Sharing Perspectives on the Design of Shape-Changing Interfaces

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CHI'16 Extended Abstracts, May 07-12, 2016, San Jose, CA, USA
ACM 978-1-4503-4082-3/16/05.
http://dx.doi.org/10.1145/2851581.2856478

Abstract
In recent years, several workshops and an increasing number of scientific publications have focused on shape-changing interfaces. This work has explored prototypes, theory and evaluations across a variety of domains, including: aesthetic experience, affective computing, adaptive affordances, data visualisation, and remote communication support, to name only a few. The aim of this workshop is to bring to light and discuss the different underlying perspectives[1] and visions on shape-changing interfaces within the community, arriving at a shared, cross-discipline vocabulary for discussing the design space. Participants will share their personal perspective and explore others' perspectives through hands-on prototyping and facilitated sketching tasks. Leaving this workshop, participants will be equipped with a clearer understanding of the different concepts being explored within the community and with a vocabulary through which to describe the intricacies and considerations of their work in the future.

Author Keywords
Shape-Changing User Interface; Tangible User Interface; Organic User Interface

[1] We use the term 'perspectives' to encompass all aspects of shape-change technology, prototypes, design, design approaches, affordances, applications, theory, and evaluation

Figure 1 - A fictional example can be found in the movie Immortal (Ad Vitam): a bathroom appliance which, within its sphere of influence, supports users of the bathroom both by providing them with the objects they might need (in this case, toothpaste) for a given task and by providing them emotional feedback to their current state of mind

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g. HCI): Miscellaneous.

Introduction

Shape-changing interfaces are designed under the assumption that, in the near future, physical objects will become as alterable as their digital counterparts in terms of form, functionality and motion, affording them a more dynamic relationship with their environment. Shape-Changing Interfaces will enable new models of interaction and more expressive user interfaces, requiring us to re-examine and re-evaluate some of the most basic interface design principles.

As a community, we must understand the dynamic properties of the material world to effectively develop and evaluate shape-changing interfaces that have the ability to morph into shapes that resemble their functionality, and approximate the look and feel of the physical material world. Furthermore, we must discern how users perceive the dynamic properties of shape-changing interfaces as to ascertain the effectiveness of physical transformation as a communication mechanism.

We aim to discuss the literatures' current diverse research approaches, technical implementations, and design practices in an attempt better understand the multi-facetted nature of the shape-changing community and highlight some of the research challenges posed within individual perspectives.

The proposed workshop builds upon a series of previous workshops [1,2,6,7,10]. Its aim is to improve the understanding of different perspectives and work practices within the community going forward. We invite input from cross-disciplinary experts in the fields of interaction design, tangible, embedded and embodied interfaces, data physicalization, affective computing, material sciences and robotics. We wish to create a mutual language to address current challenges in shape-changing interfaces. Through this, we aim to motivate new generations of shape-changing interfaces, across a broader range of disciplines.

Background

Ever since tangible interfaces were introduced, designers have strived to use them for moving computing away from the standard desktop environment into the 'real world'. Tangibles are a tool that allows designers to situate computer interaction away from the desktop, all the while drawing on, and benefitting from, our tacit skill and understanding. More recent developments in display technology allowed computers to take on arbitrary shapes, leading towards computational objects becoming more commonplace in our environment. With advances in actuator technologies and new materials, designers now have the ability to provide these computational objects with dynamic shapes. This allows computers to not only take on arbitrary forms, and also to adjust their form to fit the task at hand. A computational object can, for example, adjust its shape to better represent the information it contains (such as a spherical shape to display a map of the earth [16]) take on different shapes based on which task a user is engaged with (a smartwatch might unroll and expand if a user sits down to write a longer message [18]), or convey information on a subtle emotional level (a faucet might shy away to indicate excessive water usage[19]). So not only do shape-changing objects allow us to move computation away from the traditional desktop

