Augmenting Interface Perception through Sensory Illusion

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Abstract
We believe in the potential of augmenting reality for increasing human perception to overcome shortcomings of interface technology, such as material, surface structure or form factor. Current interfaces, for example, displays and touch-based surfaces, do not provide same degree of information as human sensory, like vision and touch. As sensory illusion can result in perception of information that was not sensed, we discuss in this position paper the potential of sensory illusion for augmenting interface perception. We first explain how sensation can be augmented using illusion and secondly, we propose to apply such approach to both, current devices and everyday things. As such, this paper argues for the vision of calm computing and hidden technology through outsourcing computation to the human illusion.

Author Keywords
Sensory illusion; augmentation; perception; ubicomp.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
While we are surrounded by many uneven and soft materials, touchscreens and touchpads are smooth and

hard. When touching a soft surface, such as rubber or textiles, we perceive the surface properties through tactile as well as through visual sensation. For example, pressing on a soft surface causes skin stretching at the fingertip as well as visually perceivable texture deformation. Such sensation is perceived when interacting in the real world but also with digital devices. However, digital devices provide some ways to provide the user with sensory feedback on his/her interaction, the possibilities available are still very limited. This absence of tactile feedback creates a host of problems, which negatively impacts user experience on a variety of levels.

Zhai et al. [12] indicated that scientific knowledge is still limited and only beginning to "address the human factors and cognitive issues" of touch-based gestures and propose that both "visual and audio feedback can potentially enhance the subjective and emotional aspects of [touch-] gesture experience". This suggested methodology goes very much in line with the intended strategy of this paper to argue for investigating how cognitive science and in particular intersensory surface perception can lead to a richer touch gesture experience.

In this paper, first the state of the art of works describing multimodal effects of multisensory on surface perception as well as of works aiming to enrich touch feedback through sensory illusions is described. Afterwards, opportunities to scale the idea of augmenting everyday objects to turn them in an interface while keeping their original appearance will be discussed. In summary, this position paper aims to add to the conceptual implementation of Weiser's vision of calm computing [9] through outsourcing parts of interface design towards illusion created in the user's brain.

State of the Art

Capacitive sensors are the dominant technology that is used for touch-based interaction. Moreover, touch is commonly accepted to be an intuitive way to interact with computers. Current touch-sensitive surfaces are constrained by the physical properties of the materials they are made from. That results in touch experience that is much poorer than touching analogue materials which our environment is made from. Consequently, it is important that we strive to build better and more satisfying touch-based interfaces, that are reactive and behave more natural which means in responds based on our own sensory expectations.

Influencing (sometimes "overwriting") the perceptual experience of one or more senses when a surface is touched can create the illusion of touching a completely different surface. This approach has been chosen to be used in the project proposed here.

Generally, simulating haptic feedback such as friction or stiffness without an actual haptic interface is referred to as pseudo-haptic feedback [5]. Most if not all the previous work with this technique used visual cues although pseudo-haptic feedback is not necessarily restricted to vision. It has also been proven that visual perception is strong enough for users to be able to identify holes and bumps in pseudo-haptic textures [6]. Similar work includes the perception of texture, resistance and spatial depth [8]. It has been shown that vision dominates during conflicts between haptic and visual feedback [7] when simulating stiffness, but also at the perception of friction and texture [5]. Vision

Figure 1: Tactile illusion of soft material is created through image distortion according to pressure force as well as through electrotactile touch feedback applied when touching the surface.

is even considered to generally dominate proprioception [10], which makes it the ideal candidate to enrich other sensations. Visual feedback has thus far often been used to simulate haptic feedback [3, 6, 8]. In addition to visual touch feedback, real haptic (electrotactile) feedback has been used to create the illusion of surface roughness when sliding across a touchscreen [1, 2], but also passive touch has been augmented through both, visual and electrotactile feedback to create the illusion of material softness, see figure 1 [11].

