Transformable Tangible User Interface Seminar – Final Report

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ABSTRACT

Transformable Tangible User Interfaces seek to bring the interaction and exchange of information between the system and the user out of the virtual world and into the physical world.

In essence, they are physical devices which can change their shape and other properties to indicate the current state of the computer system, providing the user with non-visual cues as to the state of the system. The user can also manually change the state of the underlying system by deforming the device to match the representative shape of that state. By achieving this, the user has both input and output available at one interaction point. This is particularly useful in situations where a visible screen would be impractical or dangerous.

Research into this field has been focused on user interaction with deformable devices, current methods of providing feedback and looking how current and potential future materials can be used to construct such devices.

INTRODUCTION

For the past few decades, computing has primary existed in a fully virtual environment, using a Graphical User Interface(GUI) on a display to show the state of the system, and using completely separate input devices such as a mouse and keyboard to manipulate the state of the system. The real world position and state of these devices have no relation to the current state of the system.

The field of Tangible User Interfaces(TUI) aims to reduce the separation between input device state and the system state. Transformable TUIs are an extension of this field, the key difference is that Transformable TUIs seek to completely remove the separation between system state and input device, allowing users to gain information and react to that information using the interaction element.

TUIs can be viewed as a physical hook to the virtual information, allowing the system state to be changed via more representative actions. This system works really will with applications such as PICO [6] where TUI elements were placed by the users over a virtual map to indicate placement of cellphone towers. This method further enhanced the interaction by allowing the system to move the TUI elements using electromagnets.

Transformable TUIs are still in a mostly theoretical state, but they aim to bring the interaction fully into the physical space. [3]

PROBLEMS

Tangible User Interfaces have been shown to work extremely well in systems, such as PICO [6], where physical displacement is the primary concern. For other uses however they are not as effective, mainly due the fact that in most cases, TUI elements have no way of reflecting the state of the underlying system, and the user is still dependent on some sort of visual display.

Ideally, a TUI should be able to change its state in some manner such that the user can instantly gain knowledge on the state of the system without having to resort to some sort of visual display. This is particularly important where visual distractions are dangerous, such as operating a motor vehicle.

The main obstacle faced by current TUIs is the rigid nature of conventional materials, where the shape and other features are set at the time of production.

Transformable TUIs aim to combat this limitation, allowing the user to gain information about the system state, and change the state by feeling and manipulating the properties of the TUI. The primary restriction here is that material science has currently not developed a suitable material for this need.

In the meantime, research has been focused on providing possible interaction methods for a future where these materials are available.

CURRENT WORK

The current work in this field covers three main areas; How users interact with TUIs [4], Experimenting with methods of feedback using currently available materials [1, 5, 7], and presenting theories on how new materials can be used to make true Transformable TUIs in the future. [2, 3, 5]

How users interact with TUIs

Lee et al. in [4] explores the nature of human natural behavior when presented with a deformable interface.