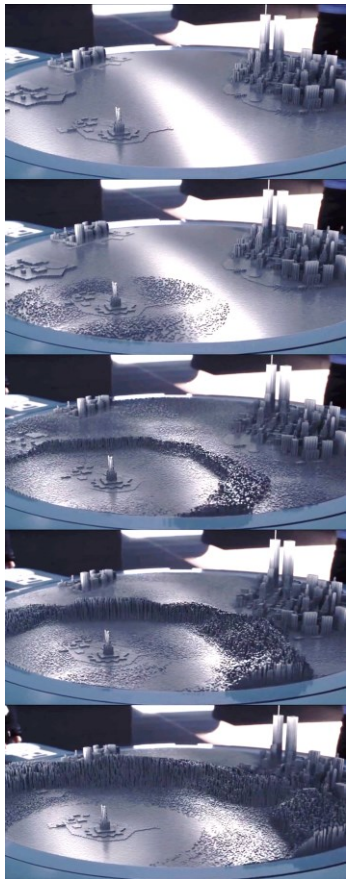

Figure 2 – Relief-Style Display, *X-Men*

metaphors, they also reach out with the ability to actively engage in interactions with their environment.

While there appears to be a shared enthusiasm towards using shape changes in interaction design, different research traditions appear to have very different perspectives on how to use shape-changes. In fact, even the definition of what a shape-changing interface is can be very different between different research labs. Further, while researchers have an intuitive appreciation of the utility of shape-changing devices, it is still not quite clear what specifically this utility is. We suggest that this problem is a consequence of the diversity of design approaches within the field of shape-changing interfaces: various studies have shown the benefits of shape changing devices for a specific problem domain or application, however these detailed explorations are difficult, if not impossible, to generalize across the field.

To improve the discussions surrounding shape-changing interfaces, it would be useful to make explicit the design choices and perspectives in shape-changing devices. This will help us better understand the generalizability of evaluation techniques. Making these design approaches explicit also provides us with tools to discuss and share perspectives. This can serve to both highlight the contribution of our own works, whilst at the same time providing us with a language to better understand other perspectives.

In the following paragraphs we will briefly outline some three popular design approaches within shape changing user interfaces:

Animism and Affective Interfaces

A recurring theme in shape-changing interfaces are animated objects demonstrating an anthropomorphic body language (Figure 1). The work in this area includes phones which might either shy away, or move towards a user's hand in anticipation of touch [14]; a faucet which not only gives you feedback over your water usage [19], but also demonstrates behaviors such as searching, or rejection; hand-held devices which are endowed with a heartbeat to communicate their emotional state [3] etc.

A slightly different but related stream within the design of shape changing interfaces are systems used to transmit emotional states between users. These include appendages to mobile devices, which have a shape that is synchronized between devices. If a user changes the shape of their device, the corresponding appendage of a friend or partner's device also changes shape [12]. Other examples include breathing picture frames which change their shape synchronized to the breath of a loved one [11], or mobile phones through which partners can poke or gently caress each other's cheeks [13].

Data Physicalizations and Shape Changing Displays

Advances in digital fabrication and material sciences have enabled physical 3D displays, such as used for data physicalizations [10]. These artefacts exploit users' rich visual and tactile senses providing enhanced support for cognition, communication, learning, problem solving and decision making. When combined with shape-change, such artefacts can then support adaptation to different data types and datasets. Examples of devices which enable such physical representations of data include Lumen [15], inForm [5] and EMERGE [17], which consist of arrays of actuated rods which can move up and down,

Figure 3 - In the movie *After Earth,* Kitai, the protagonist, finds a white rod in the wreckage of his space ship. Picking it up, Kitai demonstrates how multiple rods can extrude out of both its ends, much like the previously discussed relief style displays. However, instead of displaying information, these rods take on the form of various weapons or tools. The shape change here is not used to represent information, rather, similar to a swiss army knife, the shape change allows the tool to take on multiple functions.

creating faux 3d reliefs. These displays are also prominent in SciFi narratives, as seen in the screenshots taken *from X-Men* (Figure 2).

