Presentation of Softness Using Film-Type Electro-Tactile Display and Pressure Distribution Measurement

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Abstract. Electro-tactile display has simple mechanical structure and it can present tactile stimulus. However, electro-tactile display lacks of feedback corresponding to touching motion. In this research, we developed a device that combines an electro-tactile display and pressure distribution sensor. The device not only solves problem of unnatural electrical sensation, but also enables expression of haptics-related physical characteristics, such as softness and viscosity. In an experiment, we validated whether the presentation of softness sensation is possible. As a result, presentation of softness sensation is confirmed that is possible by using pressure distribution measurement.

Keywords: Electro-tactile display, Pressure distribution, Softness

1 Introduction

Electro-tactile display is a tactile presentation device having simple mechanical structure. The interface part is just an electric substrate with electrodes, which can be as thin as 0.1 mm, flexible and can form curved shape [1] [2]. This greatly reduces limitation when combining with existing interfaces such as force display and visual display.

On the other hand, the electro-tactile display has several issues. One of those is lack of feedback corresponding to touching motion. In general mechanical tactile presentation, when the user presses the display stronger, the sensation becomes stronger. As we have learned this innate feedback in our daily lives, we feel it “natural”. On the contrary, electro-tactile display does not have this innate feedback and typically, one feels the strongest sensation when he/she softly touches the electrode, due to insufficient contact. It leads to the general impression of “painful” or “frustrated” electrical sensation.

Electro-tactile display has the capacity to sense touch by resistance measurement for each electrode. However, in many cases, it can only detect touch, not the applied pressure. One previous work achieved pressure feedback by placing a force sensor

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under the electro-tactile display [3], but it could not measure pressure of individual electrode. Therefore, presentation of tactile feedback in accordance with the fine pressure distribution was not possible.

To address this issue, we developed a device that combines an electro-tactile display and pressure distribution sensor. This device enables measurement of the pressure distribution applied by the users, and use of the pressure distribution as input data for tactile feedback. Thus, the natural local feedback in accordance with pressure distribution becomes possible, which not only solves problem of unnatural electrical sensation, but also enables expression of haptics-related physical characteristics, such as softness and viscosity.

In this paper, after overviewing the system, we demonstrate that the pressure distribution measurement enables softness feeling, by presenting spreading sensation in accordance with pressure distribution change.

2 Experiment

In this experiment, we tested presentation of softness sensation by presenting tactile pattern in accordance with pressure distribution.

2.1 Device Structure

We use an electro-tactile display that has been developed in our previous work [2]. A film type electro-tactile display unit with 192 (8 by 24) electrodes is driven by electrical pulse generator that communicates with PC (Fig. 1). Distance of each electrode is 3mm. We also used a pressure distribution sensor unit that has 52 (4 by 13) measurement points (Fig. 2). Distance of each measurement points is 5.2mm. The electro-tactile display is placed on the pressure distribution sensor, so that the system can simultaneously measure pressure distribution applied by the users and present tactile sensation. Fig. 3 shows pressure distribution of the sensor (middle), and interpolated pressure distribution for each electrode (right). Pulse width was 30μs, and frequency of measurement and stimulation loop was 50Hz.

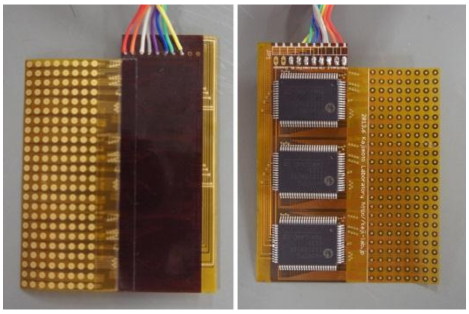

Fig. 1. Electro-tactile display

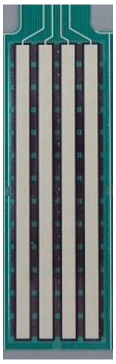

Fig. 2. Pressure distribution sensor

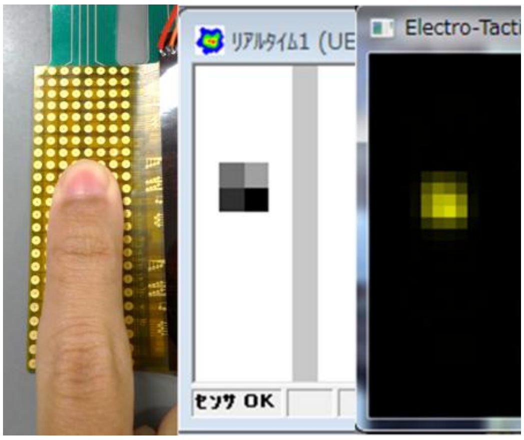

Fig. 3. State of pressure distribution measurement

2.2 Softness Presentation Method

There have been several attempts to present softness, most of which paid attention to the change of contact area [4] [5] [6]. Soft objects deform rapidly so that the finger contact area becomes larger.

