A Touch Panel for Presenting Softness with a Virtual Image

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Abstract— **In this study, we tested a novel system for manipulating the sensation of hardness and softness using a touch panel in augmented reality (AR) space. Many studies of touch panel-based haptic displays have developed methods for manipulating macro-roughness (shape), fine-roughness (texture), and friction. However, few studies have examined the sensation of softness. Here we used a film-winding mechanism to present tangential force opposite to the tangential displacement of the fingers, which functioned as a sufficient cue for the sensation of softness. We combined this with a visual cue for softness, adding visual shadow to the display of the virtual image generated by a half-mirror, which indicated visual deformation of the object.**

I. Introduction

Many previous studies have examined tactile sense presentation with touch panels, successfully developing methods for presenting various types of haptic sensation. However, although there is an evidence for five dimensions in the sense of tactile material feeling of an object[1], most previous studies of tactile sensation using touch panels have focused on three dimensions: macro-roughness, fine-roughness, friction. In contrast, studies of the other two dimensions and the presentation of the remaining two (Warmness and Hardness/Softness) are relatively rare.

Softness is a particularly important haptic dimension for various applications. For example, touch panels with softness display could enrich an augmented reality (AR) applications for demonstrating the effects of cosmetics. However, although the presentation of softness itself has been studied[2], few studies have examined softness presentation in conjunction with touch panels. Nakamura et al. [3] recently proposed a sophisticated mechanism for presenting softness with a touch panel using an electrostatically driven device to control the contact area of the finger[4]. However, this requires an additional device to be attached to the users' fingers.

We sought to present the sensation of softness with a touch panel without attaching devices to fingers. We placed a transparent film on the touch panel, and presented a tangential force opposite to the tangential displacement of the fingers, because vertical displacement is not feasible with a tablet. Although this method was only able to present tangential force, we hypothesized that it may provide a sufficient cue for softness. Furthermore, envisioning future applications of AR in the cosmetics, we created a virtual image of a soft material using a half-mirror on the touch panel, and presented shadow via the touch panel to visually show deformation.

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II. Proposed Method and Prototype

The prototype system is shown in Figure 1. We adopted a film-winding mechanism using two DC motors[3] to present force on the whole top surface of the touch panel. In this system, when users touch the realistic 3D image generated on the touch panel, they move and trace the film on the touch panel in a tangential direction with their fingers. To apply force that was proportional to the displacement, the film was wound in the opposite direction, and the reaction force in the tangential direction to the finger pad was made possible. Although the finger movement was limited to the tangential direction (without vertical movement), inconsistency of the movement direction was allowable, as shown in the evaluation experiment described below. Although a number of previous studies have proposed driving fingers tangentially on the touch panel[5][6], the primary purpose was for navigation, or presentation of shape or friction.

As a visual presentation system, a realistic 3D image of a real soft object was generated on the tablet using a half-mirror, and shadow information was superimposed around the finger as a visual effect (Figure 2). Using this system, we sought to induce users feel a sense of softness for users, not only tactually but also visually.

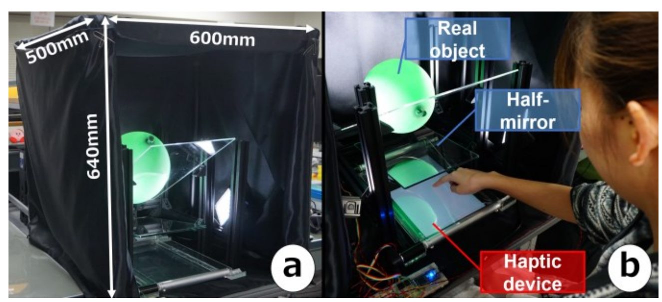

Figure 1. Prototype system.
(a) Overall view. (b) Inside view.

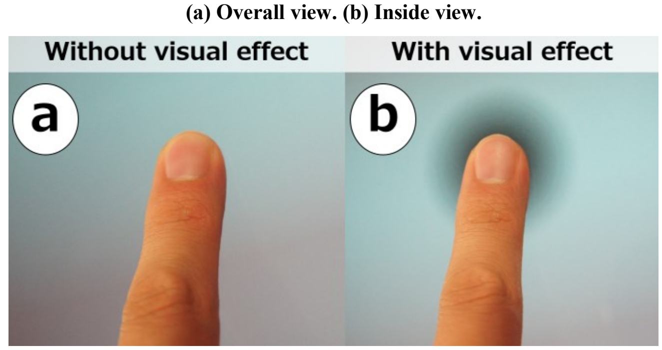

Figure 2. Photograph of the visual effect.
(a) Without any visual effect. (b) With visual effect around the user's finger.

