[Poster] A Preliminary Study on Altering Surface Softness Perception using Augmented Color and Deformation

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Abstract
Choosing the appropriate soft/hard material is important for designing a product such as sofa or bed, but typically limited by the number of physical materials that the designer owns. Pseudo-haptic feedback is an alternative way that enables designer to roughly simulate material properties (e.g., softness, hardness) by only generating the visual illusion. However, the current technique is limited within video see-through augmented reality, in which the user interact in a real space while looking at a virtual space. This paper explores the possibility to realize pseudo-haptic feedback for touching objects in spatial augmented reality. We investigate and compare effects of visually superimposing a projection graphics onto the surface of a touched object and the fingernail/finger for changing the surface tactile perception. The potential of our method is discussed through a preliminary user study.

Keywords: Spatial augmented reality, pseudo-haptics, perception.

Index Terms: H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities—Evaluation/methodology; H.5.2 [User Interfaces]: Haptic I/O—Prototyping

1 Introduction

Touch is a basic interaction for choosing a material during the design process of an industrial product. Traditionally, a designer requires several different physical materials to choose the appropriate one. Although the number of materials has obviously a significant effect in material design process, providing several materials is difficult due to budget limitation. Pseudo-haptic feedback enables a designer to perceive material properties such as softness/hardness through video see-through augmented reality (AR) without any haptic feedback devices [1]. However, it is limited within the display's field-of-view, and collaborative work is difficult to be achieved because designers required to wear an equipment.

Spatial augmented reality (SAR), which merges the virtual world with the real world without any user-worn equipment can solve this limitation. Prior work utilized SAR to modify the surface appearance by superimposing projection [2]. While this work achieved to visualize surface appearance of different materials within one physical object, it is still limited as far as interacting with the surface materials. To overcome this limitation, we propose a new pseudo-haptic feedback technique in SAR to manipulate the surface softness perception when actually touching the object. This paper presents our first implementation which would make the designer feel different degrees of softness within only one physical material. The central contribution of this research is to improve the traditional material design process by using SAR technology.

2 Visual Influence on the Surface Perception

Psychological research has focused on how tactile information interacts with mental representations of one’s own body [3]. The result of these studies reveals the effect of visual stimulation on tactile perception when looking at own body and touching it directly. Our hypothesis from this result is that, if we can modify the visual feedback which appears on our body (i.e. body variation) and surface (i.e. texture), tactile perception might be changed simultaneously. In other words, the manipulation of visual feedback by superimposing a projected appearance onto body and touching objects might modify surface perception such as softness and hardness.

Prior work in the virtual reality reveals that visual stimulus influences the perception of the object’s weight, e.g., by changing the virtual hand’s color [4]. In contrast, we are interested in the visual feedback of our physical body, for example, the changes in fingernail color when touching an object. The amplification of body variation as visual feedback might influence the surface perception. To prove this hypothesis, we conducted a preliminary experiment using easy-to-setup projector system. We projected appearance to amplify the surface deformation while touching object, and augmented body variation change, simultaneously.

3 Equipment

We use a projector (ACER DLP K10, 100 ANSI Lumens) for visually superimposing surface and body appearance, a force sensor (WACHO-TECH Dyn-pick 6-axis force 200N model) for measuring the force applied by subject’s finger touching object, and a 30 cm square flexible sponge as a material in this investigation. The visual information is rendered on an Intel Core i7 3.07GHz machine with 6GB of RAM, and projected directly to physical surface of sponge without any occlusion between user and real scene.

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4 Prototype System

The goal of our experiment is to investigate the possibility of manipulating surface tactile perception (e.g., softness/hardness) by superimposed graphics in SAR. In this system, the projector is on the ceiling, and force sensor is under the sponge material (fig. 1). Subjects are able to use their index fingers to touch a surfaces which can deform, while an amplified image of the body part is superimposed on the user’s fingernail/finger (fig. 2).

5 Experimental Setup

Five subjects (4 males, 1 female) between ages of 22 and 25 participated in the experiment. Each participant was asked to touch the sponge surface under five conditions:

C-1 Amplify only fingernail color (from skin color to red).
C-2 Amplify only finger color (from skin color to red).
C-3 Amplify only surface deformation appearance.
C-4 Amplify surface deformation appearance and fingernail color.
C-5 Amplify surface deformation appearance and finger color.

For each condition, participants touch the physical surface for 3-7 seconds, while projection is visually superimposed onto touching object and/or body (fig. 1b). Note that the amplification of surface appearance and fingernail/finger color change progressively using the Wizard-of-Oz method.

Participants are asked to evaluate the softness of the surface, comparing the way it is perceived when the color is amplified (condition) and when only white color is projected (actual). They can choose the preferred softness in 3 choice answers, (1) surface with projected graphics is softer, (2) actual surface is softer, and (3) both are the same. Moreover, the force applied by each participant during the experiments is measured in order to prove the objective of this investigation.

6 Results

Table 1 shows the result of the preliminary user study. When visually superimposing projection modify surface deformation appearance with amplification of fingernail color (C-4), or with amplification of finger color (C-5), the participants felt physical surface was softer than the actual one (i.e. the one only white color was projected).

As described in Sec. 5, we measured force applied by participant’s finger to physical surface using force sensor. An example of measured result in Fig. 3 shows that participants touched the physical surface with less force when an amplification appearance was superimposed (≈ 4.13N) than in the case of the actual surface (≈ 5.61N). However, there are no significant differences when only the fingernail color (C-1), or finger color (C-2) were amplified.

7 Conclusions and Future Work

We have presented a first prototype system that provides a visual enhancement of different softness surfaces within one physical material. In this investigation, we found it is possible to manipulate the perception of the surface soft/hard properties without requiring to separate the visual and tactile space that using in video see-through AR techniques. We plan to implement a new prototype using computer vision techniques (i.e. touch detection, force estimation), and conduct a formal study to confirm the effectiveness of our proposed method.

References


Table 1: Results of user test (Y: Surface is softer with projected appearance, N: Actual surface is softer, and S: Both are the same).

<table>
<thead>
<tr>
<th>Participant/Condition</th>
<th>C-1</th>
<th>C-2</th>
<th>C-3</th>
<th>C-4</th>
<th>C-5</th>
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</table>

Figure 2: (a) Projected appearance on a physical surface, (b) actual projection (without appearance amplification), (c, d) amplify surface deformation appearance and fingernail color, or finger color, respectively.

Figure 3: Comparison of average measurement results of force applied by participants on the actual appearance and under the condition C-4, and C-5.