BrailleTouch:
Mobile Texting for the Visually Impaired

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Abstract. BrailleTouch is an eyes-free text entry application for mobile devices. Currently, there exist a number of hardware and software solutions for eyes-free text entry. Unfortunately, the hardware solutions are expensive and the software solutions do not offer adequate performance. BrailleTouch bridges this gap. We present our design rationale and our explorative evaluation of BrailleTouch with HCI experts and visually impaired users.

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

1 Introduction

Eyes-free text entry has long been a goal of academic researchers in the arena of mobile computing, especially in the field of wearable computing [1]. In this paper, we focus on visually impaired users, whose real needs for eyes-free text input go beyond academics. For the visually impaired, eyes-free text entry is a pervasive need, especially when using mobile computing devices. Current solutions are compelling but have significant drawbacks. On the one hand, there are several special-purpose and expensive ($400 - $6000) hardware solutions available for eyes-free mobile texting (see table 1). While these hardware solutions interface relatively seamlessly with other mobile devices via Bluetooth, they still present the user with an additional item to carry, with its own expense, batteries, and setup time. This option is expensive and cumbersome enough to dissuade some members of the visually impaired community from participating in the use of mobile computing devices. One visually impaired subject we interviewed reported that she tends to not engage in mobile technology, even though much of her time "is spent waiting on others" in various places.

On the other hand, many software solutions for mobile eyes-free text entry are cheaper than the hardware alternatives. One example is Apple's VoiceOver, which comes standard with their latest generation of mobile products including the iPhone 4 ($200 with plan). Unfortunately, at 0.66 words per minute (wpm), its typing speed is impractical [2].

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Table 1. The table lists various hardware solutions for Braille text entry sorted by price in USD. The optional Braille display is typically a matrix of pneumatic pins that pop up to encode a Braille character for tactile output.

Device Name	Braille Display	Price $(USD)
Braille Sense Plus	Yes	6000
Voice Sense	No	2000
VoiceNote BT	No	1900
Refreshabraille 18	Yes	1700
PAC Mate BX 400	No	1500
Braille+ Mobile Manager	No	1400
Maestro	No	1300
Nano	No	1000
EasyLink & Pocketwrite	No	1000
GalaTee	No	400

2 Related Work

Bonner, Brudvik et al. recently developed a system called No-Look Notes [2]. No-Look-Notes is a soft keyboard for eyes-free texting on a touch screen. The interface divides the screen into eight wedge shapes, as opposed to 26 or more on a QWERTY keyboard. The eight wedges equally utilize the full screen of the phone, dividing it into eight radial segments. Users enter text through two-finger interaction, where one finger finds the appropriate wedge and the second finger manipulates a scroll window to find a letter in the group. The device provides speech feedback. No-Look Notes showed a marked improvement in input speed, error rate, and positive feedback from the participants as compared with the current accessibility application from Apple, VoiceOver. Visually impaired users were able to input an average of 1.32 wpm with No-Look Notes, as compared to 0.66 wpm with VoiceOver.

Castellucci and MacKenzie of York University evaluated and compared Graffiti against Unistrokes, which are two different stylus-based (or potentially finger-based) text entry technologies for touch screens [3]. Graffiti, so named because it closely resembles the handwritten Latin alphabet, was far easier for novices to become familiar with. Unlike Graffiti, Unistrokes does not closely resemble the Latin alphabet. Its design maps simple gestures into characters. Unistrokes, once mastered, showed consistently better results in both wpm and error rate. Both input technologies started at about 4 wpm, with Graffiti reaching just over 12 wpm and Unistrokes reaching just below 16 wpm over the course of 20 sessions. Castellucci and MacKenzie also report that the correction rates remained steady for Graffiti, while they dropped from 43.4% to 16.3% for Unistrokes.

Slide Rule was created by Kane, Bigham, and Wobbrock at the University of Washington’s DUB group [4]. It was accepted and presented at ASSETS 2008. Slide Rule is a system for general operation of a touch screen mobile device by the visually impaired, with applications that include playing music and navigating through menus. While greatly increasing accessibility in some areas, Slide Rule continues to use a QWERTY soft keyboard, a standard keyboard visually rendered on the screen, for text entry. Kane’s paper recognizes the shortcomings of this type of interaction for the visually impaired and mentions that a chorded, multi-touch input technology, like No-Look-Notes or a Braille chorded input system, are areas for future research.

