Wearable Haptic Display to present Virtual Mass Sensation

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We propose a wearable haptic display to present the weight sensation of a virtual object, which is based on our novel insight that the deformation on fingerpads makes a reliable weight sensation even when the proprioceptive sensation is absent. This device will provide a new form of ubiquitous haptic interaction.

1. Introduction

In recent times, there have been a number of computer user interface devices that have some haptic feedback functions, such as the DUALSHOCK controller [Sony Computer Entertainment, Inc. 1997] or the Wii Remote [Nintendo Co., Ltd. 2006]. However, their haptic feedback is limited to only the vibration function since there is no other method to provide haptic feedback that can be implemented with a small and inexpensive device. On the other hand, there is an increasing demand for realistic haptic feedback; thus, a simple and inexpensive method for a highly realistic haptic display is required. To meet this requirement, we propose a wearable haptic display to present the mass of a virtual object as shown in Figure 1. We focused on the mass of a virtual object, which contributes to the weight and the inertia mass in haptic interaction. If the virtual mass is presented by a haptic device, the user can perceive a more realistic sensation of the virtual object by grasping than the vibration feedback.

2. Principle

In our previous researches [Minamizawa et al., 2007], we investigated the possibility of realizing a simple haptic display on the basis of finger deformation. Conventionally, it is believed that it is necessary to reproduce the proprioceptive sensation in order to present a weight sensation and thus a large grounded device is required. However, we found that the deformation of the fingerpads due to the weight of an object can generate a reliable weight sensation even when the proprioceptive sensations on the wrist and arm are absent. Based on this observation, we designed the mechanism of the haptic display as shown in Figure 2, which has a simple structure comprising dual motors.

3. Prototype Device

We implemented the prototype device shown in Figure 3 and then confirmed the recognition ability of the weight sensation presented on the user's finger by this method. By wearing our proposed devices on the index finger and the thumb, the user can perceive the grip force and the mass of a virtual object. The grip force, gravity, and inertia mass of a virtual object are presented on the user's fingerpads during shaking and rotational motion.

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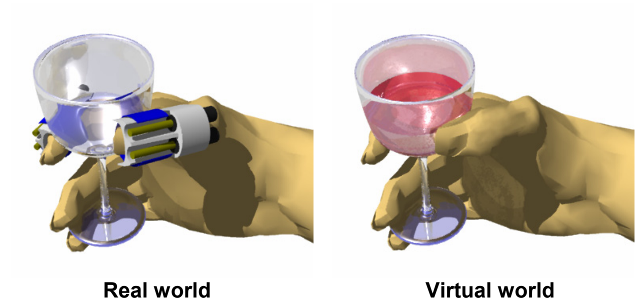

Figure 1: *Conceptual representation of our proposed device. By wearing our proposed devices on the index finger and the thumb, the user can feel the augmented weight and inertia of the water that is virtually filled in the actually empty glass.*

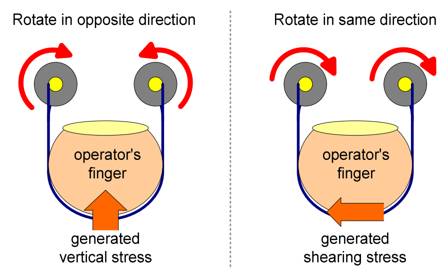

Figure 2: *Our proposed method for generating vertical stress (left) and shearing stress (right).*

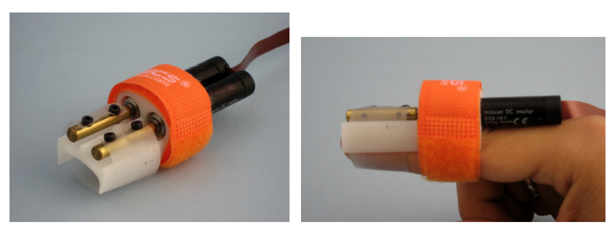

Figure 3: *Implemented prototype device.*

4. Conclusion

We found that the vertical and sharing stresses on the fingerpads due to the weight of the object can generate a reliable weight sensation even when the proprioceptive sensation on the wrist or arm is absent. On the basis of this observation, we designed a wearable ungrounded haptic display to present the gravity sensation of a virtual object using dual motors and a belt. This method is simple and it can be introduced in daily-life. We then implemented the prototype devices and confirmed that virtual mass sensations can be presented.

MINAMIZAWA, K., KAJIMOTO, H., KAWAKAMI, N. AND TACHI, S. 2007. Wearable Haptic Display to Present Gravity Sensation – Preliminary Observations and Device Design, In *Proceedings of World Haptics 2007*, Tsukuba, Tokyo, 133-138