GHOST : exploring the subtleties 'of' and 'interaction with' shape-changing interfaces

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ABSTRACT
This research explores how to design for the aesthetics of interaction with shape-changing interfaces from a phenomenological point of view.

Using shape-change as both in- and output we want to explore it as a new layer of communication between (systems) of intelligent products and people. We envision that shape-change allows for a continuous action-perception loop in which for instance just noticeable differences can transform people's behavior and feelings.

The research continuously works towards opening up the design opportunities of shape-change for expert designers and students. To this end we adopt a research through design approach that is supported with user studies to evaluate emergent interaction phenomena and patterns. The research will deliver a means to communicate about shape-change between designers, industry and end-users and create tools that allow for a high-level design of shape-change.

Author Keywords
Interaction design; respect for human capabilities; phenomenology-inspired design; shape-change.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces— Haptic I/O.

General Terms
Design.

INTRODUCTION
As the size of computers decreases and the processing power increases, they are incorporated in a wider range of products to augment the use of these products. This brings designers closer to developing products that might be called intelligent in which one no longer has to think in on/off states, but in continuous in- and output; the use of designs does not have to be dictated, but instead space can be created for exploration and ambiguity; consequently, a person does not have to be looked at solely as a cognitive being, but also as one with perceptual-motor and emotional skills [2]. With these premises in mind I envision technology to become more human instead of demanding humans to become more technological. Technology should respect the cognitive, emotional **and** perceptual-motor skills and find a balance in addressing them all. In addition it should not only have to serve to increase the effectiveness and efficiency of day-to-day work but also allow for exploration and reflection.

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Shape-change
Shape-changing interfaces are considered as a next step in HCI [9]. However, while technologies for shape-changing interfaces are rapidly evolving, our understanding of the design space of such interfaces is still limited. First attempts at developing a framework have been made [9, 10] but these mainly take a system-centered approach. While this is logical for a technology-driven field in its early stages, a people-centered approach will help us to create meaning in interaction. This, in turn, can be used to guide technological developments.

Aesthetics in interaction
Whereas many courses in design are dedicated to the aesthetics of form "form giving" or "Gestaltung", this research explores the aesthetics of dynamic form "dynamic form giving" and how to design for the aesthetics of interaction [14].

"Beauty, and thus beauty in interaction, is an experiential and social given. It is not just a quality of an object. It is the way an object speaks to us, calls us, affords us, puts us into contact with others, is meaningful to us, shares its inner horizon with us. Thus considered, beauty emanates from our unity with the world. It is pre-reflective." Hummels and Overbeeke, 2010 [4].

RELATED WORK
A possible direction for shape-changing interfaces is creating meaning by designing for the transformation of

people's behavior [11]. It would be interesting to explore expression-rich relations [12] of shape-change in order to better understand what is required to allow for aesthetic interactions that can transform behavior.

Expression-rich relations

The way people interact with computers already has a lot in common with social interaction between people [13]. Reeves and Nass witnessed people seeing affect in the information given to them by a computer, while this information was not designed to carry affect. People attribute characteristics such as intelligence and friendliness to computers and, for example, are polite or angry with a computer. Stienstra and Marti [12] have proposed a design to "explore the emergence of emphatic behavior between human and machine" through expression-rich relations. Using a squeezing device a person can grab the attention of a robot, the Care-O-Bot. In one scenario the motion of the robot is mapped to be moody; when the person does not interact with the device appropriately, the robot will change its behavior to over-enthusiastic or stubborn, for example. In this case the behavior was intentionally designed to carry affect. It would be interesting to further explore what would happen when intelligent products are designed to provide affective feedback. Shape-changing interfaces can be used to explore this, offering dynamic action-possibilities and expressive parameters to play with.

RESEARCH QUESTIONS

The goal of the GHOST (Generic Highly Organic Shape-Changing inTerfaces) project, of which this PhD project is part of, is to design, develop and evaluate shape-changing interfaces. The project focuses on the hardware and software, the industrial and interaction design and the user experience. The main goal for this PhD project specifically is to develop a means to communicate about shape-change and create tools that can help to do so. The major question I address in the project is described as follows:

How to design for the aesthetics of interaction with shape-changing interfaces?

In answering the major question of this project I also hope to address the following sub-questions:

What is the design space of shape-changing interfaces?

How does the action-perception loop manifest itself with the use of haptic sense?

Answers to these questions will support and be supported by the development of a means to communicate about shape-change and tools that allow for a high-level design of shape-change.

METHOD

Coming from a background of trans-disciplinary design I am used to envisioning and proposing intelligent products, systems and related services that use novel technologies in order to create new opportunities.

With the complexity of intelligent products, systems and related services increasing as quickly as it does, it also becomes increasingly difficult for a single designer or even a design team to quickly cover new ground. It takes more than bringing together the fields that are required to further develop these proposals. For a field like shape-change to grow I think it is necessary to operationalize low-level complexity on a higher level and lower the threshold to design with shape-change.

