Towards a Design Space for Elastic Displays

Thomas Gründer
Chair of Media Design
Technische Universität Dresden
Dresden, Germany
thomas.gruender@tu-dresden.de

Dietrich Kammer
Chair of Media Design
Technische Universität Dresden
Dresden, Germany
dietrich.kammer@tu-dresden.de

Marius Brade
Chair of Media Design
Technische Universität Dresden
Dresden, Germany
marius.brade@tu-dresden.de

Rainer Groh
Chair of Media Design
Technische Universität Dresden
Dresden, Germany
rainer.groh@tu-dresden.de

CHI 2013, Workshop on Displays Take New Shape: An Agenda for Interactive Surfaces, April 28, 2013, Paris, France.

Abstract
This position paper describes our view on the current state of research in the domain of elastic displays. Elastic displays exhibit a number of unique properties: they enable varied haptic feedback, maintain consistency of shape, and afford natural physics. The main contribution of this paper is a systematic review of current technological and conceptual issues for enabling elastic displays. We discuss shortcomings that hamper a readily adoption of elastic displays and propose three directions for future research: elastic gestures, hooks, and gravibles.

Author Keywords
Tangible Computing; Elastic Displays; Tabletops; Multi-touch; Natural User Interfaces

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces – Interaction styles (direct manipulation).

General Terms
Design, Experimentation, Human Factors

Introduction
While traditionally, tabletop systems offer a multi-touch surface, recent developments seek to increase the haptic quality of the user interaction (e.g. [2, 6, 8]). While

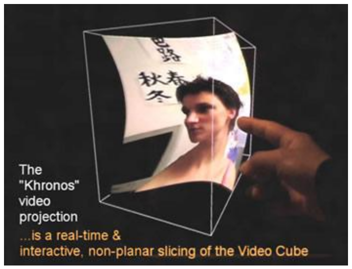

Figure 1. Khronos projector [1] uses a deformable tissue which when touched allows temporal control over a video.

Figure 2. eTable [5] implements demos that benefit from a third dimension for interacting with a tabletop.

deformable materials that allow permanent deformations have been subject of research for a short time, elastic displays that exhibit consistency of shape have only recently been found in amateur and research installations. In this position paper, the lack of literature in the field of elastic displays is addressed by outlining a design space for elastic displays and a review of existing reference systems.

Reference Systems

In this section, we distinguish displays with permanent and temporary deformations. To this end, we present recent examples of flexible and elastic displays.

Flexible Displays – Permanent Deformations

Displays that are indirectly modified and maintain a planar shape are foldable displays [3] or rollout displays [4]. The screen maintains a planar shape. Direct and local manipulations of the screen shape where the display is not planar can be found in photoelastic touch [8] or the dynamic softness control display [9].

Elastic Displays – Temporary Deformations

An early elastic display which features a magnetic fluid in order to create vibration as feedback is MudPad [2]. The system is relatively small in size and does not allow deep touching. Moreover, the third dimension is not used as parameter for the interaction. Khronos projector [1] is a vertical interactive surface which uses a deformable tissue that allows allows temporal control over a video when touched and depressed(see Figure 1). Also outside of the area of tabletop systems, Firewall [10] shows how elastic displays are installed in a vertical fashion (see Figure 3). The installation invites tactile experience, allowing users to play music and change the related visualization.

To our knowledge, DepthTouch [7] is one of the first published systems that features the tabletop setup presented in this contribution (see Figure 7). Kreek [11] is a similar design project, which implements three applications: body scanner, particles simulation, and a geological simulation (see Figure 4). A first comprehensive report in the literature is about the eTable [5], which includes results from user interaction tests, stating that acquisition of target objects in the context of 3D visualization can be aided by an elastic display (see Figure 2).

Design Space

This section describes a tentative design space for elastic displays comprising technological issues and conceptual challenges as well as possible application domains.

Technological Issues

The technical setup of elastic displays consists of three main challenges: material, projection, and tracking.

Material

Elastic materials such as Lycra or rubber-based cloth are necessary for the display. In addition, the material needs to be robust and insusceptible to staining. It should be replaceable to be washed or renewed for hygienic reasons. Other properties such as the denseness of the mesh may be determined by the tools used with the surface (see section on Hooks).

Projection

At the current stage of research, rear projections are necessary because current deformable displays are passive. This means that sufficient space between display and projector needs to be established. Both vertical and horizontal setups are conceivable. Because of

Figure 3. Firewall [10] is a vertical installation of an elastic display.

Figure 4. Kreek [11] is a design project, which implements three applications (body scanner, particles simulation, geological simulation).

the screen deformations, image warping techniques need to be applied.

