Tangible Patterns. The aesthetic of a multilayered interactive skin.

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Abstract: *Digital media and interactive technologies provide the opportunity to augment and alter the characteristic qualities of sensual and aesthetic perception. The visual and auditory senses are culturally predominant, but nevertheless the sense of touch receives nowadays increasing attention. This paper presents the perceptive potentials of touch sensations and their influences on our emotions. We will discuss how we can take advantage of these potentials using digital media and technology and how touch stimuli are forming aesthetic experiences. In this paper we are investigating the influence of an interactive "skin"- prototype on the human touch perception in the architectonical context.*

Palabras clave: sense of touch; perception; interactivity; augmented architecture

Introduction

Our senses convey an image of the environment and influence our experience and emotions. Sensations we experience, shape in combination with the cultural environment our aesthetic preferences. Today in the digital age new technologies and interactive systems are able to produce augmented architecture and to modify and extend the sensual qualities and hence our aesthetic perception. Thereby the visual and auditory senses are predominant, due to their cultural hegemony. But recently another sense growingly receives more attention: the sense of touch.

Touch stimuli are capable of providing us a direct feeling of the environment and serve as nonverbal communication channel between people. Touch sensations are correlating with our emotional states and are already used in touch based therapies for mental disorders. Moreover touch stimuli are forming aesthetic experiences and they are not limited to our hands, but engage the entire body. Thereby the common association is the reception by the skin, which provides with its heterogeneous receptor network diverse sensible zones and different perceptive qualities. Within the somatosensory process a general distinction is made between this cutaneous system, and the so- called kinesthetic system, which indicates that muscles, joints and tendons are involved in perceiving (Lederman, Klatzky, 2009). Subsystems like the tactile, haptic and dynamic touch are used to categorize the different forms of touch application and user behavior (Gibson, 1962). In this text we are using the word haptic as general term for these various stimuli.

Nowadays we are using the sense of touch to navigate through touchscreens and other interface menus, whereupon our fingertips are mostly input agents rather than stimuli receiver. In the same manner interactive architecture, at the interface between digital media and architecture, is using this sense to trigger functional processes but doesn't make use of the wide bandwidth of its perceptive qualities. This paper discusses the concept of touch aesthetic, which we investigated by different reactive surface prototypes. We are presenting the technical prototype concept, which is characterized by the grid- like surface structure consisting of identical cells, containing diverse constructive overlaid actuators. With different intensities and activations of the actuators, the surface produces so called *tangible patterns*. In empirical tests we explore what kind of reaction is provoked in the user and how these responses are correlating with aesthetic perceptions. Furthermore we are presenting biofeedback systems as an analytic instrument and future bidirectional communication channel between the surface and the user.

Sense of touch: Cultural role and the digital age

The hierarchical division into five senses is a familiar concept and can be traced back to the Greek philosopher Aristoteles. Although he established the hierarchical classification, with the sense of side on the first place, in his system every sense had unique perceptive and aesthetic qualities. Subsequent generations produced diverse theoretical concepts, reinforcing the hierarchical structure and led to the focus on the visual and auditory senses in art and architecture. But in contrast to Aristoteles, they excluded the other senses from aesthetic theories and neglected the importance of these senses in perceiving the environment in an aesthetic way.

These cultural circumstances had consequences for the perception of architecture and how architects are designing and using materials (Pallasmaa, 2005), which is until today often visually motivated, respectively based on building physics. The use of certain materials indicates the social development and within the preference of special materials, also a social code is inherent. Rare or uncommon materials are associated with social status of the user or the importance and the prestige of a building. Thus the decision which material is used for a product or a building is influenced by a certain kind of fashion, which shapes our preferences for exposed concrete, the smoothness of an iPad surface or structured seating surface. All these cultural circumstances of our everyday life effect the haptic aesthetic perception.

With novel interfaces and digital devices a trend emerged towards a more tangible representation of digital information and objects. For example, touch screens are prevailed but are often using the sense of touch only as input generator, rather than stimuli receiver. Other fields like haptic rendering are developing screens for the tangible representation of digital objects and devices like the *Phantom* are used to train surgeons with force feedback and vibro- tactile stimuli.

In the combination of these tangible media we see great potentials for interactive augmented architecture and it is of great importance to be aware of the aesthetic principles in the context of an adaptive environment. The presented project focuses on the augmentation of architectonical surface functions by the digital controlled superposition of various touch cues and intensities and its influence on the user valuation. With empirical methods we aim to comprehend possible aesthetic guidelines and to implement them in interactive design processes and strategies for architecture and related fields.

