The PhantomStation – Towards Funneling Remote Tactile Feedback on Interactive Surfaces

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ABSTRACT
We present the PhantomStation, a novel interface that communicates tactile feedback to remote parts of the user's body. Thus, touch input on interactive surfaces can be augmented with synchronous tactile sensations. With the objective to reduce the number of tactile actuators on the user's body, we use the psychophysical Phantom Sensation (PhS) [1]. This illusion occurs when two or more tactile stimuli are presented simultaneously to the skin. The location of the pseudo-tactile sensation can be changed by modulating intensity or interstimulus time interval. We compare three different actuator technologies to recreate the PhS. Furthermore, we discuss how remote tactile of this kind can improve interaction accuracy. We present our prototype and propose scenarios in conjunction with interactive surfaces.

Categories and Subject Descriptors
H5.2: User Interfaces. - *Haptic I/O.*

General Terms
Experimentation, Human Factors

Keywords
Phantom Sensation, PhantomStation, Funneling Illusion, Tactile Feedback, Interactive Surfaces

1. INTRODUCTION
Tactile feedback during the exploration and manipulation of interactive surfaces has been shown to provide a number of benefits in all metrics: performance, usability and user satisfaction. Advantages comprise the reduction of error rates and task time [3] as well as the minimization of visual and cognitive load [6]. However, most current multi-touch surfaces do not communicate haptic information about their interactive elements to the user.

Approaches to provide tactile feedback to users of touch surfaces can be grouped into three categories: First, the movement of the screen or the mobile device as a whole [4]. Thus, only single-touch input can be augmented haptically. Second, the segmentation of the display's surface in individually movable 'haptic pixels' [8]. Currently, these systems only provide a small number of actuated points due to mechanical constraints. Third, the use of actuated tangible interfaces on the table [7]. Possible drawbacks of this approach are the potential occlusion of interactive elements and the prevention of direct interaction. All of these techniques basically assume that tactile feedback for an interaction should be applied directly to the interacting body part, i.e. mostly to the fingertip.

Our approach is different. We propose the spatial separation of human-machine touch input and resulting machine-human tactile output. Tactile cues resulting from a touch interaction are removed from the fingertip or hand. Using actuator technology, haptic impressions are communicated to remote parts of the user's skin. The user is able to 'feel' the surface, form, orientation and function of the virtual elements he is touching. Thus, every interactive object can give individual tactile feedback to the user. Above all, the area of tactile stimulation is not limited to the size of a fingertip. Depending on the number of actuators, an enlargement of tactile resolution is possible. We currently assess the potentials of this effect. Our goal is to improve the accuracy of touch interaction with small virtual elements.

Figure 1. The PhantomStation is used to communicate a pseudo-tactile sensation to the user's forearm.

In order to communicate tactile cues to the user's skin, we have two possibilities where to place actuator technology. The first way is to instrument the user's environment. No wearable device hinders the interaction of the user, but the user has to be in firm contact with the tactile interface, e.g. in the back of his seat. The second way is to instrument the user with wearable actuator technology. Doing so, we can assure stable contact to the user's skin. However, the user has to wear a number of electronic devices that are potentially distracting and cumbersome.

2. PHANTOM SENSATION & FUNNELING

In order to reduce the number of required actuators for the remote communication of tactile feedback, we chose a tactile phenomenon called Phantom Sensation (PhS) or Funneling Illusion. David Alles provides a definition: *Two equally loud stimuli presented simultaneously to adjacent locations on the skin are not felt separately but rather combine to form a sensation midway between the two stimulators. This phantom sensation is affected by the separation of the stimuli, their relative amplitudes, and their temporal order* [1]. By varying the intensities or interstimulus time interval between the two adjacent actuators, we can smoothly adjust the position of the PhS between the two actuators [5]. A number of researchers describe and reproduce this psychophysical effect [9].

3. PHANTOMSTATION

At the moment, we are using the PhantomStation (see **Figure 1**). The purpose of the prototype is twofold. We compare three tactile actuator technologies in order to recreate the PhS with maximum effect. Subsequently, we use the prototype to augment and improve touch input on interactive surfaces with the remote application of synchronized Phantom Sensations.

3.1 Comparison of Actuator Technologies

Manifold technologies for the creation of tactile stimuli exist. Most actuators are based on moving components [2]. We compare three common types of tactile actuators (see Figure 2**)**. The three types were chosen for their differences in the size of the generated stimuli on the skin, the disparities in stimulus intensity and the differing oscillation frequencies.