III. EXPERIMENT

We evaluated the effect of visual and haptic modulation on a realistic 3D image. We conducted a subjective evaluation using a soft object (a human skin gel with ASKER hardness 39) by asking users to compare the state of touching the real object vertically with the sensation of touching the virtual object (our system) horizontally.

A. Experimental Conditions

In this experiment, we tested the following three conditions:

- No shadow presentation, as shown in Figure 2(a).
- Shadow presentation, as shown in Figure 2(b), where the size was kept constant (Effect 1).
- Shadow presentation, as shown in Figure 2(b), but the shadow diameter was set to be proportional to the finger displacement (Effect 2).

In addition, we tested the following two conditions for haptic presentation:

- No reaction force presentation.
- Reaction force presentation.

A total of six conditions were prepared by combining the above conditions. We used a subjectively chosen parameter that we felt was closest to the state of pushing the actual human skin gel to present the reaction force and the amount of change in the visual shadow. Participants' hearing was blocked with putting on headphones during the experiment. Participants were instructed to move their index finger in a sequence, touching the real object then the virtual object, using our proposed system. Participants were then asked to move their fingers approximately 2.5 cm in a forward direction. After each trial, subjects were asked to evaluate the following five properties using a seven-point Likert scale: 1) hardness and softness (1: hard, 7: soft), 2) visual naturalness (1: unnatural, 7: natural), 3) haptic naturalness (1: unnatural, 7: natural), 4) comfort of the whole experience (1: unpleasant, 7: pleasant) and 5) strangeness or incongruity of the whole experience (1: feels strange, 7: does not feel strange). For these properties, the real gel was set to a score of 4. Six combinations of conditions were presented three times, resulting in 18 trials in a random order. We recruited 10 naive participants (three females, seven males, 21–25 years of age).

B. Results & Discussion

Figure 3 shows participants' responses in the evaluation of "softness". Significant differences were found in seven of nine combinations with and without tactile presentation, which shows that tactile presentation is indispensable as a factor for manipulating the sense of hardness and softness. There were no significant differences associated with visual effect.

Figure 4 shows responses in the evaluation of "naturalness". The results showed that the combination of haptic and visual cues induced the impression of the experience being "natural".

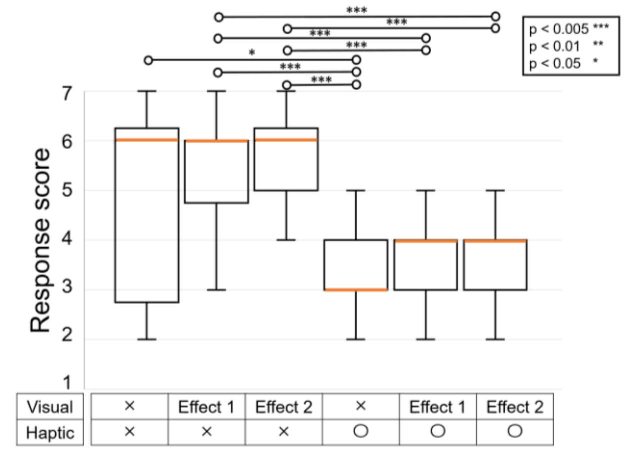

Figure 3. Results for hardness and softness measure (1: Hard; 4: Same as real object; 7: Soft)

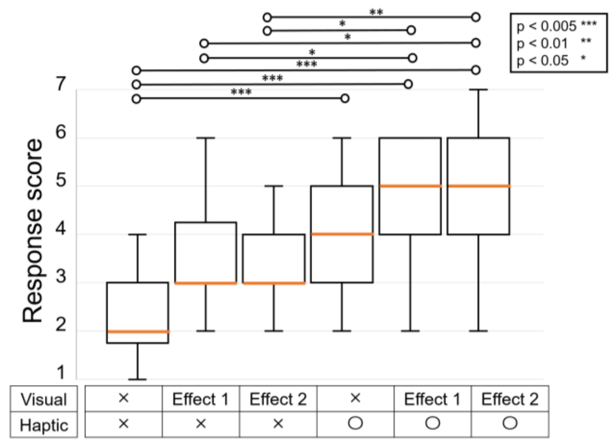

Figure 4. Results for haptic naturalness measure (1: Unnatural; 4: Same as real object; 7: Natural)

IV. CONCLUSION

In this paper, we described a new method for presenting softness on a touch panel using a film-winding mechanism. Furthermore, a realistic 3D image was presented on a display using a half-mirror, with a shadow based visual effect. Experimental testing revealed that our haptic presentation method succeeded in inducing the experience of a "softer" material, with a sufficient level of naturalness.

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