Pseudo-Softness Evaluation in Grasping a Virtual Object with a Bare Hand

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Abstract

Bare hand interaction with a virtual object reduces uncomfortableness with devices mounted on a user's hand. There are some studies on the bare hand interaction[Benko et al. 2012], however a virtual object is supposed to be a hard object or a user touches a physical object during the bare hand interaction. We focus on grasping a virtual object without using any physical object. Grasping is one of the basic movements in manipulating an object and is more difficult than simple movements like touching an object. Because of the bare hand interaction with no physical object, there is no haptic device on a user's hand and so there is no physical feedback to the user. Our challenge is to provide a user with pseudo-softness while grasping a virtual object with a bare hand. We have been developing an AR system that makes it possible for a user to grasp a virtual object with a bare hand[Suzuki et al. 2014]. Using this AR system, we propose visual stimuli that correspond with the user's hand movements, to manipulate the pseudo-softness of a virtual object. Evaluation results show that with the visual stimuli a user feels pseudo-softness while grasping a virtual object with a bare hand.

Keywords: interaction, augmented reality, pseudo-softness

Concepts: •**Human-centered computing** → **Empirical studies in interaction design;**

1 Pseudo-Softness Evaluation

Our AR system is composed from an HMD (Oculus Rift DK2, Oculus VR) with a stereo RGB camera (Ovrvision 1 for DK2, Wizapply), a position tracking camera (an accessory of the HMD) and a PC. A stereoscopic view of a virtual object and a user's hand captured with the stereo camera is displayed on the HMD in real time. By checking the positions of the virtual object and the user's thumb and index finger, the AR system determines whether the thumb and index finger collide with the virtual object. When the collision occurs, the virtual object is deformed under physical calculation so that the movements of the thumb and index finger are reflected. Also, the shape of the user's hand is modified so that the thumb and index finger touch the surface of the virtual object. With hidden-surface process, the user can grasp the virtual object with the user's bare hand on the HMD.

We prepare three degrees of the pseudo-softness: (A) "Softness a user expects," (B) "Softer than (A)," (C) "Less soft than (A)." Each visual stimulus differs in the deformation of the virtual object and the modification of the shape of the user's hand.
(A) "Softness a user expects": Based on the actual movements of the user's thumb and index finger, we deform the virtual object and modify the shape of the user's hand.

(a) (b) (c)

Figure 1: *Visual stimulus (B) "Softer than (A)"*

(a) (b) (c)

Figure 2: *Visual stimulus (C) "Less soft than (A)"*

((a) *is the actual distance,* (b) *is the modified distance,* (c) *is a visual stimulus on the HMD.)*

(B) "Softer than (A)" (Figures 1): The virtual object is deformed more than (A), and we modify the shape of the user's hand in which the distance between the thumb and index finger is narrower than the actual distance between the user's thumb and index finger. As a result, a visual stimulus looks as if the user grasps a softer virtual object with the user's hand.
(C) "Less soft than (A)" (Figures 2): The virtual object is deformed less than (A), and we modify the shape of the user's hand in which the distance between the thumb and index finger is wider than the actual distance between the user's thumb and index finger. As a result, a visual stimulus looks as if the user grasps a less soft virtual object with the user's hand.

Twenty users participated in pseudo-softness evaluation. They compared each pair of visual stimuli among the three visual stimuli. For each pair, the following questions were answered: (i) Which virtual object do you feel softer ? (ii) Which virtual object do you feel more that you have it with your hand ? (iii) Which virtual object do you feel more that you move it easily ? (iv) Which virtual object do you feel heavier ? Each user conducted the six comparison which include the reverse order of grasping the virtual object.

Forty comparison data for every question were collected and analyzed statistically. Results of the comparison between the stimuli (A) and (B) showed that the users felt that the stimulus (B) was softer and heavier than the stimulus (A) and that the stimulus (B) was marginally statistically more significant than the stimulus (A) in terms of the questions (ii), (iii). As for the comparison between stimuli (A) and (C), there were no significant differences the users felt for all the questions (i)-(iv). We conclude that the visual stimulus with the user's hand movements that shows more softness than a user expects, seems to provide the user with pseudo-softness "softer" while grasping a virtual object with a bare hand. This work was supported by JSPS KAKENHI Grant Number 15K00373.

References

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