Touch aesthetic and tangible patterns

There has been a broad variety of explanations for the principles and the perception of aesthetic in art and architecture. Terms like the golden ratio, symmetry, harmony or rhythm are frequently used in this context. Nowadays with the digital and interactive artifacts, the concept of aesthetic perception undergoes a change, regarding its function and personal perception. Nevertheless many of these interactive devices are still focused on the visual and auditory output and yet little research has been made on touch aesthetic perception (Jung et al, 2010) and even less on their superposition. In our investigation we include the entire body, not solely the hands, that are often focused in scientific investigations. In order to make a clear distinction between the established visual concepts and traditional meaning of aesthetic, we suggest to introduce the term "Euhaptics" (from Greek= good and = touch, finger). Euhaptic principles are based on the theories of limbic and neuronal aesthetic. One of the first scientists in this field was Gustav Theodor Fechner in the late 19th century. He analyzed in empirical tests the corporal reaction of probands to sensual stimuli. Today the instruments and the digital sensors for such scopes are much more sophisticated and supported by the possibilities of software evaluation. Every positive or negative sensory experience provides stimuli, which triggers neuronal processes and evokes measurable changes of body parameters. Therefore we use biofeedback devices to trace user reactions, and as analytic instrument beside user surveys. The corporal reactions emerge from previous valuated touch experiences, which are saved in our implicit and explicit touch memory and they are also correlating with the actual emotional state. This combination of factors and the cultural impact, are forming the Euhaptic preferences. Emotional factors are not predictable and they are not following certain rules, hence the surface cannot be controlled with predefined rules, instead it should adapt flexibly.

We consider, that touch cues are fading out in the perception process, if they are applied for a longer time period. This temporal and the spatial resolution of the skin is unequally distributed (Grunwald, Beyer, 2001), what we are regarding as an issue of the tangible pattern design. With the method of tangible patterns we produce an altering surface for stimulating the entire bandwidth of touch based stimuli. Different combinations of actuators and their intensities on the surface grid form the patterns. We designed a graphical user interface with the representation of the cell activation and the different predefined patterns. The colors blue, red and grey indicate the temperature or the inactivity of the peltier

elements, the saturation represent the intensity of the vibration motors(see Figure 1).
Blending a wide range of actuators lead to optional diversity of touch stimuli. Such a new form of overlay provides the users of architecture an opportunity to feel and experience multimodal touch sensations. So far we designed a series of predefined patterns to systematically classify the user reactions. Additionally the user himself has the possibility to adjust the pattern deliberately using a graphical representation of the surface grid, programmed in "Processing".

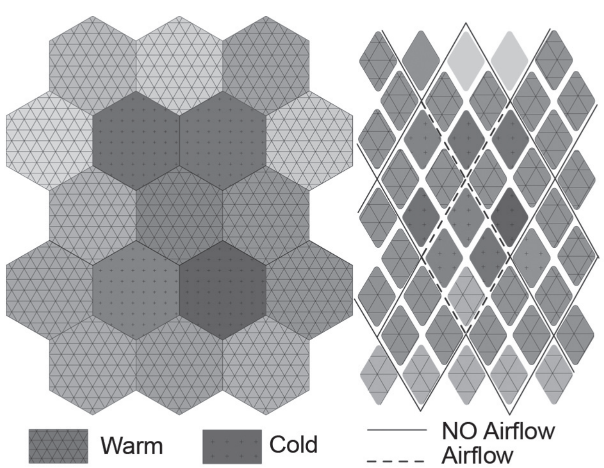

Fig.1. Tangible patterns. Average user preferred pattern and a pattern designed for a second prototype.

Euhaptic and interactivity

Today the word interactivity is omnipresent, but during our work, we developed a more sensible and differentiated understanding of the interactive concept.
Our aim is to create an intelligent surface, which is able to adapt intuitively to the unique user preferences, without the imperative of a user control. The theoretical framework is formed by the communication theory of the cyberneticist Gordon Pask []. In his theory interactive systems are communicating with other systems, the environment or human beings. The communication process itself enables the system to analyze the reaction contextually and undergoes by the feedback loop a self-learning process.
Based on the fact that aesthetic sensations evoke precognitive physical reactions, of which the user is not always aware, we will use biofeedback signals, like changing heartbeat, breathing rate or muscle- relaxation to trace the corporal reactions and to give the system feedback information. If we use biofeedback as communication platform, the system has to know how to interpret user reactions. Currently we are examining the underlying principles of the Euhaptic perception and guidelines, that can be established for the approximation process towards an optimal surface adaption.
The empirically determined test results will serve as principle guidelines for the design of multilayered touch based surfaces.