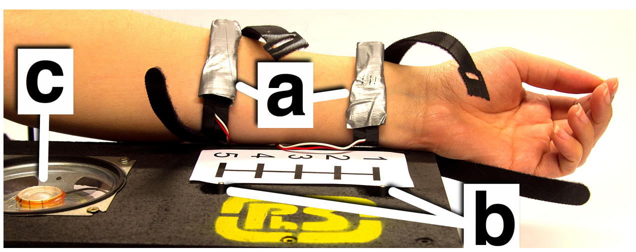

Figure 2. The PhantomStation is used to compare three actuator technologies: (a) vibrational motors, (b) linear solenoids , (c) voice coil actuators

The glabrous skin of the user's forearm is in contact with only one of the three pairs of actuators at a time. To make contact with the two linear solenoids or the two voice-coil actuators, the user rests his arm on the device. The vibrational motors are worn on the forearm. Position and placement of the actuators correspond to values of related studies (e.g. [5]). For every actuator technology, stimuli with different intensities and interstimulus time intervals are given.

3.2 Funneling Remote Tactile Feedback

We propose two classes of scenarios for the stimuli generated using the PhantomStation (see Figure 3). The Phantom Sensations could be used to communicate tactile cues about the orientation, size and form of interactive elements that are manually explored by the user. One could think of the movement of a virtual fader or the sensation of a pressure sensitive widget. Additionally, stimuli could be used to convey abstract information or semantics of the current interaction. Examples are the tactile representation of a zooming level or a progress bar.

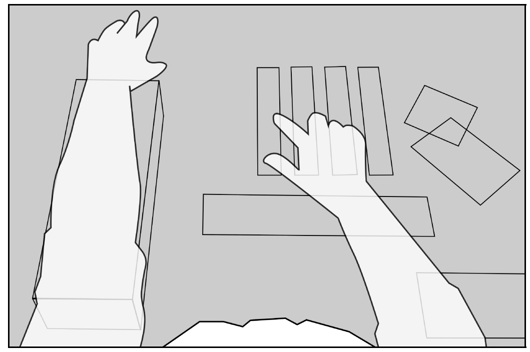

Figure 3. The PhantomStation (left) can be used to communicate Phantom Sensations synchronized with a touch interaction (right) to remote parts of the user's body.

4. CONCLUSION

With the PhantomStation, we present an interface that provides modifiable tactile feedback with a variable sensation location using only a pair of actuators. At the conference, we intend to demonstrate the PhantomStation as a means to communicate rich tactile feedback resulting from a simultaneous touch interaction. We hope to exchange ideas of how to advance touch-based HCI using haptic actuators.

5. REFERENCES

[1] Alles, D. Information Transmission by Phantom Sensations. *IEEE Transactions on Man Machine Systems 11*, 1 (1970), 85-91.

[2] Benali-Khoudja, M., Hafez, M., Alexandre, J.M., and Kheddar, A. Tactile Interfaces: A State-of-the-Art Survey. *International Symposium on Robotics*, (2004), 721-726.

[3] Hoggan, E., Brewster, S.A., and Johnston, J. Investigating the Effectiveness of Tactile Feedback for Mobile Touchscreens. *Proceedings of CHI 2008*, 1573.

[4] Kaaresoja, T., Brown, L.M., and Linjama, J. Snap-Crackle-Pop: Tactile Feedback for Mobile Touch Screens. *Proceedings of Eurohaptics 2006*, 565–566.

[5] Kato, H., Hashimoto, Y., and Kajimoto, H. Basic Properties of Phantom Sensation for Practical Haptic Applications. LNCS, Haptics: Generating and Perceiving Tangible Sensations 6191, (2010), 271-278.

[6] Leung, R., MacLean, K., Bertelsen, M.B., and Saubhasik, M. Evaluation of Haptically Augmented Touchscreen GUI Elements under Cognitive Load. *Proceedings of ICMI 2007*, 374–381.

[7] Marquardt, N., Nacenta, M., Young, J., Carpendale, S., Greenberg, S., and Sharlin, E. The Haptic Tabletop Puck. *Proceedings of ITS 2009*, 93-100.

[8] Poupyrev, I., Nashida, T., Maruyama, S., Rekimoto, J., and Yamaji, Y. Lumen. *Porceedings of SIGGRAPH 2004*, 17.

[9] Rahal, L. and Cha, J. Continuous Tactile Perception for Vibrotactile Displays. *Robotic and Sensors*, (2009), 86–91.