2.2 The Braille Code

Braille is a 3 by 2 binary matrix that encodes up to 63 characters, not counting the all-null state, which is when no dots are present ($63 = 2^6-1$). In English Braille, a single matrix combination encodes one character. For example, position 1 (upper left) encodes the letter “A”, while positions 1 and 4 together (upper left and upper right) represent the letter “C” (see Figure 1) [5]. This code progresses in a logical and expanding pattern of neighborhoods that include landmarks that serve as mnemonic devices. For instance, the letters “A” through “J” only reside in the top four positions. The letters “K” through “T” add a dot on the third row (lower left) and repeat the same pattern of the first 10 letters. At “U” the pattern repeats itself with the addition of position six (lower right). Note that the patterns of the first two rows of a Braille cell repeat every 10 letters. For example, “A”, “K”, and “U” have identical first two rows, as do “B”, “L”, and “V”. The letter “W” does not follow this pattern because it doesn’t exist in Braille’s native French and was added after the system was created. Thus, “X”, “Y”, and “Z” share the patterns of the first two rows of “C”, “D”, and “E”. These and other landmarks help users learn Braille. There are special sequences to type capital letters, numbers, and punctuation marks.

Louis Braille, who was blinded at age three, developed and then published this writing system in 1829. Braille was inspired by a system of communication called Night Writing that was developed for French artillery personnel during the Napoleonic Wars [6]. This tactile communication code was a 2x6 matrix of dots which represented sounds instead of letters. Braille’s version improved upon Night Writing by not only conveying letters instead of sounds, but also by using the binary code more efficiently [7]. The Braille code now exists for many languages, including English, Japanese, Hebrew, and French. There are also Braille codes for musical and mathematical notations.

Braille is an efficient encoding system that allows users to type with reasonable speed and accuracy. Unfortunately, it is extremely difficult to find rigorous statistics of its typing performance. Consequently, we resorted to interviewing people in the industry. According to Jude Jonas, head engineer at Perkins Products, users of traditional Braillewriters achieve 3 to 7 keystrokes per second, which roughly converts to 36 to 84 words per minute [8, 9]. This is well within the range of traditional full-sized QWERTY keyboards, where expert users can reach speeds of 70 –100 wpm [10].

For over one hundred years, new technologies have brought Braille literacy to the visually impaired community. In 1892, Frank Hall invented a Braillewriter that functioned in a similar manner to a typewriter. In current times, Braille reading may be in decline because of the great success of text-to-speech software solutions. On the other hand, given that there are few alternatives for the visually impaired to input text on a mobile device, Braille typing may be on the rise.

Although only 16% of the visually impaired in the US today are fluent readers of Braille, there are three reasons we believe our BrailleTouch text entry system will be successful in the visually impaired population [11]. First, based on observations and communications with members of the visually impaired community, especially Braille instructors, writing Braille is considerably easier and more pervasive than Braille reading within the population. Second, members of the population who are already fluent in touch-typing on a Braille keyboard can easily translate this skill for use on the BrailleTouch device, as the mapping of fingers to the primary six keys is the same on both devices. Third, the population that is not fluent in typing on a Braille keyboard may easily use the audio feedback feature of BrailleTouch to become fluent.

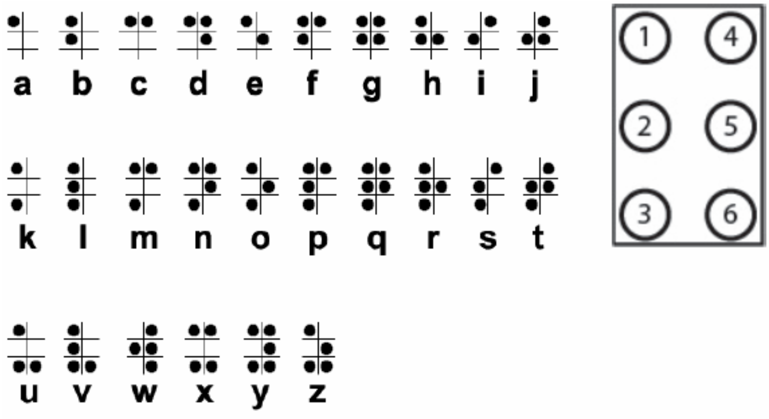

Fig. 1. English Braille and the number labelling of each cell

3 Design of BrailleTouch

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. The key aspect of the technology is that it has fewer buttons than fingers. Thus, 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.

