EdgeTouch: A Prototype to Explore Offset Pointing

Ian Oakley
Ulsan National Institute of Science and Technology, Ulsan, Korea
ian.r.oakley@gmail.com

ABSTRACT
The touch screen interaction paradigm, currently dominant in mobile devices, begins to fail when very small systems (sub-6cm) are considered. Specifically, "fat fingers", a term referring to the fact that users' extremities physically obstruct their view of screen content and feedback, become particularly problematic. This paper presents a novel hardware prototype that attempts to address this issue based on sensing touches to the edges of a device featuring a front-mounted screen. While rigorous studies of user performance are beyond the scope of the current paper, we believe that the system, and interaction concepts it enables, represents a valuable stand-alone contribution.

Author Keywords
Touch, Pointing, Mobile Devices, Edge Interaction.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Technological advances are enabling us to embed more and more computational power into smaller and smaller packages. This is valuable and, indeed, very small devices (e.g. with dimensions of around six cm and below [1]) have already opened up new application areas in the domains of mobile and wearable computing. These include systems that support unobtrusive health monitoring (www.fitbit.com), tangible gaming (www.sifteo.com) or serve as fully-fledged mobile media or communication devices (www.imwatch.it) or remotes that interface with such tools. The motivations for, and benefits of, miniaturization are substantial and include wearability, portability, comfort and aesthetics.

However, interaction with small devices presents novel challenges. Most prototypes currently take the form of flat slabs sporting touch-screens [e.g. 2], a practical setup also used in larger devices such as smartphones. Although sophisticated display technology allows such systems to provide high-resolution and expressive output despite their diminutive dimensions, standard touch-screen interaction techniques do not scale-down so well [3]. A key reason for this is fat-finger problem [4], a phrase referring to the fact that touching an interactive screen inevitably obscures the targeted content, lowering selection accuracy and hiding graphical feedback. A lack of screen real estate also means that effective solutions to this problem on larger devices, such as providing offset graphical cues [6] are rendered ineffective on very small systems.

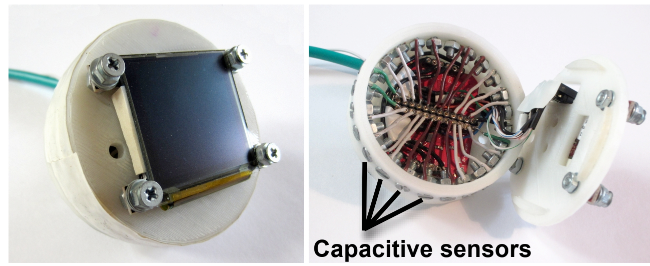

Figure 1. Two views of the EdgeTouch prototype, showing the top mounted OLED screen and the ring of 24 metallic capacitive sensors around the (vertical) edge of the device.

Inspired by everyday tools such as watches, this paper introduces a novel solution to the problem of interacting with small devices based around incorporating an array of touch sensors into the edge of a system with a front-mounted screen. As it is offset, touches to such a sensor system inherently avoid obscuring content on the screen. This short paper describes EdgeTouch (see Figure 1), a prototype system that realizes this functionality and briefly discusses its implications.

EDGETOUCH SYSTEM

EdgeTouch Hardware Prototype
The EdgeTouch prototype is shown in Figure 1. It is a 3D printed hollow disc with a removable lid, 1.8 cm in height, 6 cm in diameter and with a resultant circumference of 18.85 cm. A 2.7 cm square full color OLED screen with a resolution of 128 by 128 pixels (a 4DSystems µOLED-128-G1) was secured to the center of the lid using M3 bolts through integrated fixtures; it sat proud from the surface by 7 mm. The screen features an on-board graphics processor that can be controlled remotely via commands delivered over an RS232 serial link and is capable of rendering limited amounts of text and simple graphical primitives to the screen in real time. Although the screen is square, a disc shaped housing was chosen to ensure a one-to-one mapping between touches to the edge of the unit and positions on a circular region around the center of the screen.

