StringTouch – A Scalable Low-Cost Concept for Deformable Interfaces

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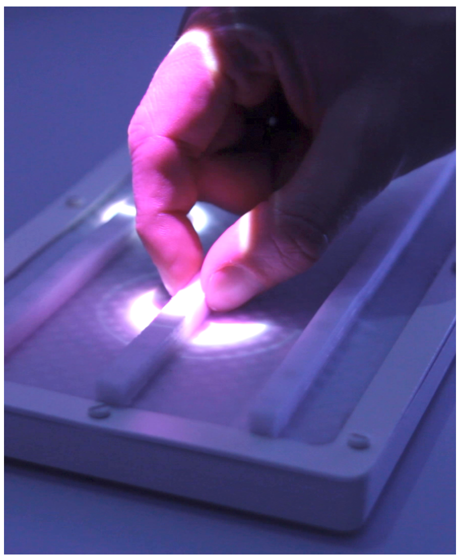

Figure 1: StringTouch combines features of touch screens with haptic elements. Along three silicone ridges the user can perform gestures and deform the material in inwards and outwards direction.

ABSTRACT

This paper describes a demo prototype of a tangible user interface (TUI) concept that is derived from the expressive play of musical string instruments. We translated this interaction paradigm to an interactive demo which offers a novel gesture vocabulary (strumming, picking, etc.). In this work we present our interaction concepts, prototype description, technical details and insights on the rapid and low-cost manufacturing and design process. (Video demonstration: https://vimeo.com/309265370)

CCS CONCEPTS

• **Human-centered computing** → **Haptic devices**; **User interface design**; **Interaction design theory, concepts and paradigms**.

KEYWORDS

Tangible User Interface; Ambient Interaction.

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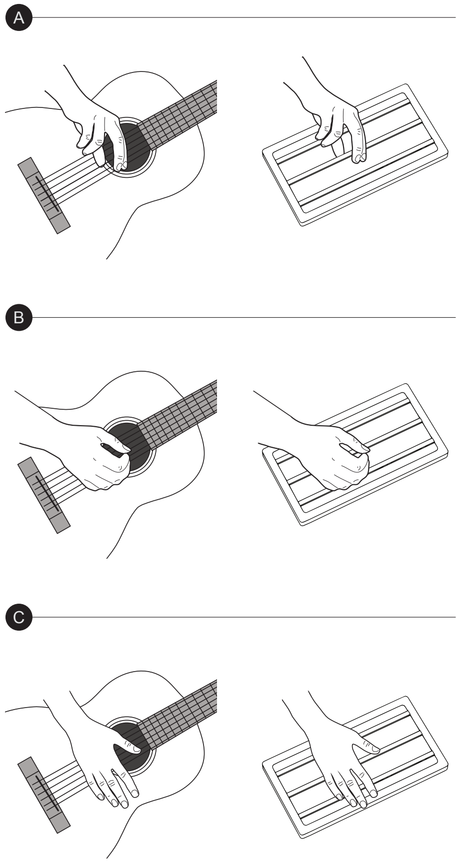

Figure 2: Native gestures of string instruments (picking, strumming, muting) are adapted to the interface of StringTouch. On a meta-level, meaningful equivalents can be formed between them: Muting the strings corresponds to terminating or leaving a task.

INTRODUCTION

In recent commercial user interface development, there is a tendency to overwhelm users with visual information presented via ubiquitous screens. In the car industry the number of build-in touchscreens is currently considered to be a sales and differentiation feature. Hence, there is a tendency to increase the implementation of more screens than are needed or are useful which results in visual overload and does not lead to an increased awareness or user satisfaction. Instead, they mostly lead to more confusion and distraction [8]. Tangible interaction instead draws use of all senses and therefore incorporates user's cognitive and motor skills while not depending excessively on visual attention.

Developing our here presented prototype we envisioned an interface solution which aims at reducing user distraction while providing expressive interface elements. Therefore, we investigated the expressive interaction with musical string instruments and transferred this mental model to a interaction concept we call StringTouch. Our contribution is twofold: In our interactive demo we will present a novel interaction concept along with technical details to replicate our approach.

RELATED WORK

In consumer devices the formerly binary interaction of touch is increasingly enriched with pressure sensitivity [5] in order to open up a new dimension of interaction. Beyond that, current research exploits the aspect of depth and deformation in the interaction with surfaces. These interfaces usually integrate flexible materials as their interaction surfaces [7] which are tracked with depth cameras (e.g. Microsoft Kinect) or sensed with motorized pins [3, 4]. These pins also facilitate the surface's shape manipulation. Both approaches allow for large scale interfaces but have high minimum space requirements based on the external tracking equipment and therefore struggle with miniaturization. Also the discipline of shape changing interfaces [1] is dedicated to the challenge of integrating the actuation as well as the measurement of deformation into their designs. Where consumer products have already started to use depth/force on small scale devices they still lack the utilization of the full dimension. Here, the interaction surface's deformation is just captured on the positive scale: pushing the screen inwards. Based on the rigid quality of touch screens pulling out of the screen is not feasible.

STRINGTOUCH

The concept of StringTouch combines haptic qualities and benefits taken from the play of string instruments (see Figure 2) with technology to create new interaction possibilities. Elaborated gestures are reused and therefore contain meaning based on their physical origin. Three string-like silicone ridges enable interaction techniques such as pushing into as well as pulling the ridge away from the surface. Therefore, the previously one-dimensional half-scaled touch interaction (e.g. force touch) is extended to its full range.