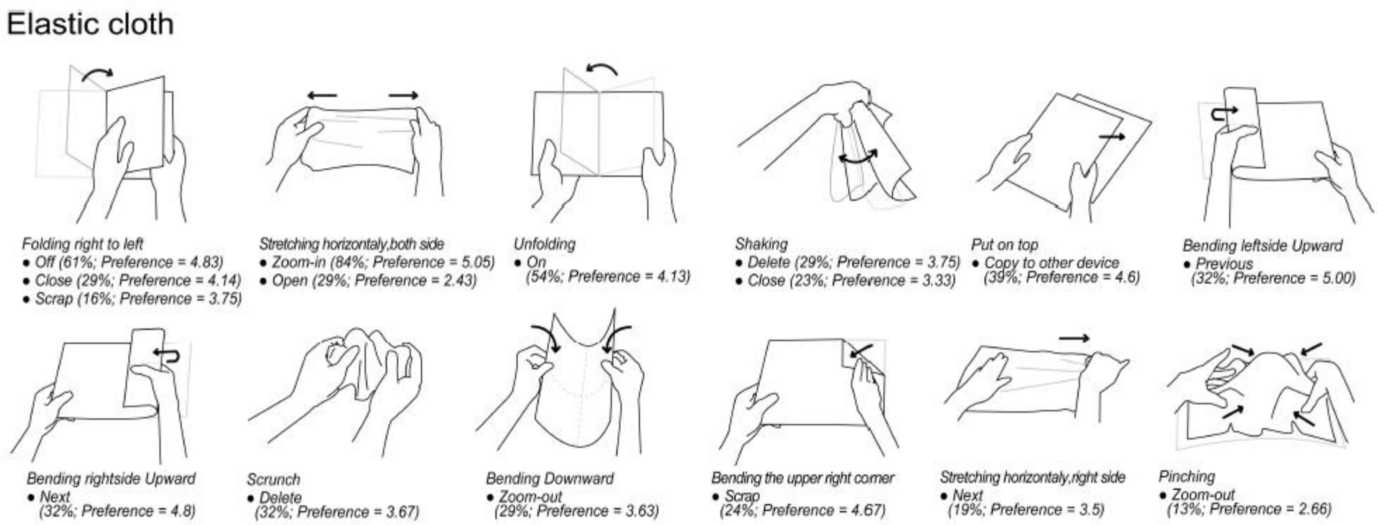

Figure 1: Extract of preferred gestures from [4]

Method

[4] presented the participants with a sheet of either plastic, paper or elastic cloth, used to represent a form of flexible

display. The participants were then tasked to create a method of executing select commands (such as 'On', 'Delete' etc.) in the context of eBook content. The participants were then asked to give each interaction a preference score. The resulting data was then collated to provide an insight on how natural human behavior (for a right handed person) would expect a deformable TUI to work.

Findings

Lee et al. stated in [4] that they expected the largest agreement between participants to occur when using the more rigid plastic, as the number of available motions is restricted by the lack of available movements. This was shown not to be the case however, as the more flexible elastic cloth showed a better agreement score than the plastic.

The findings were collated into separate pictorial diagrams showing the most preferred gestures for each material. (See Figure 1)

Feedback methods using current materials.

Several papers have explored the possible methods of feedback in TUIs currently available, these focus on mostly non-visual feedback to relay information to the user.

Some of the feedback methods covered are vibration [1], tactile shape sensing [5], and temperature. [7]

Methods

Bianchi et al. in [1] present a device called the "Haptic Wheel". This device is a basic input wheel which can be rotated in either direction to provide input. The system can provide feedback about its state using vibration, controlled by a pager motor, at varying frequencies.

Seaborn and Antle explored the use of temperature and basic light cues in [7]. They set up a simple experiment, based on a children's game, where the user has to find the correct 'door' using the TUI.

The TUI elements would provide feedback on a scale, with the light based one moving from a blue color to indicate the user was far away, to a red color to indicate that the user was approaching the desired location. The temperature based TUI worked on a similar principle, however as a cool temperature was not available under the current design, the device scaled from room temperature (off) to warm under the same conditions.

The TUI tested in [5] differs from the previous two, as it was a crude prototype for a theoretical transformable TUI. In this paper, Michelitsch et al. constructed an input device for navigating through video content. The TUI provided tactile feedback, with the user being able to tell what navigation mode the system was in just by feeling the overall shape of the device.

This TUI used a circle shape to represent a smooth, frame by frame navigation of the video; a rectangle shape to represent scene by scene navigation; and a semi-circle to represent navigation by the semantic of a 'happy' scene.

The shape of the device was manipulated by the user by depressing the semi-circular buttons on either side of the solid rectangular center.

Findings

Seaborn and Antle [7], observed that the warming effect took some time to occur, this would disadvantage quick users as the required feedback from the device is taking too long to be generated. The light based TUI works better in this regard, however requires the user to visually observe the TUI element, something which is not ideal in a practical sense.

Michelitsch et al. in [5] ran an experiment using people experienced in video editing. Their device received very positive feedback from the participants, who found the tactile state recognition and the ability to change states on the same device used to navigate was easy to use and speed up their ability to locate a particular section of the video.

These findings show a definite advantage to having non-visual feedback in TUI elements, allowing a faster, more multi-tasked approach by the user.

Theoretical Future

The future of Transformable TUIs is highly related to Materials Science, as the materials currently available are insufficient for creating such devices.

Methods

Ishii et al. in [3] presents an overview of the concept of Transformable TUIs, coining the term 'radical atoms' as their vision of TUIs in the future.

