Visuo-haptic Interaction with Mobile Rear Touch Interface

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Fig.1 Polygon deformation on pushing

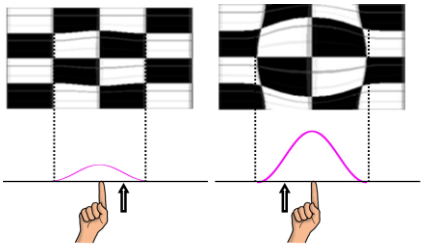

Fig.2 Sine wave deformation

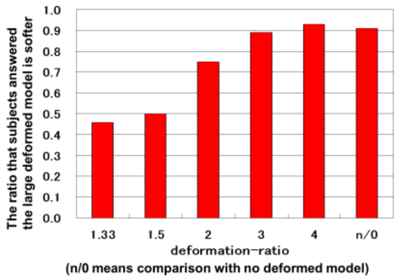

Fig.3 The ratio that subjects answered the large deformed model was softer against deformation-ratio

1. Introduction

In this paper, we propose the visuo-haptic system that is able to evoke the haptic sensation on the mobile device, without any haptic devices, only using visuo-haptic interaction.

Touch panel is a compelling input modality for interactive devices. However, touch input is inaccurate and hard to see objects under touch due to occlusion by a user's finger. To solve this problem, the rear touch interface is actively researched and commercialized [Wigdor et al. 2007]. Using this interface, users can input with a touch panel arranged behind a device, and a cursor shows the touching point on the screen.

On the other hand, there are increasing numbers of works that focus on passive haptics, like the visuo-haptic interaction. The visuo-haptic interaction is a kind of cross modal effect between our visual and haptic sense. Pseduo Hpaitcs is one of the well known phenomenon of the visuo-haptic interaction, which indicates an illusional perception in our haptic sensation evoked by vision [Lecuyer 2009]. This illusion is evoked under an inconsistent situation between the physical behavior of our body and the one observed in our vision. For example, it is revealed that the mismatch between a speed of physical computer mouse and the one of corresponding cursor in display evokes illusional force feedback on our hands.

To provoke the visuo-haptic interaction which includes pseudo haptic effect, it is need to hide a user’s hand or put it other place like the positional relation between a cursor on the screen and a hand on a mouse. Thus it is difficult to provoke the visuo-haptic interaction, for the normal type of touch panel which we contact directly. Meanwhile, with the rear touch interface, we are able to evoke the visuo-haptic interaction because users hands are hidden behind the screen.

In our system, we compose a rendering algorithm of visual feedback to evoke the effect of the visuo-haptic interaction with mobile rear touch interface, which affects our perception of softness. We compose a system with a rear touch interface that can deform the shape of the polygon on the monitor as a function of pressure of pushing (Fig.1).

2. Affect Perception of Softness with Rear Touch Interface

To make up an inconsistent situation between our vision and haptic sensation to affect our perception of softness, we composed a rear touch interface which can control the deformation amount of the polygon on the monitor which users push from the back of devices.

To investigate the effect of the visuo-haptic interaction with rear touch interface, we constructed prototype system. For this system, we used an android mobile device, and attached a pressure sensor on the back of it. The shape of polygon on the monitor is deformed depending on pressure intensity with which users push the back of the device. The visual feedback of the polygon’s deformation modifies the user’s perception of softness. To deform the polygon, we assumed the situation that a user locally pushes the center of the device's backside, and the polygon is deformed as a shape of sine wave (Fig.2). The softness of the polygon was determined by the value of deformation module, k ($d = k*p$, d and p means amount of deformation and inserted pressure respectively). We constructed 5 polygon models whose deformation modules were set to the ratio of 0:1:2:3:4.

3. Experiment and Results

To investigate the effect of visual feedback to the perception of softness, we conducted user experiment. In each trial of this experiment, subjects were asked to push in the center of the device's backside with two different models and answer which model is softer or same. The study had 12 subjects, and we conducted this trial 60 times to each subject (20 combinations to choose 2 from 5 models, and 3 times of each combination).

Fig.3 shows the ratio that subjects answered the large deformed model was softer against deformation-ratio. Deformation-ratio is defined as the value of larger k divided by smaller k of two models to compare in each trial. In this graph, the larger deformation-ratio is, the more subjects likely to feel the gap of softness between two models. Moreover, the graph tend to go flat where deformation-ratio is under 1.5 and over 3.0. This fact indicates that it is possible to change the perception of softness gradually by controlling deformation-ratio between 1.5 and 3.0.

Our result shows that it is possible to affect the perception of softness using visuo-haptic interaction with rear touch interface. For future works, we will do accurate and quantitative evaluation of the effect of visuo-haptic interaction of softness. In addition, we are currently working on evoking other force than softness and applying these forces to applications on mobile devices. Especially, shear force can be evoked using pseudo-haptic effects. Moreover, we are trying to evoke stronger haptic sensation by showing deformed image of user’s hand on the monitor.

References

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SIGGRAPH 2013, July 21 – 25, 2013, Anaheim, California.

ACM 978-1-4503-2261-4/13/07