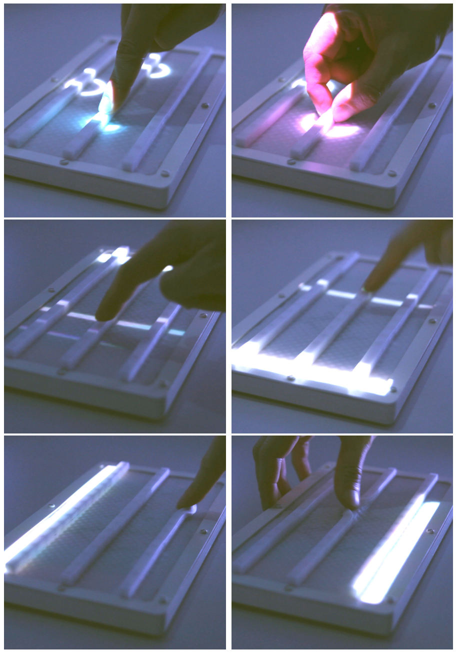

Figure 3: On StringTouch, the following interactions can be performed with a pseudo UI: push and pull, swipe left and right, strum down and up.

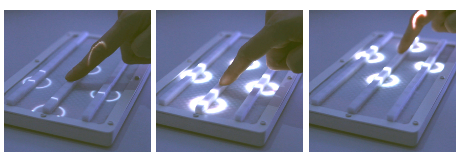

Figure 4: Such as a pie menu, the UI appears around the user's hand and follows their movement. Once the user has learned certain motion sequences, he/she can perform them blindly.

Gesture Vocabulary, Relative Control and Midas Touch

As an addition to interaction techniques with elastic displays [9] our gesture vocabulary is based on interaction techniques found in string instruments. These gestures are inspired from left- and right-hand techniques as well as fretted and fretless instruments. On the instrument side gestures can be clustered into string excitation and pitch manipulation techniques. In this demonstration four basic gestures are presented: Strumming, picking, sliding and muting. Unlike touchscreens, where interaction is performed on predetermined locations, StringTouch is based on gestures being performed relative to the current hand position (see Figure 4). This concept is comparable to pie menus [2] and enables a non-visually based interaction. The Midas Touch issue [6] is bypassed by the ability to differentiate touching, pushing and pulling the ridges.

Implementation

The core of our work is a low-cost prototyping technique to sense concave and convex surface deformation. Our approach offers the advantage of a being simple, precise and independent from depth-cameras or mechanical sensors. Magnets enclosed inside the silicone are used to detect push/pull gestures via the read out of hall effect sensors[1]. These sensors are typically used to determine the positioning of objects, often in a binary manner (doors, lids) or of rotating objects (motors). With this sensor we translate the surface deformation and the resulting variations of the magnetic field into voltages that can be processed and interpreted by a microcontroller[2]. In addition, copper plates for capacitive touch are integrated into the PCB and allow to recognize and differentiate light touches from deformations. In order to achieve a precise placement of the magnets a two-step casting method has been developed. The first half of the mold is casted with a cover imprinting indentations for the magnets. After curing the silicone and placing the magnets, the second coat completes the casting and secures the magnets in their designated places. Currently the user interface is projected onto the surface and is an abstract interface demonstrating the new interaction possibilities (see Figure 3).

Observational Study

Initial informal observations investigating the practical usability and desirability of our prototype setup were gained during a design workshop presentation: The prototype was developed in the context of an interdisciplinary design workshop with an industrial partner form the automotive domain. In a formal presentation setting 14 participants were confronted with the prototype and executed given tasks: switching on/off, decreasing increasing, navigation. Participants expressed positive feedback after interacting with the prototype. The prototype invited for playful exploration and made it possible to replicate the given tasks at the first try. The interaction concept has been perceived as simple and intuitive to operate along with a level of playfulness which raised curious discussions afterwards.

[1] http://www.ti.com/lit/ds/symlink/drv5053.pdf

[2] https://www.pjrc.com/teensy/teensyLC.html

Although being a first informal observation we received overall very positive feedback. However, subsequent formal studies will be conducted in further rounds of development.

DISCUSSION AND CONCLUSION

A core beneficial aspect of our implementation is the scalability and easy deployment to uneven and multiple shaped surfaces and environments. Therefore, any flexible (i.e. fabric) material can be augmented to an interface using our approach. Further, the reference to familiar modes of interactions inspired from musical instruments such as strumming, picking etc. might prove as an accessible, easy-to-use and easy-to-remember interaction paradigm. However, this assumption taken form early informal testing sessions has to be substantiated through further investigations. Considering the limitations of the current prototype setting we acknowledge that the design does not include an embedded visual feedback solution. Currently, the projections on the surface are prone to be overshadowed by the user's hands and therefore lead to discomfort and disturbed perception. In future design revisions, we therefore aim at experimenting with flexible display and PCB solutions which might prove as a promising extension for our approach. Further, we plan to share our rapid design and manufacturing processes in more detail as well as give in-depth insights into our technical implementation to enable others to create new similar prototypes fast and effectively.

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