User Created Tangible Controls Using ForceForm: a Dynamically Deformable Interactive Surface

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ABSTRACT

Touch surfaces are common devices but they are often uniformly flat and provide little flexibility beyond changing the visual information communicated to the user via software. Furthermore, controls for interaction are not tangible and are usually specified and placed by the user interface designer.

Using ForceForm, a dynamically deformable interactive surface, the user is able to directly sculpt the surface to create tangible controls with force feedback properties. These controls can be made according to the user's specifications, and can then be relinquished when no longer needed. We describe this method of interaction, provide an implementation of a slider, and ideas for further controls.

Author Keywords

Interaction techniques; tangible interaction; tactile feedback.

ACM Classification Keywords

H.5.2 Information Interfaces and Presentation: User Interfaces - Interaction Styles

INTRODUCTION

Touch surfaces are common devices in mobile and tabletop scenarios as they can be intuitive to use and the visual information displayed can be dynamically changed to suit the application. When we consider their tangible properties, they are often flat and unable to be physically altered. The importance of tangible interaction has been well documented.

Obake [3] is a deformable surface that uses linear actuators to allow the user to raise the surface at localised points. Haptic Chameleon [4] attempted to provide user interface control devices that can be altered. They developed a dial that provides different haptic feedback patterns using a servomotor. Harrison et al. [2] fabricated button overlays that consisted of inflatable buttons that can protrude from a flat surface and flatten when no longer needed.

We present a method of interaction that allows the user to directly sculpt a deformable interactive surface to create their own tangible controls with force feedback properties. The user is able to specify a size and location for the tangible controls, and can remove them when no longer needed. This is achieved using ForceForm, a dynamically deformable interactive surface. The user is able to interact using relatively minimal effort as no extra tools such as pucks [6], or the fabrication of purpose built button overlays [2], are needed.

In a study that analysed 81 hand gestures for interacting with touch surfaces, Morris et al. [5] found a user preference for simple gestures, particularly gestures using a single hand or, better yet, a single finger, allowing users to multitask. The study also revealed user preference for gestures which refer to desktop and mouse functions. We have designed our interaction techniques with these findings in mind.

Our method gives the user freedom to dynamically place, alter and resize UI elements, unlike many tangible interfaces which use physical objects. As well as providing the user with increased control over their interaction, our method also provides tangible controls to touch surfaces.

FORCEFORM

As shown in Figure 1, ForceForm [7] consists of a latex surface *(a)* that has been augmented with a grid of neodymium permanent magnets, 8mm in diameter and 1mm thick. An underlying grid of 16 computer controlled electromagnets *(c)*, similar to that of the Actuated Workbench [6], is used to attract and repel the permanent magnets, deforming the surface at localised points. There is one permanent magnet per electromagnet in our prototype.

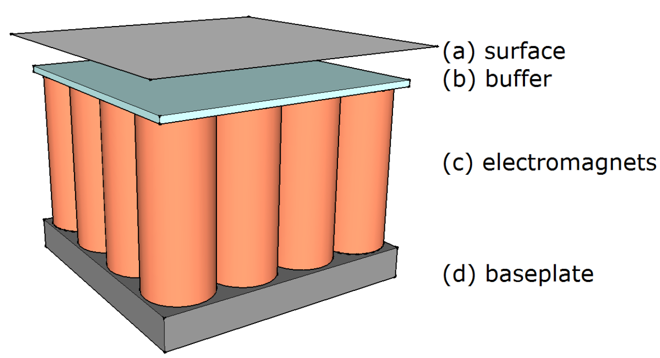

Figure 1: The configuration of the ForceForm prototype

A 2mm Perspex sheet *(b)* lies between the deformable surface and the electromagnets, to prevent the surface magnets

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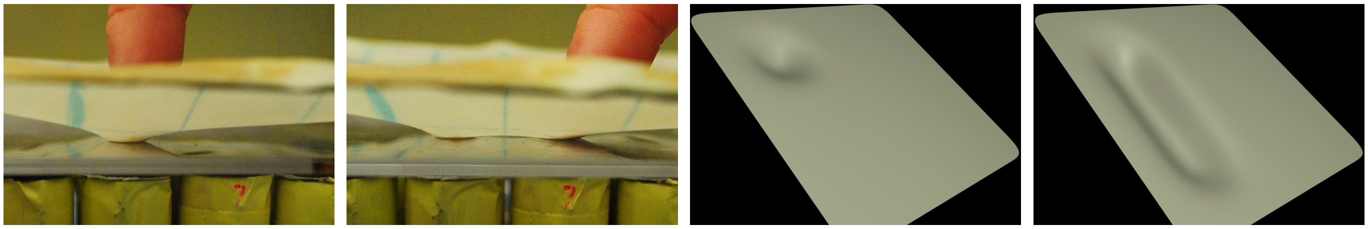

(a) The user presses down to make a single indent. (b) The user slides their finger to the right to create a longer indent. (c) Example of a single indent. (d) Example of a longer indent.

