Perceive-Sleeve: Towards Personalized Tactile Feedback on Interactive Surfaces

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Abstract

Tactile feedback on interactive surfaces such as touch-screens provides significant benefits in terms of reducing error-rates, enhancing interaction-speed and minimizing visual distraction [2].

Research about tactile feedback on direct-touch-surfaces can be categorized as follows: First, mobile actuator systems like the one used by Kaaresoja et al. [6] move the mobile device or the device's screen as a whole using motors or piezoelectric actuators. With this approach only a single touch-input can be augmented haptically. Second, shape displays, such as FEELEX [5] or Lumen [8] are based on the segmentation of the interactive surface into individually movable 'haptic pixels'. Currently, these systems only provide a small number of actuated points due to mechanical constraints.

All these approaches share the assumption that haptic feedback has to be given at the location of the interaction. We propose spatially disuniting the body-part of interaction (hand, finger) and the resulting tactile feedback. In other words: while the user explores a virtual element on the interactive surface

with his finger or hand, the resulting haptic stimuli are applied somewhere else on the body. Decisive for the position of application are human physiological conditions, the character of tactile information to be conveyed and the nature of the used haptic interface. This approach is potentially beneficial for providing haptic feedback on multi-touch surfaces, accuracy of interaction as well as additional personalized information via the sense of touch.

PERCEIVE-SLEEVE

An integral part of our scientific work towards the aforementioned goal is to gain an overview of tactile interfaces for sensory impaired people. Such systems have traditionally been studied and used in the field of sensory substitution [11].
Visually impaired people gain access to digital information using assistive technologies based on the sense of touch such as Braille [9] or pin-matrix displays such as the *OPTACON* [3]. Other sensory-substitution systems like the Tactaid VII[1] or the Tactuator [10] help to provide information to deaf or Hard of Hearing (HoH) people.
In addition to assisting the sensory impaired, the conveyance of abstract tactile messages using tactile interfaces can improve human-computer-interaction in general [1]. We believe that a consolidation of both areas of research is conducive.

As a step towards haptic feedback on interactive surfaces, we are interested in the perception of stand-alone abstract tactile cues. These tactile cues are generally conveyed to the non-interacting user, in other words: the tactile stimuli don't result from a user's action. Based on the research of Karam [7], Gunther [4] or Brewster [1], we take theoretical elements of music like frequency, instrument, note-duration or rhythmic patterns as abstract information. We translated concepts of auditory information into vibrotactile cues.

Within the bounds of a pre-test with 36 participants, we wanted to explore how hearing and deaf people experience tactile interfaces in everyday life. We assumed that hearing impaired people are more experienced with tactile interfaces and abstract tactile cues. In order to evaluate differences in the perception of tactile stimuli, we presented the patterns mentioned above to hearing and hearing-impaired users. For that purpose, we designed a simple prototype, the *Perceive-Sleeve* (see Figure 1). Course of action and results are presented in brief below.

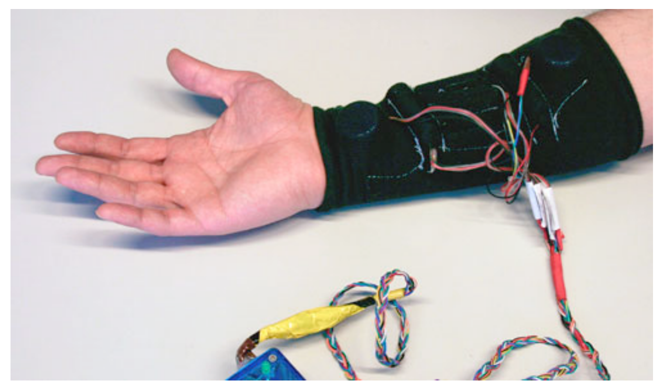

Figure 1 The *Perceive-Sleeve* is attached to the underside of the lower arm of a non-interacting user

[1] Audiological Engineering Corp., Somerville, MA http://www.tactaid.com/

The prototype consists of seven mechanical actuators firmly attached to the skin of the user's underarm using a textile armband. The actuators differ in position and frequency, following the concept of the Model Human Cochlea proposed by Karam, Russo and Fels [7]. The *Perceive-Sleeve* was designed in consideration of several physiological conditions including position (glabrous skin, two-point-discrimination threshold) and frequency (250 Hz and lower). Using this approach, three dimensions of information-encoding are available: frequency, duration and position of stimulus. We designed three groups of vibrotactile patterns: monophone with equal duration, monophone with varied duration and polyphone patterns. The patterns were grouped in pairs and presented to the participants consecutively after a training phase. The participants were asked to sense whether there is a difference between these two patterns. In the second part of the pre-study, we asked about the usage of tactile interfaces in daily life.

The results of our pre-test show only basic experience with tactile interfaces in both groups. The most common tactile cues are mobile phone alerts or vibrotactile alarm clocks. The deaf participants achieved a slightly higher percentage rate of correct differencing both patterns. This disparity is more distinct when looking at people under the age of 15. However, our results show a trend and do not constitute a significant difference in the perception of abstract tactile stimuli of both groups.

Accordingly, our results support the assumption that the use of (abstract) tactile cues in HCI can be considered reasonable and potentially beneficial for both hearing and deaf people.

FUTURE WORK

Gaining an overview of haptic interfaces in the commercial and scientific domain is a major cornerstone of our approach to provide haptic feedback on multi-touch surfaces. In other words: the simultaneous transmission of tactile cues about a virtual object's geometrical, functional and semantic characteristics to more than one finger or hand. We refer to this goal as **Multi-Haptics**. Accordingly, the area of tactile stimulation is not limited to the size of a fingertip; haptically enlarging the tactile resolution of multiple contacts to the interactive surface becomes possible.

In the next step, we plan to assay the personalized transmission of tactile cues to multiple users of a shared interactive display using the aforementioned approach (**Personalized Tactile Feedback**). This means that one user is enabled to perceive tactile characteristics of an interactive element but another user of the shared touch-surface perceives different sensory cues (or none at all) during the tactile exploration of the same virtual object. One benefit would be the creation of an individual channel of tactile information to each user of a shared interactive surface. We plan to assay how this channel can be used to carry private information.

We developed three first prototypes, the *Tactile Thimble*, the *Haptic Armrest* and the *Edge Matrix* (see Figure 2). These three haptic interfaces share the approach of providing tactile cues (resulting from an interaction) on body parts that are not interacting. The prototypes differ in construction, body location of application and type of conveyed tactile information.

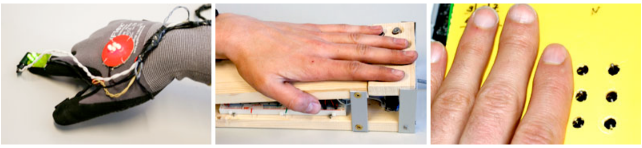

Figure 2. First prototypes (from left to right): Tactile Thimble, Haptic Armrest, Edge Matrix

Technical limits and conceptual challenges of the prototypes like noise development or improper tactile stimuli are to be dealt with. Studies based on the three prototypes will be conducted in the future.

The results so far support our approach of probing concepts and findings from the fields of sensory substitution and assistive technology. Research on the sense of touch as personal and universal communication-channel in HCI is substantial.

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