The iPod prototype includes an ergonomic case to help the user hold the device and position the fingers on the keys. Users hold BrailleTouch with two hands, and use their fingers in a layout and functionality with a one-to-one correspondence to a Braille writer. Concretely stated, the left index goes over key 1, the left middle finger, over key 2, and so on. Users hold the device with the screen facing away from them. Some hold it with their pinkies, their thumbs, and cradle the device in their fingers (see Figure 2); others grasp it with the balls of their hands or even their palms.

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 (see Figure 3). As the user types, BrailleTouch provides audio feedback for each selected character.

Fig. 2. BrailleTouch's back faces the user

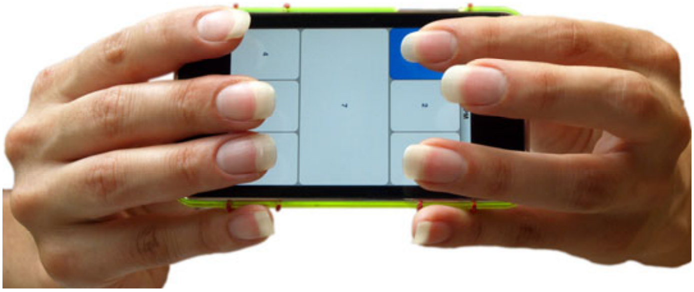

Fig. 3. BrailleTouch's input surface faces away from the user

It is important to point out a caveat to the design of BrailleTouch. A traditional Braille typewriter has extra keys including a space bar and a backspace key. We implemented a large central button for the space bar, and we coded the backspace button to be a combination of button 6 and the space bar (see Figure 3).

4 Evaluation

Several experts in the field of usability have examined BrailleTouch. The most consistent feedback was to change the case in a way to better guide users to the proper position for operation, with the screen facing away from them. This is important because for most individuals, even the visually impaired, the natural inclination is to hold the device with the screen facing toward them. Two visually impaired users also provided feedback on BrailleTouch. One person was fluent in Braille, while the other claimed only a slight ability. Within a few minutes, both people were able to successfully operate BrailleTouch. The person fluent in Braille confirmed that, with practice, BrailleTouch would be as quick and easy to use as the Braille input device he uses every day, a model similar to a Refreshabraille 18, which retails for approximately $1700. During the interview, the authors were able to observe how the visually impaired use Braille input devices, which resulted in several additional improvements to the case design.

These user interviews, along with the comments from one of the usability experts, encouraged us to further explore the potential of BrailleTouch as a teaching tool. We interviewed two visually impaired Braille instructors. Both felt that this device has strong potential in this area. One likened it to a device called Braille and Speak, which was from the era of the child's toy Speak and Spell [12]. This instructor also expressed excitement about BrailleTouch and encouraged us to fully implement the device as quickly as possible. Both instructors participated in non-logged bench tests. They were able to input text at rates quick enough to cause the verbal feedback to vocalize letters consecutively. Since most sound files we used for the letters of the alphabet are a quarter of a second in length, this roughly translates to 30 to 50 words per minute.

We also received information that dispelled some of our assumptions on how the members of the visually impaired community interact with their world. One vital new piece of information concerned the case design. In the original version (see figure 2) there are raised lines and tactile Braille characters on the back of the case, which faces the user. Our purpose for this design was to provide the user with a mental map of what is occurring on the front. After several awkward attempts to read the back of the case, our initial interviewees explained to us that they don't use their thumbs to read Braille. The skin on the thumb is too thick to be sensitive enough to read. In a future version, we will change the case in favor of a comfortable and high grip surface. We may place some markers on the front of the case or on a screen protector to allow the indices to read clearly without interfering with the interaction with the touch screen.

5 Conclusion

We have demonstrated BrailleTouch, an eyes-free text entry application for mobile devices. BrailleTouch, as an assistive technology for the visually impaired, offers advantages over comparable technology that is currently available. Compared with existing solutions available today, BrailleTouch has the potential to be considerably less expensive than the hardware options, while offering superior performance to the software options. In addition, BrailleTouch technology can be incorporated into existing mobile touch screen devices, such as the iPhone and Android smart phones, so that the user does not need to carry an additional piece of hardware while on the go.

6 Future Work

We are currently designing a study to formally evaluate BrailleTouch through both quantitative and qualitative methods. In this study, we will measure the typing speed and accuracy of visually impaired users operating this device. We will also capture the feedback from study participants in areas such as comfort, ease of use, and perceived value. Our previous feedback from Braille instructors has inspired us to also evaluate the utility of BrailleTouch as a teaching tool, through interactive games as well as traditional Braille instruction methods. 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 methods.

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