Hap-Link: Wearable Haptic Device on the Forearm that Presents Haptics Sensations Corresponding to the Fingers*

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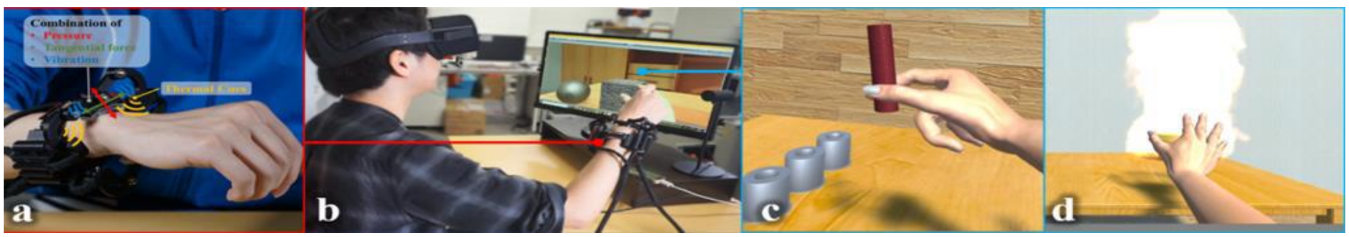

Figure 1: Images showing (a, b) the haptics display, (c) the touching and grasping of an object, and (d) thermal cues

ABSTRACT

We developed a device that presents the haptic sensation of the fingertip to the forearm rather than to the fingertip as a new haptic presentation method for objects in a virtual reality environment. The device adopts a five-bar linkage mechanism and a Peltier element and presents the strength and direction of a force, vibration and the thermal sensation to the forearm. Compared with a fingertip-mounted display, it is possible to address issues of weight and size that hinder the free movement of fingers. Users can feel differences in texture and hardness/softness of objects, and experiences in the virtual reality environment are better than those without haptics cues even though haptics information is not directly presented to the fingertip.

CCS CONCEPTS

• Human-centered computing → Haptic devices;

KEYWORDS

Virtual Reality, Tactile Displays, 5 bar-link mechanism

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1 Introduction

Many studies have attempted to present tactile information in the virtual reality (VR). Fingers are the main targets of haptics presentation in VR and many wearable tactile displays for the fingers, such as finger-type and glove-type displays, have been proposed [K.Minamizawa 2008][M.Gabardi 2016]. However, the weight and size of these tactile displays typically hinder the free movement of the fingers, especially in a multi-finger scenario. We have therefore proposed a method of presenting the haptic sensation of fingertip, including the direction of force, to the forearm to address these issues [T.K.Moriyama 2018].

When we manipulate an object, various kinds of tactile information are presented to the fingers. Among many sensory channels of the fingertips, particularly important channels are those of the strength and direction of a force, which are indispensable information when manipulating an object. Senses of vibration and temperature are also important in identifying a grasped object, and the reality of experiences in the VR space is considered to be high when reproducing the three elements. In our previous report, we developed a device using a five-bar link mechanism that presents information on the force, including the direction, perceived by the fingertip. The top side of the forearm was found to be an appropriate part corresponding to the index finger. In this report, we developed a new device by changing the driving system to a DC motor to achieve a faster response and to resent vibration and adopted Peltier elements to present thermal sensation. Furthermore, by making the device correspond not only to the index finger but also to the thumb, it is possible to present a haptics sensation for the task of gripping and lifting objects. The device weighs about 80 g and is made of acrylonitrile butadiene styrene injected by a three-dimensional printer. It can be attached and detached using Velcro tape. The device is connected to a personal computer through a microcontroller (NXP mbed 1768). LeapMotion device was used for finger tracking.

2 System Design

The device adopts a five-bar linkage mechanism, which, unlike the original structure, adopts an M-shaped structure. Tsetserukou [D.Tsetserukou 2014] proposed using this link mechanism for presenting the sensation of a force to the fingertip. On the basis of this previous study, we created a device that can be worn on the forearm. Two-degree-of-freedom (2-DoF) movement can be achieved by controlling two DC motors. The parts that present the haptic sensation can move up and down, left and right. A pressure sensation can be presented by the up and down movement and a tangential friction sensation can be presented by the left and right movement. In the previous report, a RC servo motor was used to drive the system but we adopted a DC motor in the present study. This makes it possible to achieve a quick response to follow the user's operation and to provide a sense of vibration by adding a vibration signal to the DC motor [V.Yem 2016]. In addition, we used two Peltier elements (15 mm by 30 mm) on two sides of the device.

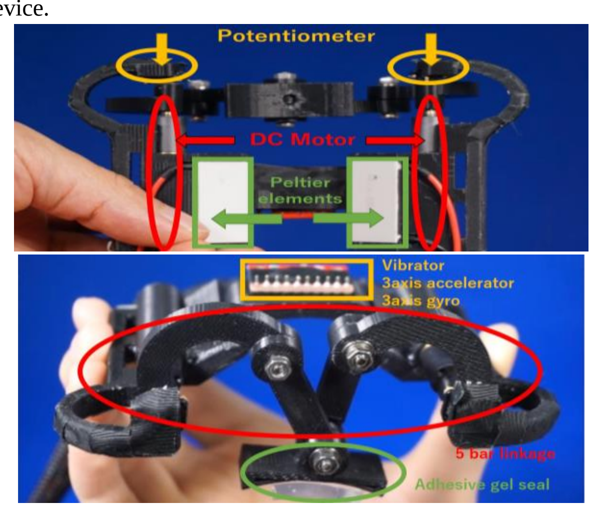

Figure 2: Device overview

3 User Experience

The following describes the user experience in our demonstration. First, various objects were placed in VR space and users handledthem using our developed device. The presentation of a combination of pressure, a tangential force and a vibration sensation to the forearm allowed users to feel differences in the texture and hardness/softness of objects. In addition, by presenting a temperature sensation, the texture of an object became more realistic. Second, a demonstration related to handling task performance was performed. We prepared a classical peg-in-hole task, in which users grasped the peg and place it in the hole. We confirmed that our haptics device allowed this task to be completed within a shorter time.

These two demonstrations, identification and manipulation of a contact object, suggest that our device allows the user to work in a VR environment without haptics information being presented directly to the fingertip and that it can be applied in various situations and applications.

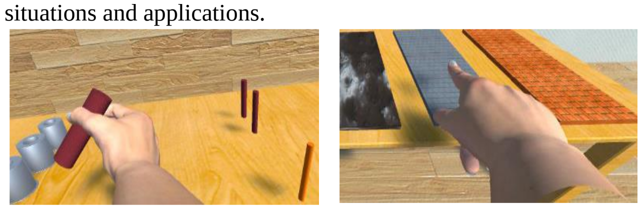

Figure 3: VR application examples

4 Conclusion and future work

We proposed and developed a device that presents haptics information at the fingertip to the forearm. Specifically, we created a device that presents tangential and vertical forces and vibration and thermal sensations to the forearm and showed that the device can improve experiences in the VR environment without presenting haptics information directly to the fingertip. Because the device currently has only two DoFs, we could only present the sensations of pressure (up and down) and tangential friction (right and left). We will improve the device by adding a third DoF to present various sensations.

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