Vision

This position paper envisions to investigate sensory illusion and how surface perception can be enriched by intersensory feedback, e.g. when being touched. Recent years have witnessed a fundamental shift in how people interact with technology. With the rise of touch-based interfaces, interactive screens became one of the most important ways in which we interact with computers, and as such will not only provide interfaces for devices, but also for smart surfaces built into furniture, walls, doors, cars, and clothes. However current touch-sensitive surfaces are constrained by the physical properties of the materials they are made from. For example, the sensory experience of a person touching an interface made from glass is limited to the intersensory information available from touching that material, e.g., a specific smoothness and silence. However, influencing (sometimes overwriting) the perceptual experience of one or more senses when a surface is touched may create the illusion of touching a completely different surface. For example, by introducing different modal stimuli (sound, vision, haptics) when a glass surface is touched, the intersensory effects of the different modal inputs can cause the illusion of surface materiality, e. g. sandpaper.

The approach proposed here aims to use such intersensory effects between different modal stimuli to induce different sensory illusions of touched surfaces we are surrounded by. We thereby aim to turn surfaces familiar to us from various everyday objects into interfaces of ubiquitously distributed computers that disappear when not being used as then, the interfaces will not appear as in- and output device but as surface of the environment.

The proposed approach relies on insights into sensory perception, especially how sensory stimuli influence the perception of surfaces. The results of the proposed research can have a strong applied dimension and could have a strong, positive impact on novel strategies for interface design, such touchscreens embedded in interactive furniture.

In the following section, examples for environmental and everyday things augmentation using sensory illusion are discussed to show the benefit of such sensory augmentation relying on illusion.

Illusion-based interfaces

In this section interface types that could be enriched through sensory illusion are discussed, including proposals of interaction design that become possible using illusions. We consider any surface to possibly be an interface believing that windows, furniture and even the floor we walk on will be an interface one day.

Enriching touchpads through haptic illusion

Different touch-based interactions have been shown to allow for perceptual augmentation, such as drag [1, 2] and press [11]. Electrotactile stimuli can induce the impression of texture from various roughness as well as may create the sensation when touching different material properties. For example, softness may be felt, which can be used for enriching touchpad interaction in the following described manners:

Enlarging the number of (perceived) materials of touchpads: Current touchpads are smooth and do not support the perception of materiality. As the illusion of touching different materials can be created, touchpads may change their material to intuitively refer to the application kind that is being used. For example, during online cloths shopping, touch-based cloths selection could be perceived like touching textile, while an application that allows to configure car design may induce the illusion the user is touching metal.

Enriching UI elements: The design of UI areas, such as menus or texts, as well as the design of UI elements, such as buttons or sliders, can be enriched through haptic illusion. The position, size, and orientation of UI areas and elements could be indicated through tactile feedback. For example, when sliding a finger across text, a subtle rough surface could be perceived underneath the fingertip; and a button may be perceived to be smooth in its centre while crossing its border may result in a haptically perceivable outline. As we can also simulate different levels of softness, buttons may be perceived to allow for easily being pressed for recommended commands, while a press on the delete button may feel harder to remind the user to think twice before deleting data.

Enriching touchscreens through visual illusion

Wolf and Bäder showed that not only electrotactile, but also visual stimuli can be used to create different material illusions. When, for example, the illusion of texture deformation is created after pressing an undeformable surface, the user may belief a soft material was pressed. Kaaresoja et al. [4] showed that latency in tactile feedback induces the illusion a button may be harder to press. These effects can be used for:

Enriching touchscreens: Current touchscreens could, similar to touchpads, be augmented by various material properties. Wolf and Bäder, for example, showed that the distortion of an image the user is pressing can lead to the belief he/she is actually touching the material shown on the image. Through such illusion of material deformation, a touchscreen could be perceived at 2.5 dimensional display which enriches the design space of current 2D UIs and may allow for new kinds of applications, games and GUI elements. Maps, for example, may have feelable height information indicating a geographical structure of an area. Games may take advantage of the sensation of softness for creating the illusion of touching real objects and materials which may result in higher immersion and richer experience. Finally, the material of icons could refer to the application they belong to or buttons could have more states than they currently have, such as half-pressed.

Conclusion

This position paper proposes sensory illusion being a perfect candidate for building interfaces that are calm through augmenting their surface perception which may bring us closer to a world in that computer are ubiquitous but enjoyable to use.

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