These 'radical atoms' are stated to be able to *transform,* changing its shape to represent some change in the current state or data contained in the system. Also these atoms should be able to be transformed by the user as well, providing input to the system to change the underlying state.

The 'radical atoms' must also be *constrained* to ensure safety, and that they must *Inform* the user of its capabilities.

They envision that these 'radical atoms' will expand the current interaction space, allowing users a more natural and tangible interaction, with the TUI changing according to context to make the users interactions easier.

In the remainder of [5] not yet discussed, Michelitsch et al. proposed a TUI that could be molded into various shapes by the user, with each one representing a different input type. The concept used the same shapes covered above to navigate through video content.

In [2] Cohelo and Zigelbaum focused on the materials currently being developed, and how they could be used to create Transformable TUIs. They discussed the properties of the materials, such as *Speed* and *Recoverability*, and how they affect the potential of materials being used for transformable TUI construction.

Findings

To test the Transformable TUI proposed in [5], Michelitsch et al. conducted an experiment where the users were attached to Phantom devices, which allowed them to simulate grabbing and deforming the interface element portrayed in a virtual simulation. This setup proved difficult to use however, as the participant only had two or three points of contact to manipulate the virtual TUI with, and no true 3D vision to assist with the task.

This presented an interesting glimpse at possible future interactions, but the restrictions of dealing with it in a virtual environment appeared to greatly impede this test.

In [2], Cohelo and Zigelbaum present several current materials that have the ability to change their shape. They put focus on the stimulus required, and other properties.

While no conclusions are drawn on which material is better, they show a preference towards Shape Memory Alloys (SMA) due to the fact they are already being used from interesting applications in the field of Transformable TUIs.

They cover some examples of these applications, including *SpeakCup* which is a device which either records or plays sound depending in which direction it is bent. This is an important first step towards Transformable TUIs, as the state (Playing, Recording, Idle) of the system can be observed by feeling the shape, and also the internal system state is changed just by the user deforming the object to one of the other representative states.

FUTURE WORK

Work is this field is highly reliant on the material sciences, as further development of transformable materials is needed to realize the dream of true Transformable TUIs.

Future work for this field would require researchers to further understand the how the users would expect certain interactions to affect the system. As this is a new way of interacting with computer systems that more closely resemble the natural method of interaction of the world around us, we should be careful to make sure that any Transformable TUIs conform the natural expectations of the actions.

Also future work can focus on current and new transformable materials, discovering how they can be used together to create Transformable TUI's and evaluate how appropriate they are for the task.

CONCLUSION

The field of Transformable Tangible User Interfaces is a fresh area of research which may drastically change the way in which we interact with our computing devices. Currently it is difficult to gauge user reaction to such devices, as they currently cannot be produced, however [5] demonstrated with their prototype using current materials that the users adapted quickly and preferred an interface where more information and control was available purely by touch.

As the field of Transformable Materials progresses, the field of Transformable TUIs will be opened up to many new and exciting methods of interaction.

REFERENCES

1. Bianchi, A., Oakley, I., Lee, J.K., Kwon, D.S., and Kostakos, V. Haptics for tangible interaction: a vibro-tactile prototype. In *Proc. TEI 2011*, ACM Press (2011), 283-284.
2. Cohelo, M., and Zigelbaum, J. Shape-changing interfaces. *Personal Ubiquitous Comput 15,* 2 (2011), 161-173.
3. Ishii, H., Lakatos, D., Bonanni, L., and Labrune, J. Radical atoms: beyond tangible bits, toward transformable materials. *interactions 19*, 1 (2012), 38-51.
4. Lee, S., Kim, S., Jin, B., Choi, E., Kim, B., Jia, X., Kim, D., and Lee, K. How users manipulate deformable displays as input devices. In *Proc. CHI 2010*, ACM Press (2010), 1647-1656.
5. 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. In *Ext. Abstracts CHI 2004,* ACM Press (2004), 1305-1308.
6. Patten, J., and Ishii, H., Mechanical constraints as computational constraints in tabletop tangible interfaces. In *Proc. CHI 2007,* ACM Press (2007), 809-818
7. Seaborn, K., and Antle, A.N. The tiresias effect: feedforward using light versus temperature in a tangible user interface. In *Proc. CHI EA 2010,* ACM Press (2010), 3427-3432