Figure 2: Real and modelled depictions of a user creating their own slider using ForceForm.

from attracting to the ferrous steel cores of the electromagnets. The user's finger position is tracked by using a Cyclotouch T-series touch overlay. A steel baseplate *(d)* is attached to improve the strength of the electromagnets.

USER CREATED TANGIBLE CONTROLS

The surface of ForceForm can be both raised and lowered at localised points, differing from previous work such as Obake [3] which can only be raised. The basic ForceForm interactions are pushing the surface down with the user's finger, and pulling the surface up, which can be achieved by using a two fingered 'pinching' motion at an indented point on the surface, or simply running the finger over an indented point to level it again. For each electromagnet, the surface can currently achieve one state where the permanent magnets are attracted downwards, a neutral state where the electromagnet is off, and multiple states where the electromagnet is repelling the permanent magnets upwards at different strengths. The range of motion between the peak and trough is around 25mm with our current prototype. As Morris et al. [5] found a user preference for simple gestures, particularly gestures using a single hand, we have designed our interaction with these findings in mind.

Slider

The user is able to run their finger along the surface, creating an indent in the surface as illustrated in Figures 2a and 2b. This is further illustrated in 2c and 2d in an emphasised graphic model of the result of the action upon the surface. This indent is used as a tangible slider and the user can run their finger along it to adjust a setting, such as the volume. The user can feel the indent, so they are able to operate the slider in an eyes-free manner. The slider is also capable of localised haptic feedback, so the user can be alerted to the slider's current setting by having that position vibrate. When the user has finished adjusting the volume, they can relinquish the screen space taken up by the slider by performing a gesture on it, similar to 'crossing' something out. This releases valuable screen real estate.

To implement the slider, we track the user's finger position. When the user runs their finger along the surface, we negatively energise the electromagnets in those positions. This causes the permanent magnets on the latex to attract downwards, resulting in the persistent indention. Haptic feedback is implemented by rapidly switching the polarity of the electromagnet at the user's finger.

Further Tangible Controls

- **Physical boundaries.** When multiple users are interacting with a large touch surface, a user can segregate their workspace from their coworker by drawing a line between them, deforming the surface downwards, which defines the separate interaction spaces in a tangible manner.
- **Snap to grid points.** A number of indents in the surface can be used as tangible points of reference to 'snap to' when the user is drawing shapes.
- **Buttons.** A button can be created by deforming the surface upwards in a location. The button can have varying levels of stiffness, according to the strength of the electromagnet.

CONCLUSION AND FUTURE WORK

We have presented deformable surface interaction techniques that are created by the user and cease to exist when no longer needed. As these interaction techniques use a deformable interactive surface, different interaction techniques beyond those offered by traditional touch surfaces are possible. Further work is needed to better understand how these interactions can be reinforced with projected visuals. We are also experimenting with methods for information visualisation taking into account the user's deformations of the surface, similar to the Khronos Projector [1].

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REFERENCES

1. Cassinelli, A., and Ishikawa, M. Khronos projector. *Proc. SIGGRAPH 2005 Emerging Technologies*.
2. Harrison, C., and Hudson, S. E. Providing Dynamically Changeable Physical Buttons on a Visual Display. *Proc. CHI 2009*, 299–308.
3. Hemsley, R., and Dand, D. Obake: Interactions with a 2.5D elastic display, 2013. http://dhairyadand.com/sec/?page=projects&id=obake
4. Michelitsch, G., Williams, J., Osen, M., Jimenez, B., and Rapp, S. Haptic Chameleon : A New Concept of Shape-Changing User Interface Controls with Force Feedback. *Proc. CHI 2004*, 1305–1308.
5. Morris, M. R., Wobbrock, J. O., and Wilson, A. D. Understanding Users' Preferences for Surface Gestures. *Proc. Graphics Interface 2010*.
6. Pangaro, G., Maynes-Aminzade, D., and Ishii, H. The Actuated Workbench: Computer-Controlled Actuation in Tabletop Tangible Interfaces. *Proc. UIST 2002*.
7. Tsimeris, J., Dedman, C., Broughton, M., and Gedeon, T. ForceForm: A Dynamically Deformable Interactive Surface. *Proc. ITS 2013*.