WholeGrip: Grip Type Master Hand with the Whole Hand Tactile Feedback

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1. Introduction

For the intuitive manipulation of teleoperating robot hand and virtual avatar hand (slave hand), tactile feedback is essential. This is especially true when the slave hand interacts with virtual or real objects. Many manipulation devices (master hand) with tactile feedback functionality have been developed [Sato et al., 2007][Sato, 2002][Endo et al., 2009], but the following issues remain to be solved.

First, wearing the glove type device is cumbersome, and sometimes causes trouble when the user has large/small hand. Second, presentation of tactile feedback only at the fingertips of the user can afford limited part of action. Many hand manipulations such as grasping tools and shaking hands require tactile presentation to palm. Third, low spatial resolution in the case of using a vibration motor or an actuator for each fingertip can present limited tactile information.

To cope with these issues, we developed WholeGrip (Figure 1), a grip-type master hand that has electro-tactile display at the whole side surface. The users grasp the WholeGrip using their whole hands and interact with the objects using the whole hand. The above issues are solved as follows. First, the cylindrical shape enabled the user to grasp without attachment. Second, the device can present tactile sensation to the whole skin of the hand that contacts the device. Third, the electro-tactile display enabled 3 mm interval high resolution tactile stimulation, which is the same as the two-point discrimination threshold of the finger except fingertip.

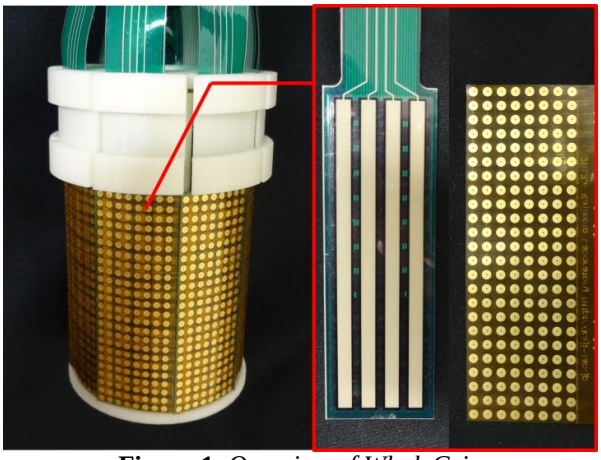

Figure 1. *Overview of WholeGrip*

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2 System Overview

The WholeGrip is composed of the unit that combined previously developed film type electro-tactile display [Kajimoto, 2012] and film type pressure distribution sensor. The electro-tactile display is placed on the pressure distribution sensor, so that the system can simultaneously measure gripping force and present tactile sensation [Takei et al., 2014]. The electro-tactile display is composed of 1536 electrodes with 3 mm interval. The pressure distribution sensor is composed of 416 elements with 5.2 mm interval. The diameter and height of the cylindrical shape is 63 mm and 72 mm, which can be easily grasped by most users. Both the electro-tactile display and the force sensor is connected to the PC via USB.

The system recognizes fingers position by image processing of resistance distribution measured by the electro-tactile display, measures exerted force by each finger by the pressure distribution sensor, and converts the force to the posture of the slave hand (Figure 2). The pressure distribution data is interpolated in accordance with the resolution of the electro-tactile display by bilinear interpolation. The force applied by each fingertip is converted to the joint angle of the finger. The force is also used for modulating tactile feedback.

The WholeGrip is currently mounted on a desktop type force feedback device (Novint Falcon) (Figure 3), which enables active interaction using arm motion.

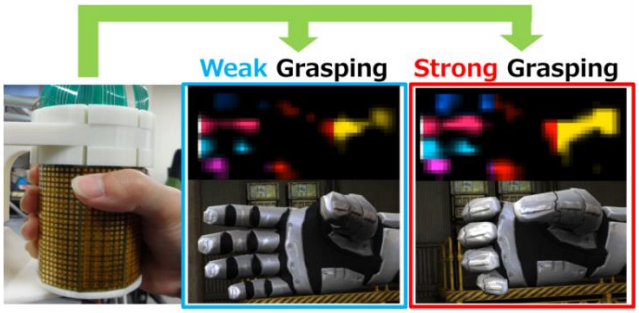

Figure 2. *Slave hand manipulation (Left: A user's hand, Center, Right: Pressure distribution and posture of slave hand)*

Figure 3. *Overview of the prototype system with force feedback device*

3 Demonstration

We will demonstrate the slave hand manipulation in virtual environment using the WholeGrip and the force feedback device. Users can interact with the virtual objects by many kinds of actions (touching, pressing, grasping, rubbing and so on). The system presents not only tactile feedback to the whole skin of the hand that contacts the WholeGrip, but also force feedback to the hand when the users interact with the virtual objects. The feedback enables the users to recognize the shape of contact object.

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