Squeezing the Sandwich: A Mobile Pressure-Sensitive Two-Sided Multi-Touch Prototype

Georg Essl[1,2]
[1]University of Michigan
Computer Science & Engineering and Music
gessl@eecs.umich.edu

Michael Rohs[2] *and Sven Kratz*[2]
[2]Deutsche Telekom Laboratories, TU-Berlin
Ernst-Reuter-Platz 7, 10587 Berlin, Germany
{ michael.rohs,sven.kratz}@telekom.de

ABSTRACT
Two-sided pressure input is common in everyday interactions such as grabbing, sliding, twisting, and turning an object held between thumb and index finger. We describe and demonstrate a research prototype which allows for two-sided multitouch sensing with continuous pressure input at interactive rates and we explore early ideas of interaction techniques that become possible with this setup. The advantage of a two-sided pressure interaction is that it enables high degree-of-freedom input locally. Hence rather complex, yet natural interactions can be designed using little finger motion and device space.

ACM Classification: H.5.2 [Information Interfaces and Presentation]: User Interfaces – input devices and strategies, interaction styles.

General terms: Design**,** Human Factors

Keywords: Pressure sensing, two-sided input, multitouch, bimanual input, high degree-of-freedom input

INTRODUCTION

It is a central theme of mobile interaction research to try to cope with the size and form factor imposed by handheld devices. Showing interface elements in the limited screen space comes at a cost. Touch-based interactions additionally lead to occlusions of information that may be valuable. In recent years numerous proposals have been made to improve interactions on mobile phones using a multitouch paradigm, including flexible displays and two-sided interactions [4,5,6,7]. Pen-based pressure input has also been introduced to give additional flexibility to a touch-screen [3,6].

In this demonstration we describe a working prototype which allows for two-sided multi-touch pressure interactions at interactive rates. This offers a large number of local degrees of freedom and hence allows for packing a lot of control in a small screen area. If large numbers of parameters can be manipulated with no or limited motion, space frees up for content which would otherwise be used up for UI elements. Thus the amount of occlusion is reduced.

Furthermore there are natural hand motor actions that are not typically supported on traditional mobile devices. Primary among those motor actions are grabbing, twisting, turning, and squeezing. All these actions rely on two opposing fingers (typically thumb and index finger) [2]. Many touch interfaces either place all fingers on equal footing, or rely on a point-and-touch paradigm for all their interactions.

Figure 1. Sandwich prototype.

In an everyday grabbing action like holding we control the pressure to the object directly by simultaneously applying the forward-acting force and the counter-acting force. We believe that opposing thumb actions are good candidates for allowing more fine-grained pressure control, which can already be experience with our prototype.

In our concept we aim to interact with a single point of contact simultaneously from the front- and the back-side. In thumb-index-finger pinching, the same location on the screen can be touched from two sides. Minute shifts of the touch points of the two fingers can be used to define rotations around arbitrary axes. In addition, the location between thumb and index finger can be squeezed with high precision to generate additional information.

Pressure-sensitive dual-surface interaction opens up a large design space of rich interactions of which we offer an early demonstration.

RELATED WORK

Gummi [4] uses bending to control transitions between views, transparency, and zooming. In our setup, such a gradual control can be achieved by applying different amounts of pressure on the device. HybridTouch [6] uses a touchscreen in the front and a touchpad in the back of a device. LucidTouch [7] is a two-sided multitouch input device which reduces visual occlusion by emphasizing behind-the-back interactions. Shen et al. [5] propose a two-sided multitouch interaction device and describe related

UIST'09, October 4–7, 2009, Victoria, BC, Canada.

gestures. In contrast to our work they do not use pressure as an input parameter and thus require an additional mechanism for object selection. The idea of using pressure for embodied interaction with devices has been formulated some time ago [1]. To incorporate precise pressure input in standard interactions Ramos et al. developed *pressure widgets* [3]. These are continuous pressure-sensing GUI elements which are operated with a stylus. ShapeTouch [8] uses the contact shape of hands on multitouch surfaces to directly control objects. ShapeTouch infers contact forces from the size of contact regions. Our prototype would support this approach to controlling objects and additionally can measure contact forces directly.

