Next Steps in OUIs: Crafting Interactions with Deformable and Actuated Display Surfaces

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Abstract
New technologies and materials enable the physical form of display surfaces to become dynamic in terms of shape and movement. This enables devices to form a more intimate relationship with software data and the user's environment. The research area of actuated interfaces aims at leveraging these qualities to enhance interaction with and representation of digital information, as well as creating new implicit communication channels between people and devices.

This workshop provides a forum for debating emerging trends in deformable and actuated display surfaces that explore changes to the overall topology of display devices to enable more expressive interactions with digital information.

Author Keywords
Shape-Changing Interfaces; Deformable Displays; Self-Actuation; Organic User Interfaces; Interactive Surface; Flexible Input.

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

ACE 2014, November 11–14, 2014, Funchal, Madeira, Portugal.

Introduction

The emerging field of Actuated Display Interfaces explores a new generation of materials that can change appearance thus becoming as dynamic as their digital representations. Physical deformations have the potential to communicate the state of a computing device through changes in the visual appearance or haptic qualities of its overall shape (Figure 1) [13].

As a community, we have yet to fully appreciate the implications of interacting with dynamic display surfaces or to understand how to merge organic motion design with future hardware devices. Designers face challenges associated with developing self-actuated surfaces for different contexts of use or how to incorporate shape transformations into interface design. We believe actuated display surfaces might enable physical form transformations that mimic the context of digital information.

This workshop aims at understanding how users perceive actuations on shape-changing interfaces as well as discussing prototyping and implementation techniques for crafting actuated, non-planar interfaces. The overarching goal is to bring together an interdisciplinary group of academic and industrial researchers to define the current and future challenges of crafting self-actuated display surfaces.

Background

Enabling the overall shape of a device to closely mimic the content being displayed, rather than forcing digital information to fit into predetermined shapes, improves the mapping between digital data and physical form factors, thus enabling a core principle of Organic User Interface Design, where *form follows functionality*. Additionally, self-actuated shapes can conform to varying usage scenarios and modes of interaction. Actuated Interfaces promise to change how we perceive and interact with digital information. Deformable surfaces may support deformation via user input or self-deformation, or both. While studies have been conducted on the use of actuation in rigid bodies [5,6] pixelated displays [3,9], and shape-changing interfaces [2,4,5,6,8,13] one area that has received little attention to date is the actuation of display surfaces.

Auxiliary Shape Change

Research in the domain of actuated surfaces has been extensively explored [2,3,4,5,6,8,9,13]**.** However, we find few projects where shape transformations were seamlessly integrated in deformable display devices. A more common approach is augmenting a device, or a part of a device with shape changing properties: Dynamic Knobs [6] showed a rigid mockup phone capable of changing shape in a small extension on one of its sides. Hemmert et al. [5] explored the concept of a shape-changing device that uses one and two-

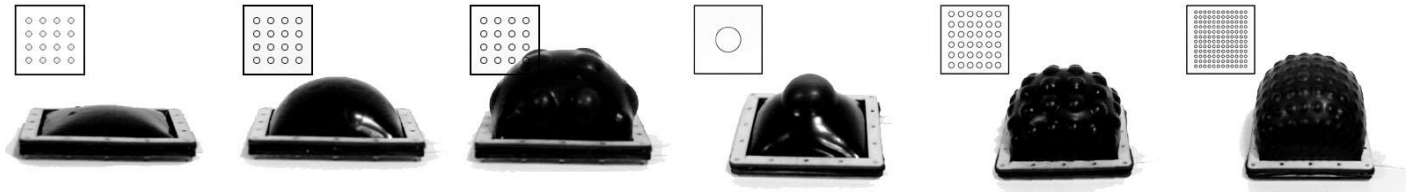

Figure 1 – Shape Deformations from global to local regions [13]

dimensional tapering (Figure 2) to display the directionality of off-screen contents. Park et al. demonstrated the use of shape changes as additional information channels for couples in long distance relationships [7] and between close friends [8] (Figure 2).