Embodied Design and Dynamic Affordances

Changing the shape of a device to change its affordances (Figure 3) is a theme often explored in HCI, particular in respect to Organic User Interfaces (OUI). Examples include devices such as PaperFold [8] or Snaplet [18]. Snaplet is a portable device which, when wrapped around the wrist adopts the functions one would expect of a smartwatch. If rolled out on a table, Snaplet allows users to interact with it much like they would with a notepad. If shaped into a curvature fitting the face, Snaplet transforms into a phone.

Other research has considered the adaptation of material properties. Examples of such materials are jamming interfaces [4], which can adjust their stiffness to the task at hand.

Another approach aims to interact with the body on an even more intimate level, for example hand-held devices guiding users along the right path by dynamically adjusting its shape or the internal distribution of their mass [9].

While these examples represent prominent ideas regarding shape-changing interfaces, this is not intended to be an exhaustive list, rather, we are hoping to discover and discuss even more approaches during the workshop. The goal of this workshop is to identify these different design approaches, to discuss their utility, how they are different from each other and what synergies they might have with each other.

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Organizers

The organizers of this workshop are actively involved in both research into shape-changing user interfaces and teaching shape-changing interfaces in design and arts

classes. *Tim Merrit* teaches the Shape Changing Interfaces Course at Aarhus University while *Antonio Gomes* and *Paul Strohmeier* have taught Computing and Creative Arts at Queen's University. *Giovanni Troiano* has been lecturer on the topic of Shape Changing Interfaces. *Jason Alexander*, *Paul Strohmeier* and *Antonio Gomes* were organization members of the previous workshops on shape-changing interfaces and maintain the continuity between previous and current workshops. *Aske Mottelson* supports the team with web-design and IT infrastructure.

Giovanni Maria Troiano is a PhD candidate at University of Copenhagen. His research focuses mostly on deformable interfaces for input, with special focus on musical interfaces and user experience investigation. His current project uses nanotechnologies and soft silicones to create multi-dimensional deformable interfaces. His paper User Defined Gestures for Elastic, Deformable Displays was awarded Best Paper at AVI'14.

Antonio Gomes is a PhD Candidate at the Queen's University Human Media Lab. He has designed and evaluated technologies in the area of organic and shape-changing user interfaces. He investigated self-actuated physical transformations in flexible mobile devices and explored the use of shape-transformations for triggering GUI viewport transformation in multi-segmented mobile devices. His current research explores the ways people interact with self-levitating tangible interfaces.

Paul Strohmeier conducts research on the role of our bodies in HCI. He is interested in human-technological systems that make complex problems simple, allow for graceful ageing, expand what we can perceive and in consequence what we can think. He is interested in the dynamics between shape-changing interface and the body as shape-changing medium. Paul is a PhD student at the department of Computer Science in Copenhagen, Denmark.

Aske Mottelson is a PhD student at the Department of Computer Science at University of Copenhagen. He is interested in enhancing the user experience with innovative computer systems, especially body based and affective user interfaces.

Jason Alexander is a lecturer at Lancaster University in the UK. His research focuses on bridging the digital-physical divide through the design, implementation, and evaluation of novel interactive systems. His recent work explores the application of shape-changing displays, their use for data physicalization, and methods for letting non-technical researchers engage with shape-changing displays.

Tim Merritt is associate professor at the Aarhus School of Architecture and lecturer at Aarhus University teaching interaction design courses focusing on various levels of scale from the handheld to city scale. His recent research explores how shape-changing and haptic interfaces can function as tools for communication and learning for activities such as cooking, photography, extreme sports, and creativity.

Website

The workshop will have its own website at www.shapechangingUI.org. This website will be maintained beyond the workshop. The goal of the website is to create a portal of resources on shape-changing user interfaces. Inspired by http://softroboticstoolkit.com/ we wish to: present an

overview of the field and its different streams of thought; host position papers; provide a curated list of relevant literature; provide resources for prototyping and provide resources to support experimental evaluations

Pre-Workshop Plans

We will advertise the event using standard HCI mailing lists. Additionally we will identify and target mailing lists in related fields (architecture, design, robotics, material sciences).

The website will receive continuous content updates as we add resources, examples, related work etc. We hope to establish the website as a portal for research and design surrounding shape-changing interfaces independent of the workshop. This portal will be used as a teaching resource at Queen's University, Kingston, Ontario, the Department of Computer Science at Copenhagen University as well as the Aarhus School of Architecture.