INTERACTION CONCEPT

Our prototype offers front and back 2D touch coordinates for up to five fingers on each side, and four pressure values associated with each corner of the device at update rates of 50Hz. This allows for a range of interaction concepts, including direct touch interactions on 2D and 3D objects as well as widget-based interactions.

We demonstrate real-time interactions with 3D objects using two-sided pressure interactions, allowing for intuitive rotation, scaling and translation with opposing-thumb grabbing and rolling actions on the device.

We also demonstrate early examples of squeezable widgets which we call "squidgets," that combine the information provided by pressure widgets [3], with the high degree-of-freedom of local two-sided interactions such as local rotations and two-sided sliding.

Since our prototype affords two-handed interactions we can even support interactions that are impossible with traditional one-sided touch input. For example, a user might grab a deformable object with one hand and twist or bend it with the other hand. This requires a model of the physical properties of the object and is planned for future work.

PROTOTYPE HARDWARE AND SOFTWARE

The design goal was to provide two-sided interactions with pressure information. In principle this can be achieved by an array of different sensing technologies. For our prototype we use two iPhones placed back-to-back as a platform to provide multitouch capabilities both in the front and the back of the device. In order to provide pressure information we placed four force-sensing resistors (FSRs) between the two iPhones. This offers some directionality for the pressure information. The sensors are arranged in a rectangular pattern: One near each corner of the device.

Retaining good sensitivity of the force-sensing resistors was the main difficulty in the prototype design. We build various versions of this layout experimenting with various gluing, plastic and elastic materials. We found that in order to get the full dynamic range of the force-sensing resistors, they should be coupled via elastic material between the phones. A thin acrylic plate was placed and carved to make space for wirings and rigid support for the sensors.

So far we built two iterations of the prototype. The first prototype connected the force-sensing resistors via long wires to an Arduino board. The untethered second prototype instead utilizes break-out connectors directly connected to both iPhones and a small circuit-board carrying an Arduino Nano plus simple voltage dividers for signal conditioning of the FSRs. The Arduino Nano is powered by the iPhones through the breakout connector.

The Arduino board runs software to forward the multitouch events via serial protocol from the back to the front iPhone. Additionally the Arduino inserts the pressure data into the serial data stream at a rate of 50 Hz.

CONCLUSION

This demonstration shows a running prototype of pressure-sensitive two-sided multi-touch mobile device setup. With this setup one can exploit the grabbing ability of opposing thumb and fingers in ways that are akin to natural and familiar manipulations such as grabbing, which is also a good way to apply pressure. Any neighborhood of an interaction point hence offers a number of degrees of freedom allowing for a range of complex interactions being performed locally.

We plan to conduct a full study of the performance of this device in a range of interaction tasks, specifically to compare local interactions on squidgets to earlier proposal in the literature.

REFERENCES

1. B. L. Harrison, K. P. Fishkin, A. Gujar, C. Mochon, and R. Want. Squeeze me, hold me, tilt me! an exploration of manipulative user interfaces. In Proc. of CHI '98, pages 17–24, 1998.

2. C. L. Mackenzie, and T. Iberall The Grasping Hand. Amsterdam: North-Holland Publishing, 1994.

3. G. Ramos, M. Boulos, and R. Balakrishnan. Pressure-widgets. In Proc. of CHI '04, pages 487–494, 2004.

4. C. Schwesig, I. Poupyrev, and E. Mori. Gummi: A bendable computer. In Proc. of CHI '04, pages 263–270, 2004.

5. E.-L. Shen, S.-S. Tsai, H.-H. Chu, J. Hsu, and C.-W. Chen. Double-side multi-touch input for mobile devices. In CHI'09: Work-in-Progress, April 2009.

6. M. Sugimoto and K. Hiroki. Hybridtouch: An intuitive manipulation technique for PDAs using their front and rear surfaces. In Proc. of MobileHCI '06, pages 137–140, 2006.

7. D. Wigdor, C. Forlines, P. Baudisch, J. Barnwell, and C. Shen. Lucid touch: A see-through mobile device. In Proc. of UIST '07, pages 269–278, 2007.

8. C. Xiang, A.D. Wilson, R. Balakrishnan, K. Hinckley, S.E. Hudson. ShapeTouch: Leveraging contact shape on interactive surfaces. In Proc. of TABLETOP'08, pages 139-146, 2008.