In my opinion, developing the means to communicate about shape-change and design tools this research sets out to deliver would benefit from a research through design approach. In this iterative process subsequent experiential prototypes [1, 3] are designed, built and evaluated. The experiential prototypes that lead to and come from the means to communicate about shape-change and design tools will expand the existing body of shape-changing interfaces and inspire a design process in which analyzing and synthesizing are balanced.

ONGOING WORK

In the 8 months the GHOST project has been running I have been involved in a number of activities that I would briefly like to discuss.

I started my PhD with a one-week boot camp that we ran for Industrial Design Master students. In this boot camp students were given the opportunity to build and explore shape-changing interfaces. Inspired by the students' work I (re) build 6 shape-changing interfaces to serve as stimuli for a repertory grid study that we set up and are planning to run late 2013. We ran a second boot camp, this time giving the students two weeks.

During the first boot camp students built interactive shape-changing surfaces and developed the behavior of these surfaces in order for it to be natural. With natural we mean that it maps in- and output in time, location, direction, modality, dynamics and/or expression [15]. Students were asked to consider the explorative processes of static 3D objects [6] and translate these to shape-changing interfaces. The students used Arduinos, hobby servos, capacitive touch sensors, force sensing resistors and IR sensors to build experiential prototypes [1, 3] that, in most cases, allowed for 1 degree of freedom and offered one (type of) sensor as input. The behavior could be described as an elaborated on/off button.

Subsequent to the first boot camp we have set up a repertory grid study for which I (re) build 6 stimuli (fig. 1), three of which were directly inspired by student work. The stimuli were selected to be heterogeneous and homogeneous at the same time; they differ in type of shape-change [9] but are of the same size, share the same style and show similar behavior. The study is in collaboration

Figure 1. 6 selected stimuli from 1st generation of shape-changing interfaces, exploring dynamic form, volume and texture

Figure 2. 2nd generation of shape-changing interfaces, exploring dynamic orientation, form, volume and texture.

with the University of Copenhagen, Denmark (one of the GHOST partners) and with it we hope to explore the design space of shape-changing interfaces from a users' point of view.

We combined our early experience with designing, building and evaluating shape-changing interfaces in a second boot camp. In developing this boot camp we drew from the form integration study that is common in classic industrial design education [7]. A budding product designer first has to get acquainted with basic shapes and explore possible transitions when integrating these shapes before moving on to more complex shapes and integrations and eventually product designs. There is nothing to design for at this point; no problem to solve and no opportunity to create. It is about developing sensitivity for form that the designer will use in his career. In our case this is sensitivity for the behavior of an interactive surface; the possible transitions between different states of the interface. The result is a second generation of shape-changing interfaces (fig. 2) that allow for 1, 2 and 3 degrees of freedom and offer multiple sensors (of one type) as input. The behavior has increased in complexity and in some cases the interfaces achieved to engage users in a continuous action-perception loop.

In the work described above incremental steps are made in terms of complexity (of the interface and its behavior). We feel that this is necessary because the complexity increases exponentially and there is a risk it becomes incomprehensible. We will continue to develop similar courses, increasing the complexity and eventually tailoring them for design experts in order to get a better

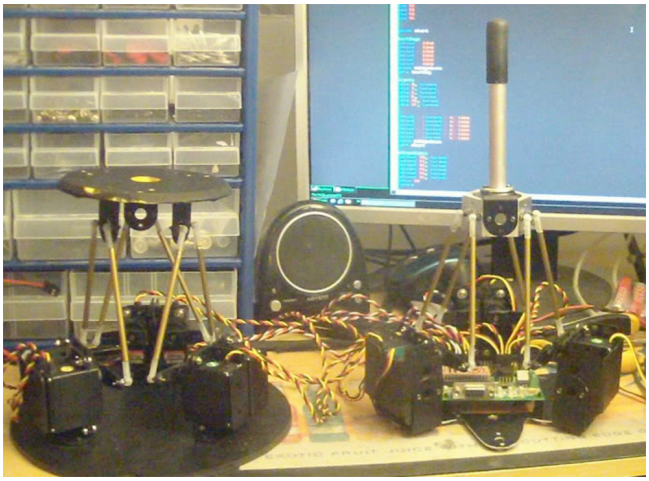

Figure 3. A master and slave platform with 6 degrees of freedom that could be used to physically sketch shape-change.

understanding of what is required to lower the threshold to design with shape-change. At the same time, each iteration

of the course results in new experiential prototypes that serve as physical hypotheses that fuel discussion and thereby contribute to an understanding of shape-change in general.

The next step is to build a 6-degrees of freedom platform (fig. 3) with a variety of sensor types that can be programmed physically [7]. In interaction design, choreography has often been used [5] to embody features before designing them and I want to aim for a similar experience. I envision that designers will sketch shape-change with this platform, requiring a minimal amount of programming knowledge. Lowering the threshold will help push the field of shape-change and the body of work from which to draw inspiration will quickly grow.

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