University of Stuttgart
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Illusion of Surface Changes induced by Tactile and Visual Touch Feedback

Abstract. The work presented here aims to enrich material perception when touching interactive surfaces through simulating changes in the perception of various material properties, such as softness and bendability. The thereby created perceptual illusions of surface changes are induced using electrotactile stimuli and texture projection as touch/pressure feedback. A metal plate with an embedded electrode was used to provide the user with electrotactile stimuli when touching the surface with a finger that is also equipped with an electrode (Fig. 1). The distortion of material textures projected on the touched surface was used to visually simulate surface deformations. An experiment has shown that both feedback modalities, haptics and vision, can induce the illusion of surface deformation when provided separately. When tactile and visual touch feedback has been presented at the same time, the perception of surface changes did not increase compared to just using one feedback modality only.

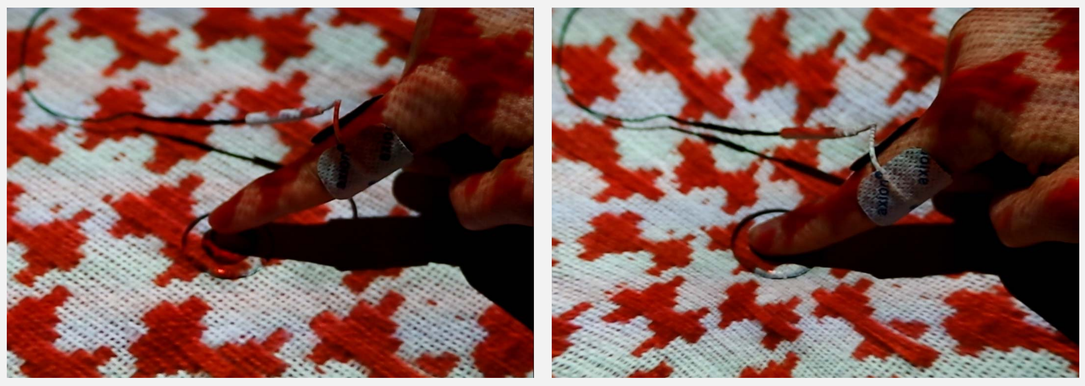

Fig. 1: Texture is projected on a flat metal surface (top) and it is deformed when touched (bottom), which generates the illusion of surface deformation. Additionally or alternatively electro-tactile touch feedback can induce the illusion of touching a deforming surface. Electro-tactile stimuli are generated when touching an electrode embedded into a surface while another electrode is attached to the finger. The apparatus consisted of a TENS device for the electro-tactile feedback, a projector for the visual output, and a pressure sensor underneath the surface to detect the touch/pressure events.

Background

Electrovibration under a fingertip and the displayed image of sandpaper underneath can cause the illusion of touching real sandpaper [2]. Previous work induced the illusion of different surface materiality, namely roughness, when a finger was sliding across a surface using electrotactile touch feedback [1, 2]. Other research investigated how information from one sensory modality, such as audio or vision can simulate tactile perception [3, 4] or even can create a tactile surface illusion [5, 6].

Study

We conducted an experiment with 16 participants, a within-subject design with two independent variables: electrotactile feedback (on/off) and projected texture deformation (on/off). As texture we covered a broad range of natural materials cardboard, cloth, corkboard, fur, Styrofoam, grass, jam, leaf, sponge, and wood, as shown in Fig. 2.

The perception of the ten texture types were recorded for all four feedback conditions using ten 7-item Likert scales. Participants rated the perception of: softness, stretchability, smoothness, thickness, solidness, wetness, hardness, stickiness, viscosity, and bendability.

Findings

Regarding the surface perception, we found that the characteristics softness, stretchability, solidness, hardness, and bendability can be simulated through electrostatic stimulation of the touching fingertip or through distorting texture while it has been pressed.

In summary, our work extends the research body on triggering material perception through electrostatic stimulation as well as through visually simulated texture distortion. Simulating surface properties for passive touch and pressure enables richer touch feedback, which can lead to richer experience of touch-based interaction. Thus, enriching surface perception and thus creating more natural means of touch interaction through generating touch-based illusions can support the myriads of touch-based devices. That potentially enriches the experience when interacting with mobile phones, tablet devices, tabletop devices, and interactive surfaces that may have no built-in touchscreen but that potentially can use visual cues generated by projections.

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[4] Lécuyer, A. Simulating haptic feedback using vision: A survey of research and applications of pseudo-haptic feedback. Presence: Teleop. Virt. Environ. (2009), 39-53.

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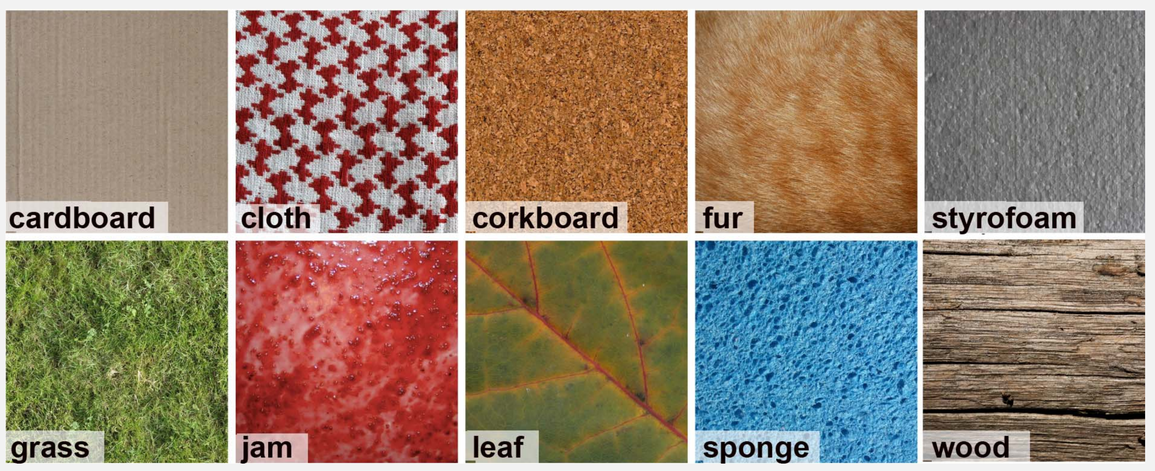

Fig. 2: The texture types represent ten different materials.

Katrin Wolf

University of Stuttgart
Human-Computer Interaction Group
Katrin.Wolf@vis.uni-stuttgart.de

Timm Bäder

University of Stuttgart
mail@baedert.org