BrailleTouch: Designing a Mobile Eyes-Free Soft Keyboard

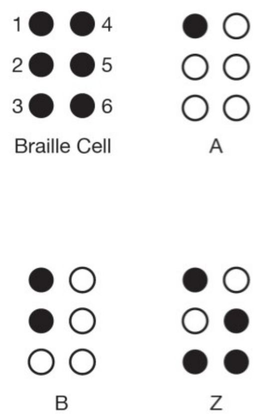

Figure 1. Definition of the 3 by 2 Braille Cell and sample characters, A, B, and Z.

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Abstract
Texting is the essence of mobile communication and connectivity, as evidenced by today's teenagers, tomorrow's workforce. Fifty-four percent of American teens contact each other daily by texting, as compared to face-to-face (33%) and talking on the phone (30%) according to the Pew Research Center's Internet & American Life Project, 2010. Arguably, today's technologies support mobile text input poorly, primarily due to the size constraints of mobile devices. This is the case for everyone, but it is particularly relevant to the visually impaired. According to the World Health Organization, 284 million people are visually impaired worldwide. In order to connect these users to the global mobile community, we need to design effective and efficient methods for eyes-free text input on mobile devices. Furthermore, everyone would benefit from effective mobile texting for safety and speed. This design brief presents BrailleTouch, our working prototype solution for eyes-free mobile text input.

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Keywords
Mobile computing, HCI, eyes-free, accessibility, Braille, soft keyboard, multi-touch, touch screen, text entry.

Introduction
Currently, there are 5.28 billion cellular subscriptions worldwide, according to the International Telecommunication Union, October 2010. Of these, 3.8 billion cell phone subscriptions are in the developing world and 1.4 billion are in developed nations. Taken together with the fact that 90% of the world's visually impaired people live in developing nations (WHO 2010), it is a moral imperative to design an accessible interface for effective mobile eyes-free text input.

BrailleTouch explores the use of Braille for eyes-free text input on touch screen mobile devices. The Braille code consists of a 3 by 2 binary matrix that encodes up to 63 characters, excluding the state with no dots (Fig.1). In English Braille, a single combination encodes

Figure 2. Mechanical Perkins Braillewriter introduced in 1939.

Figure 3. Electronic Refreshabraille 18 c.2009.

Mobile Braillewriters	$(USD)
GalaTee	400
EasyLink	1000
Nano	1000
Maestro	1300
Braille+ Mobile Mngr	1400
PACMate BX400	1500
Refreshabraille 18	1700
VoiceNote BT	1900
Voice Sense	2000
Braille Sense Plus	6000

Table 1. List of mobile Braillewriters.

one character. For example, position 1 (upper left) encodes the letter "A", while positions 1 and 2 together (upper and middle left) encode the letter "B". Braille code now exists for most languages, including English, Japanese, and French. While there are no published rigorous statistics for Braille typing performance, Jude Jonas, head engineer at Perkins Products, reports that users of traditional Braillewriters achieve 3 to 7 chords per second or approximately 36 to 84 wpm.

It is important to distinguish writing from reading. Braille reading involves the tactile perception of raised dots. Braille writing, by comparison, is much simpler and easier to learn. Mechanical Braillewriters, such as the Perkins Brailler (Fig. 2), exist since the 1890s, and electronic Braille keyboards are now available (Fig. 3). These devices feature six main buttons, one for each dot in the Braille cell. To type Braille on these chorded keyboards, the user presses multiple buttons at the same time. While text-to-speech technologies have been supplanting Braille reading for a number of years and some research indicates that Braille reading rates may be dropping, Braille writing rates may be climbing due to the lack of options for eyes-free mobile text input. Although mobile electronic Braille keyboards are available for the Visually Impaired, these specialized devices are expensive (Table 1).

Background

There are a number of hardware and software solutions for texting on mobile phones. Simply put, they all have too many buttons for the restricted size of the devices. Hardware keyboards, such as T9 and mini-QUERTY, have some physical affordances for eyes-free texting as they provide tactile and audible feedback. Unfortunately, these keyboards have up to four times as many buttons as we have fingers and they are too small to fit a finger without looking at the keys. Moreover, they are subject to mechanical wear and tear and have limited adaptability. Typically, users need to see the keyboard for input, which is both inefficient and dangerous.

