bergamasco. 2007. A data-glove with vibro-tactile stimulators for virtual social interaction and rehabilitation, Presence, pp.345-348.

H. T. Massie, K. J. Salisbury. 1994. The PHANTOM Haptic Interface: A Device for Probing Virtual Objects, Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems.

P. Lemmens, F. Crompvoets, D. Brokken, J. Van Den Eerenbeemd, G. –J. De Vries. 2009. A body-conforming tactile jacket to enrich movie viewing, IEEE World Haptics, pp. 7–12.

J. Gugenheimer, D. Wolf, E. R. Eiriksson, P. Rukzio. 2016. GyroVR: Simulating Inertia in Virtual Reality using Head Worn Flywheels, UIST, pp.227–232.

M. Sato, R. Matsue, Y. Hashimoto, H. Kajimoto. 2009. Development of a Head Rotation Interface by Using Hanger Reflex, IEEE RO-MAN, pp.534–538.

Y. Kon, T. Nakamura, H. Kajimoto. 2016. Hanger Reflex of the Head and Waist with Translational and Rotational Force Perception, AsiaHaptics.