Capacitive sensing was implemented with two Sparkfun breakout boards featuring the MPR121 capacitive sensing microprocessor from Freescale. These were fully enclosed within the prototype. Each three-by-two cm board has the ability to read 12 individual binary sensors and features inbuilt auto-calibration functionality that optimizes sensing parameters on power-up. The 24 sensing electrodes were positioned in holes situated equidistantly (e.g. with a 7.8 mm inter-sensor spacing) around the mid-point of the rim of the disc. They took the form of simple eight mm M3 bolts (five mm head diameter) secured to the plastic shell by nuts and wired directly to the jumper points on the two MPR121 boards. The bolts were screwed as flush as possible to the surface of the disc and, in order to provide a smoother texture, a layer of electrical tape was also wound around the rim of the device. The MPR121 sensor boards communicate using the I2C protocol. Figure 1 (right) shows the internals of this hardware setup; the ultimate dimensions of the device were selected to minimize size while robustly enclosing all elements of the sensing and display hardware.

A remotely situated Arduino Mega 1280 interfaced with the sensing and display hardware and communicated, via a second RS232 serial link, to a host PC as and when required. In order to minimize latency, most computation took place on the Arduino and the link to the PC was used primarily to log data and issue high-level commands. The Arduino polled the sensor boards 100 times a second and distributed commands to screen sporadically and in response to feedback requirements and application logic.

EdgeTouch Sensor Software

EdgeTouch features 24 binary individual sensors; these were interpolated to create a total of 48 uniquely touchable locations – if two adjacent sensors were simultaneously active, a touch was recorded at the mid-point, leading to a uniquely identifiable location every 7.5 degrees (or 3.9 mm). The sensor data was also processed to more reliably identify individual touches. Essentially, small blocks of adjacently selected sensor locations (1-3) were resolved to a single central touch while larger blocks (4-7) were treated as two touches and still larger blocks simply ignored. All detected touches were marked as small round brightly colored cursors drawn on the edge of a 2.7 cm diameter circle centered at the midpoint of the screen and device. The rim of this circle was always 1.65 cm distant from touches made on the rim of the EdgeTouch device; see Figure 2 for examples of this feedback. Finally, in order to provide a more consistent experience during touches that involved movement on the device surface, changing patterns of sensor activation were processed and cursors that animated smoothly to match such dynamic, persistent touches were presented to users. This tracking process led to a small latency (approximately 100ms) in the accuracy of the cursor positions rendered on the screen.

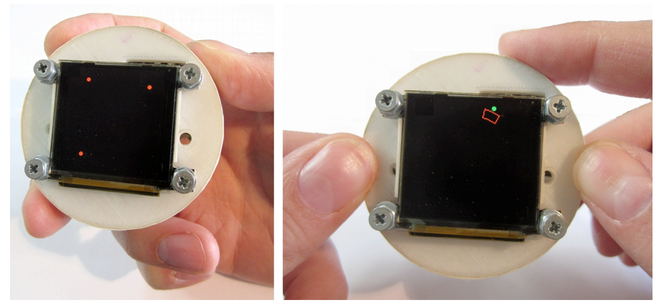

Figure 2. Three finger grip on the Edgetouch showing red cursors (left). An example interaction technique showing selection of a target (a hollow red polygon). The green cursor marks the position of the right index finger.

DISCUSSION AND CONCLUSIONS

In summary, this paper introduced the idea of using touches to the edge of a small mobile or wearable device as a general purpose input technique. This notion is inspired by the longstanding placement of, for example, watch buttons in analogous locations and aims to confer similar benefits: ready physical access, clear mappings between touches and displayed content and uninterrupted visibility of the device screen. A hardware prototype realizing this idea was built. Future work will focus on improving the hardware and exploring and evaluating interactions on the device. Particular areas of interest will include gestures, strokes, multi-touch input and an investigation of how pose, the way the device is held [5], can inform application behavior. Ultimately, we believe that the kind of offset touches proposed in this paper will be a useful tool supporting rich interactions on very small mobile and wearable computers.

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