We also applied this principle to present softness by electro-tactile display. Fig. 4 illustrates our methods. When the device is pressed strongly, the device presents stimulus that spreads like a ring to the outside of the contact area of the device and finger (Fig.4, left, named Method 1). It enhances spreading of the contact area so that it should be perceived as soft. Fig.4 right (named Method 2) illustrates control condition, in which electrical stimulation is applied to the inside of the contact region.

In this experiment, we compared these two methods. In Method 1, the stimulation was presented at electrodes that are pressed with 1.35 to 9.021gf, which naturally achieve ring-shaped stimulation area. In the Method 2, the stimulation was presented at electrodes that are pressed with the weight bigger than 9.021gf.

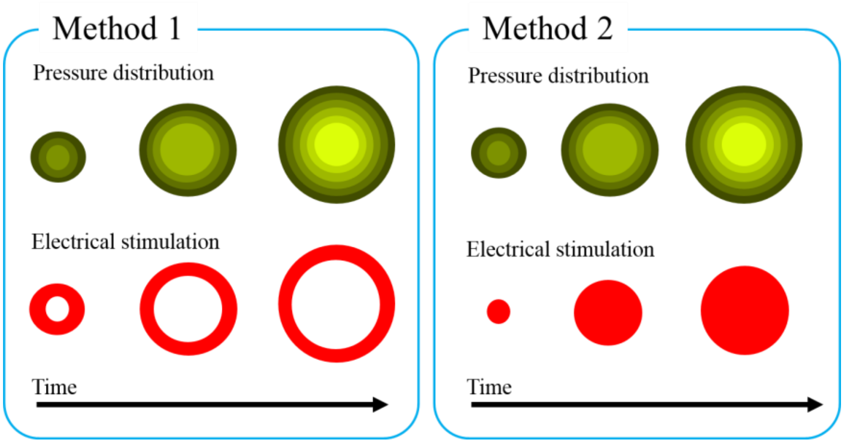

Fig. 4. Schematic view of stimulation methods

2.3 Procedure

We recruited five participants (all males, 22 to 25 years old) from our laboratory. First, participants pressed the device and adjusted the stimulus volume so that they do not feel pain. In subsequent procedure, the volume was fixed.

The main experiment was carried out by the following procedure.

1. Method 1 or Method 2 was presented to participants randomly, and the participants pressed the device by following visual indicator
2. The other method was selected, and the participants actively pressed the device by following visual indicator.
3. Participants chose which of the two was felt softer (forced choice)

The visual indicator was as shown in Fig. 5. The top bar expands and contracts between 0 to 463.5g, with 1Hz sinusoidal curve. Participants controlled their pressure to match the bottom bar (participants' pressure) to the top bar. The experiment was conducted five times for one participant.

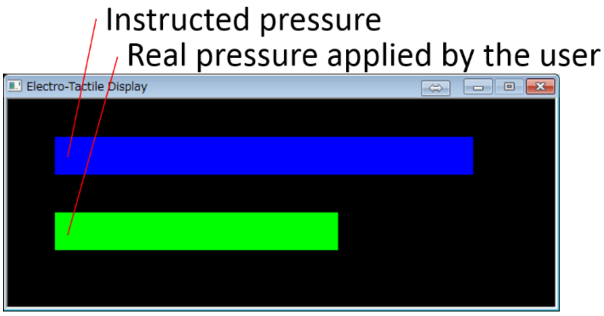

Fig. 5 Assistance of vision that presented to user

2.4 Result

84% chose Method 1 as softer. We performed the paired comparison test of the ratio, and found a significant difference between chance level (50%) and the result ($p=0.001374$).

3 Conclusion

Based on the idea that electro-tactile display can express various physical properties by combining with pressure distribution information, we performed an experiment to present softness sensation using electro-tactile display and pressure distribution sensor. The result indicated that users felt softness sensation when electro-tactile display presented stimulus that spread like a ring when they pressed the electro-tactile display.

Our future work will include implementation of other physical properties such as viscosity and adhesion. We will implement the method to the application of interaction with virtual objects.

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