Figure 2 - Tapered Phone & Wrigglo

Actuated Tabletops

Poupyrev et al. [9] pioneered pixelated shape-changing displays. Follmer et al. [3] suggested a range of gestural and direct manipulation for interacting with dynamic surfaces. We believe display technology has evolved to a point where researchers and practitioners should be moving forward from projection mapping and complex controlled environments, and push forward towards favoring real displays over projection mapping, and find plausible solutions to overcome the limitations associated with working with real displays.

Increased Shape Resolution

Roudaut et al. [10] proposed a framework defining metrics for shape resolution in shape-changing devices. We are particularly interested in further discussing some of the features described by the authors, namely: increase the possible surface area of hulls; granularity of control points; curvature; amplitude; number of zero-crossings and stretchability of future actuated display surfaces.

Workshop Goals and Topics

The goal of the workshop is to investigate practical application scenarios, merging organic motion design with flexible hardware prototyping; propose a shape transformation vocabulary for deformable interfaces; and derive a number of design recommendations for interacting with actuated display surfaces. The workshop will be based around key themes that emerged from the CHI 2013 workshops on *(Re)Shaping Interactions with Deformable Displays* [11] and *Displays Take New Shape* [1].

Actuated Display Surfaces

Introducing shape transformations into computing will radically change the way people perceive input and output modalities. There are no standardized metrics for understanding motion design in computing. This workshop aims at identifying input and feedback properties unique to deformable surfaces, review existing evaluation criteria and their limitations, and discuss new methodologies for designing and implementing future malleable interfaces.

Shape Transformation Vocabulary

Interacting with transformable display surfaces poses challenges not present in traditional UIs. For example, a shape transition might completely change the topological properties of a display: deforming, increasing, decreasing or completely fracturing the display real estate. Consequently, display objects must be able to dynamically adjust the on-screen data to the device form and orientation. Not only the potential shapes need to be considered, but also the transitions between these shapes. Finally, different users might perceive similar shapes and shape transformations in distinct manners. While designing dynamic interfaces,

we need to consider shape and shape transitions as distinct input and output modalities.

Prototyping and Implementation

Current actuated display prototypes do not fully explore the tradeoff between shape and display resolution. Devices such as MorePhone [4] demonstrated a high resolution display, however a limited shape resolution. Lumen [9], on the other hand, presented a display surface with a relatively high shape resolution yet low display resolution (Figure 3). Both explorations, however, engage with the constraints provided by working with physical display and actuation technology. These constraints provide these devices with their unique look and feel.

Figure 3 - MorePhone & Lumen

A large portion of actuated display surfaces discussed in the literature relies on projection. Despite being an accepted methodology within the research community and a valuable contribution to interaction designers, we believe that in order to ascertain the potential of shape changing display surfaces, it is important to implement solutions that take into account the limitations of working with real hardware prototypes.

While we recognize the challenges of devising such prototypes within university research laboratories, we believe that exploring the constraints of working with physical prototypes is necessary. Working with physical prototypes allows us to design interactions which reflect the physical nature of the devices. Furthermore, working with physical prototypes also helps us understand what steps are necessary to extend what is achievable with current technology. We aim at investigating potential prototyping methods, materials and technologies, identifying the benefits and drawbacks of different actuation and display technologies as well as discussing control and feedback mechanisms of shape changing devices.

To encourage stimulating discussions, we aim at exploring the following research questions:

- What is the potential of shape transformations for designing expressive & engaging interfaces?
- What will the future forms of interactive display surfaces be?
- What types of communication and information are suitable to be represented by shape changes?
- Which prototyping methods, technologies and materials can support further investigation of shape changes
- How can researchers and practitioners define a universal vocabulary for shape changes?

Expected Outcomes

This workshop will generate valuable knowledge aimed at understanding interaction design with actuated display surfaces. Additionally, it will provide a platform for establishing a community of researchers and practitioners interested in the emerging field of actuated display surfaces. The results of this workshop will be shared on the workshop webpage, including all position papers and materials created during the workshop.

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