Software keyboards, by contrast, are adaptable. Each key's location, orientation, size, label, and function can be programmatically changed. Unfortunately, these keyboards do not provide tactile affordances or feedback for eyes-free typing. In current devices, the most common use of soft keyboards is to type with both thumbs, significantly lowering the potential texting throughput and forcing the user to constantly look at the screen and hunt and peck for keys.

Voice recognition (VR) offers another alternative for text input. While it works eyes-free, hands-free, and naturally, VR has some fundamental drawbacks. It is not appropriate to talk in all possible contexts and the user has no privacy. There are also a number of practical challenges to voice recognition, including noisy environments and individual accents and intonations.

Problem Statement

Our design goal is to produce an efficient text input system that fits on space-constrained mobile devices and can be effectively operated eyes-free. Our design should work on existing out-of-the-box commodity hardware, with no modifications or external accessories required. Cost should be minimal, as compared with the total cost of the mobile hardware. The text input system should not incur significant drain on processor or battery resources. It should adhere to the form factor and ergonomics of existing mobile devices. Our

Figure 4. Fixed keyboard layout: iPod Touch Prototype of BrailleTouch.

Figure 5. Adaptive keyboard layout: iPad Prototype of BrailleTouch.

system should be easy to learn and provide users with a positive out-of-the-box experience.

Design Solutions

Fixed keyboard layout: iPod Touch Prototype
BrailleTouch is an eyes-free text entry technology for touch screens. It is a Braille soft keyboard prototyped as an application on an iPod Touch and an iPad (Fig. 4). The key feature of the technology is that it has fewer buttons than fingers. Thus, on the iPod Touch, the user does not have to move the fingers around to find the correct sequences and combinations to type. Once placed, the fingers remain in the same position. This is crucial for eyes-free text input on a smooth surface, like a touch screen or a touch pad. Simply stated, BrailleTouch allows touch-typing on a touch screen.

Users hold BrailleTouch with the screen facing away from them with two hands. They arrange their fingers in a one-to-one correspondence to a standard Braillewriter. Concretely stated, the left index goes over key 1, the left middle finger, over key 2, and so on. Some hold it with their pinkies, their thumbs, and cradle the device in their fingers; others grasp it with the balls of their hands or even their palms (Fig. 4).

The six buttons on BrailleTouch spatially correspond to the mental map of the six cells in a Braille character as well as to the placement of the six fingers. As the user types, BrailleTouch provides audio feedback for each selected character (see video figure).

Adaptive keyboard layout: iPad Prototype
We have also implemented a prototype of our BrailleTouch design on the Apple iPad (Fig. 5). Due to the increased screen real estate available on the iPad, we are able to offer a linear six-button layout that is comparable to the industry standard Braille physical keyboards, such as the Perkins Brailler. In this version, we also implement an adaptive Braille keyboard. The user can issue a special command (a six-finger double tap gesture) that will reset the six soft button positions for each input key (see video). This adaptive feature is important for successful eyes-free operation of a touch screen. Rather than searching for six fixed button locations on the screen, the user is able to self-define a comfortable position for each button, without the need to ever look at the screen. In future design iterations, we plan to add the adaptive soft keyboard technology to the iPod Touch version as well, where we expect it to offer performance and accuracy improvements as well.

Conclusion and Future work

We have presented BrailleTouch, an eyes-free text entry application for mobile devices. BrailleTouch, as an assistive technology for the visually impaired, offers cost and performance advantages over current technology. In addition, BrailleTouch can be incorporated into existing commodity mobile touch screen devices, such as the iPhone and Android smart phones. We are currently designing a study to formally evaluate BrailleTouch through both quantitative and qualitative methods. We will measure the typing speed and accuracy of visually impaired users, and capture the feedback from study participants in areas such as comfort, ease of use, and perceived value. Furthermore, we will explore the use of BrailleTouch by sighted users, as a universal eyes-free mobile text input technology to be used in place of soft QWERTY keyboards, Graffiti, and other current mobile text input technologies.