TRACKING
Optical tracking of touches on the display can be combined or substituted by depth sensors. A combination of sensors allows more precise tracking and mitigates occlusions.

Conceptual Issues
This section briefly discusses shortcomings that hamper a readily adoption of elastic displays such as the lack of permanent deformations and proposes three solutions: elastic gestures, hooks, and gravibles.

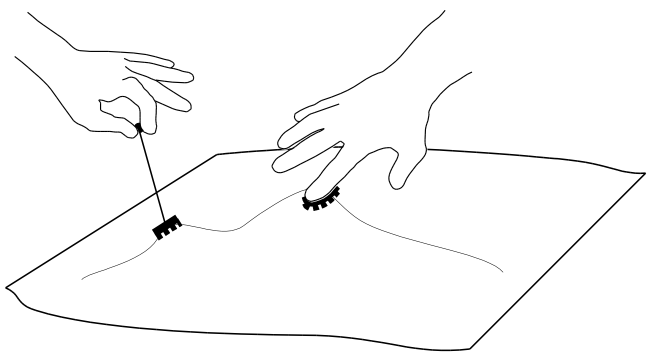

Figure 5. Hooks facilitate the handling of the elastic display.

ELASTIC GESTURES
Elastic gestures help to handle natural physics on an elastic tabletop system. A combination of indirect and direct manipulation of objects on the elastic display is conceivable. By implementing appropriate physical behavior, objects move away from slopes or into valleys. Special gestures with multiple fingers can also create permanent barriers for physical objects to be constrained in their movement. Also by depressing very deep, permanent holes could be created. An important issue is the formalization of these properties in order to create sets of elastic gestures that are usable in different applications.

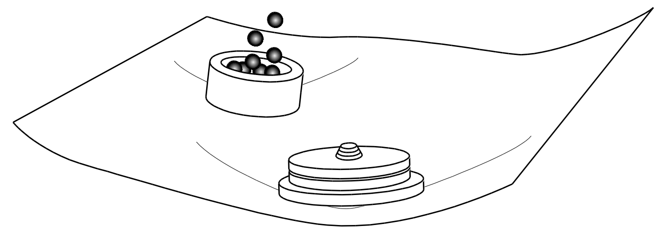

Figure 6. Gravibles can be stacked or filled with weights to control the deformation on the elastic display.

HOOKS
Hooks are aides that are used to manipulate the elastic display other than with bare hands. They facilitate the handling of the cloth and might be more suitable with lose meshes or velcro that does not harm the cloth. Hooks are either applied directly to fingers using velcro fastening or remotely installed and facilitate pulling of elastic displays that are based on textiles. Automatic hooks under the surface could lock the cloth when it is depressed very deep.

GRAVIBLES
Gravibles are tangible objects that can be placed on large horizontal elastic displays and can be fitted with weights in order to create permanent deformations. Their identity could be determined by markers on the bottom of a gravible. It is also conceivable to use stackable weights or fluids to influence the impact of the gravible. A gravible could be held in place using velcro, hooks, or other properties of the used display

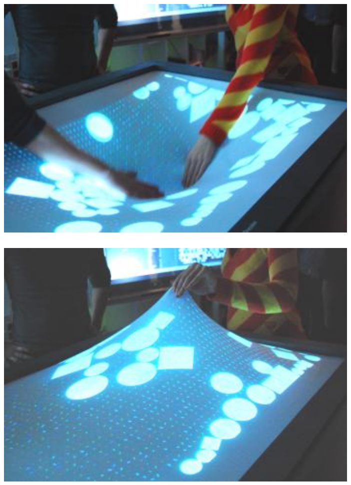

Figure 7. Depressing and pulling of the elastic display of DepthTouch.

material. For instance, magnetic fibres in the cloth would impose a grid for the placement of gravibles.

Application Domains

Identifying suitable application domains is a key issue for future work. Handling of 3D data, time-dependent data or multivariate-data are first promising research directions. Applications like the Khronos projector [1] or Kreek [11] benefit from local warping and semantic zooming techniques. Further attractive topics in the educational sector are applications to learn physical rules of gravity, magnetic, or electrical fields.

Conclusions and Future Work

In summary, this paper outlines a design space for elastic displays. The novel proposed concepts for elastic gestures, hooks, and gravibles raise new research opportunities and challenges. To consolidate this design space, we intend to demonstrate the proposed design space in our DepthTouch system in the future.

Acknowledgments

On behalf of Thomas Gründer, this work has been supported by the European Social Fund and the Free State of Saxony (Young Investigators Group; CogITo). On behalf of Marius Brade this research (contract no. 080951799) has been funded by the European Social Fond and the Free State of Saxony as well as SAP Research.

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