Wearable Haptic Device that Presents the Haptics Sensation of the Finger Pad to the Forearm and Fingertip

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Abstract. Many methods have been proposed for presenting tactile sensations from objects in the virtual reality environment. In particular, many wearable tactile displays for the fingers, such as fingertip- mounted haptics display and glove-type haptics displays, have been developed. We developed a device that presents the haptic sensation of the fingertip to the fingers and to the forearm rather than only to the fingertip as a new haptic presentation method for virtual reality environment. The device adopts a vibrator on the fingertip to present positional and collisional information, and a five-bar linkage mechanism on the arm to present the strength and direction of force. Compared with fingertip-mounted haptic displays, combination of the two devices enables small size at the fingertip, yet direction of force can be expressed. Our preliminary test revealed that it is easily to associate the haptics sensation provided from the device to the forearm with their own fingertip.

Keywords: Virtual Reality, Tactile Displays, 5 bar-link mechanism, Vibration.

1 Introduction

Many studies have attempted to present tactile information of the fingers in the virtual reality (VR) environment and many wearable tactile displays for the fingers, such as finger-type and glove type displays, have been proposed [1][2]. However, the weight and size of the tactile displays typically hinder the free movement of the fingers, especially in the multi-fingers scenario. We have therefore proposed a method of presenting the haptic sensation of the fingertip, including the direction of force, to the forearm to address these issues.

When we manipulate an object, various kinds of tactile information are presented to the fingers. Among many sensory channels of the fingertips, one of the most important channels are those of the strength and direction of a force, which are indispensable information when manipulating object.

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[3]. The top side of the forearm was found to be an appropriate part corresponding to the index finger. Furthermore, by making the device correspond not only to the index finger

but also to the thumb, it was possible to present a haptics sensation for the task of gripping and lifting object. We also conducted a user study, in which participants were asked to grip and lift an object in a VR environment. The result suggested that the use of the device can lead to an improvement in the realism. However, the comments from the users showed that training time was required to associate the haptic sensation provided from the device to the forearm with the haptics sensation of their fingertip.

To address this issue, we propose to attach small fingertip-mounted display using a vibrator, in combination with a five-bar linkage mechanism which presents the strength and direction of force to the forearm (**Fig. 1**). When touching an object in VR scene, haptics cue is given to the fingertip via vibrator for a short period of time. Then strength and directions of the force are given to the forearm.

Fig. 1. Device design

2 System Design

The fingertip mounted device is made of acrylonitrile butadiene styrene injected by a three-dimensional printer. It embeds a small vibrator (13000 rpm) and it can be attached and detached using Velcro tape. The device for the forearm adopts a five-bar linkage mechanism, which, unlike the original structure, adopts an M-shaped structure. Tsetserukou proposed using this link mechanism for presenting the sensation of a force to the fingertip[4][5] and to the palm. On the basis of this previous study, we have developed a device that can be worn on the forearm [3]. Two-degree-of-freedom (2DoF) movement can be achieved by controlling two servo motors. The parts that present the haptics sensation can move up and down (pressure sensation), left and right (tangential friction sensation). The two devices are connected to a personal computer through a microcontroller (NXP mbed 1768). LeapMotion device was used for finger tracking.

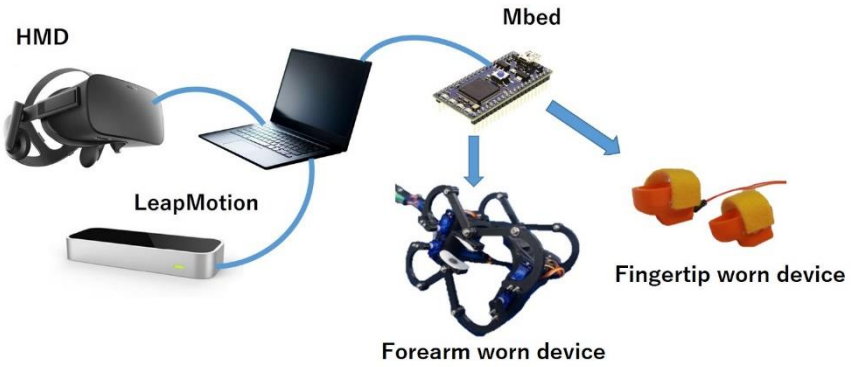

Fig. 2. System Design

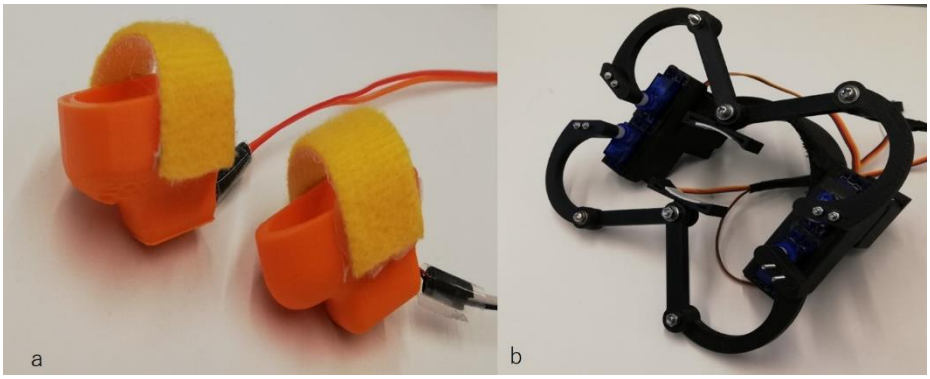

Fig. 3. Fingertip worn display (a); Forearm worn display (b)

3 User Experience

The following describes the user experience in our demonstration. Various objects were placed in VR space and users handled them using our developed devices. The presentation of vibration sensation to the finger is short time, and allows users to grasp which finger contacted and when the strength and directions of the force are expressed by the arm worn device. User can touch, grasp, and manipulate objects in VR scene, and tasks such as peg-in-hall is performed by the users.

Fig. 4. Grasping a cup in VR environment (a); peg-in-hall application (b)

4 Conclusions and future work

We developed a device that presents the haptic sensation of the fingertip to the fingers and to the forearm rather than only to the fingertip. Specifically, we created a device that presents vibration sensation to the fingertips for the haptics cues to associate the haptics information provided to the forearm with the fingertips. Our preliminary test revealed that it is easily to associate the haptic sensation provided from the device to the forearm with their own fingertip.

Because the device on the forearm currently has only two DoFs, we could only present force to limited directions. We will improve the device by adding a third DoF to present various sensations.

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