Workshop Structure

Day One

INTRODUCTION

The workshop will start with a series of lightning-talks in which each participant will have briefly introduce their work and their perspectives on the use of shape-changing interfaces (~3mins). We also encourage participants to bring and present physical or visual demonstrations of their work. This first step will be necessary to inform all participants about the different perspectives and generate ground for later discussion.

SHARING PERSPECTIVES

Participants will collaboratively generate a wall-sized mind-map, connecting the different artefacts, design perspectives and technologies presented in the lightning talks. In doing so, participants will be able to identify similarities and differences between their approaches. The goal of this step is to introduce participants to a wide range of different perspectives, applications, technologies and practices used and applied in designing and manufacturing shape-changing interfaces. To prepare for the next session, participants will identify open design challenges within different design perspectives.

ADOPTING OTHER PERSPECTIVES

Participants will, in small groups, choose a paradigm, workflow, technology or approach they are not accustomed to and will use it in designing or prototyping a shape-changing interface. They will use this perspective to address a design challenge established in the previous session. We will provide participants with materials (i.e., sensors, actuators, Arduino boards) which they can use to implement their own designs or prototypes. Participants are encouraged to do so outside of the domain they usually work in (e.g., an expert of mobile phones working on biologically actuated interfaces).

Day Two

COMPLETING AND DOCUMENTING PROTOTYPES

Participants will complete their prototypes and document them in the form of a video and short description. These documents will be published on the website.

SYNTHESIZING PERSPECTIVES

Using the wall sized mind-map generated on the previous day as a presentation tool, participants will present their prototypes and designs; each participant will explain the challenges they had in adopting other

design perspectives as well as what they have learned in the process.

Post-Workshop Plans

We will use the website to document the results of our workshop in the form of essays, images of prototypes and designs as well as reports on the different design perspectives. The website will be kept online indefinitely and will be used as a place to collect resources for researchers, designers and practitioners wishing to work with shape-changing interfaces. The website and its resources will be also available as a platform to other researchers wishing to host future workshops on related topics.

Call for Participation

Over the past years, several workshops and an increasing number of scientific publications have been dedicated to shape-changing interfaces. It is clear that the interest in shape-changing interfaces is growing within the HCI research community. However, perspectives of how shape-changing interfaces should or can contribute to HCI are diverse. Different research groups and cultures focus on different qualities of shape-changing objects, such as their abilities to convey emotion, change the affordances of an object, or visualize dynamic information.

This workshop will provide a forum to discuss and share the different ways in which researchers and designers use shape-changes. We will facilitate hands-on exploration of these different approaches to the design and implementation of shape-changing user interfaces by providing participants with tools and materials to implement and explore different ideas on the spot, these will include: elastic polymers, shape memory alloys, electroactive polymers, pneumatic actuators, linear and rotary motors and encoders as well as thermoplastics for structural elements and all required tools and interfaces. If you have no experience in prototyping, we will be able to provide you with simple instructions to ease the process.

We invite you to submit a 2-4 page position paper, in ACM Extended Abstracts format, that describes how you personally work with shape-changing interfaces or your perspective on their opportunities/limitations. Your submission can focus on the design, the ideation process, the theory, the technical implementations or a combination which is applicable to your workflow. The abstracts will be used to compare and contrast the different ways we have of utilizing shape changes. For more detailed instructions please check www.shapechangungUI.org.

Please indicate which of the position paper authors will attend the workshop. Places are limited and we may need to cap the number of attendees per accepted paper. At least one author from each accepted paper must register for the workshop and at least one day of the conference.

Workshop website: www.shapechangungUI.org
Format: 2-4 pages in ACM Extended Abstracts Format
Submission: by email to papers@shapechangingui.org
Early Submission Deadline: 14th of December 2015
Early Notification: 21st of December 2015
Final Submission Deadline: 8th of January 2016
Final Notification: 15th of January 2016
Camera Ready Submission: 12th of February 2016
Workshop: 7th and 8th of May 2016