Prototypes and user tests

Our first prototype (Pohl, Hirschberg, 2011) using a grid structure is a surface with hexagonal cells (diameter twelve centimeters), applied on a box, which contains the microcontroller and the electortechnology.The seventeen identical cells are integrated peltier elements for the temperature change and vibration motors (see figure 2). Depending on the vibration frequenzy the motors simulate dynamic movement and surface roughness. It is the first one finished after a series of prior prototypes with other actuators like pneus, headpads and shape memory alloys, but without the concept of the homogenous grid structure, which caused a problem in the actuator positioning. Each cell on this surface is identical, in terms of property and potential. The actuators are connected to an Arduino board and can be controlled individually, which is also the case regarding their intensity.
The three implemented kinds of cutaneous stimuli are important to recognize surface and material properties and give us the opportunity of layering these attributes in a new and uncommon way. For the users the activated surface with the diverse tangible patterns was a new experience and encouraged them to design their own patterns, what was offered in the user interface. We tested different body zones regarding the sensibility of the receptor network, in combination with active and passive user behavior. The tests showed that every user is experiencing and behaving individually, but we observed a clear preference for certain kinds of patterns depending on the body zone.
The constructive concept of the surface is similar to the different layers and receptors of the human skin, because the different kinds of actuators are arranged in a layered structure and produce various outputs for the sense of touch. The drawback of the prior hexagonal prototype was that the cell size diminished the stimuli precision of the entire surface and did not correspond at all with the precise resolution of the skin receptors.

We developed a second prototype with a rhombic cell shape of four by two and a half centimeters (see figure 2). In the gabs between the cells we embedded perforated plastic tubes to produce airflow. The vibration motor was replaced by solenoids with the aim to produce vibration and a more precise movement, by lifting each cell with the solenoid. We are developing new sorts of predefined patterns, based on the prior findings of the empirical tests and the new actuator.

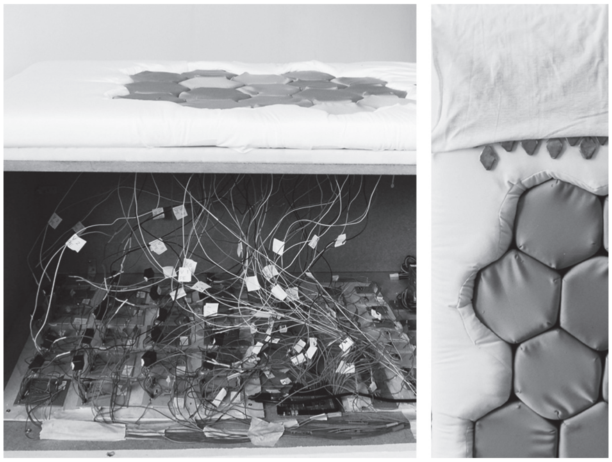

Fig.2. Prototypes, left: first prototype with the elector technical area, right: size comparison between new and prior prototype.

Conclusion and outlook

In this paper we presented the ongoing research project, which seeks to establish a new usage of the sense of touch in interactive architecture and technology. One key aspect is the novel concept of aesthetic perception by the sense of touch in an interacitve environment and the layering and mixing of diverse actuators in a raster structure.

We are starting now to implement biofeedback systems in the empirical test to get detailed insights in the euhaptic phenonema. In our future investiagtion we will focus on the issue of the finsihing material, which effects the entire haptic appearance of the prototypes. The cover material and the physical materiality of the cells should not constitute the attributes of the surface, rather the actuators and their outputs should simulate superposed and new material characteristics and hence evoke a Euhaptic feeling in the user.

How can such an interwoven concept between interactive technology and emotive driven experiencing be applied in practice? We see the potentials of the understanding of Euhaptic in the design of new interactive materials, applicable on architectonic surfaces, able to enrich the user experience in new ways. This sensitive responsive surface system opens up future key directions for applications of such individualized interactive touch systems in the architectural design context and beyond as implementation of such models in the medical (Grunwald, 2001) and therapeutic field. There is a wide range of benefits due to the influence of touch sensations on the human psychological processes and the bodily implications.

The sense of touch with its broad perception spectrum, will be exploited by this technical embedded superposition. It reveals an augmented form of interaction with surfaces and interactive material structures. Applications on tectonic shapes allow the user to feel the sensations on the entire body in a holistic manner by the juxtaposed arrangement of identical multilayered cell-units. The environment becomes a unique "touch" for users.

With the new technologies we will be able to create space phenomena augmenting our perception in a prosthetic way, beyond the visual conception of space.

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