International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 - 5161

General Article

Brailler: Enabling the visually impaired to use smartphones

Vinay Harish Gaba[Á*], Dhaval Desai[Á], Archit Desai[Á] and Sanjay Kumar Pandey[Á]

[Á]Information Technology, Thadomal Shahani Engineering College, Mumbai, India.

Accepted 12 Oct 2014, Available online 20 Oct 2014, **Vol.4, No.5 (Oct 2014)**

Abstract

With the increase in the number of smartphone users, it is increasingly important to make the smartphones accessible everyone. Most smartphone have a touchscreen interface, which makes it even more difficult for the visually impaired to use it since it does not provide tactile feedback. According to the World Health Organization (WHO), 284 million people are visually impaired worldwide. It is very important that we make it easier for such a huge population of the world to be using their smartphone devices just like any other user. This paper presents a working prototype solution for enabling the visually impaired to use smartphones.

Keywords: *Mobile computing, Blindness, Human Computer Interaction, Braille.*

1. Introduction

Long are the days where mobile phones were considered a luxury, as they are now an integral part of our daily lives. Progressively more powerful, these devices allow an ever growing set of functionalities, meant not only for communication purposes, but also for productivity and leisure. Even though they are becoming increasingly ubiquitous, they are still far from being accessible to everyone. Disabled target groups, such as blind people, still struggle with these visually demanding devices.

The emergence and success of touch screen devices, which are gradually replacing the traditional keypad ones, can pose a daunting future to the blind, as several challenges arise. Interaction with touch screens is even more demanding from a visual standpoint, as familiar and more easily identifiable input methods, such as keyboards, are replaced by their virtual onscreen counterparts. The lack of tactile feedback and the physical stability offered by keypads can turn selection of targets much harder, or even render the blind user virtually lost. Besides the fact that these devices are usually devoid of physical buttons, the interface is constantly changing from screen to screen, depending of context, making it hard to navigate and access the desired content.

The aforementioned problems make touch screen text-entry a major challenge for a blind person. Several single-touch, as well as multi-touch solutions, based on hitting targets, gestures or a combination of both have been proposed to address this problem.

In light of these problems, we present Brailler, a single-touch text-entry system for touch screen devices. Brailler allows the blind user to enter text as if he was writing Braille using the traditional 6-dot matrix code. The Braille system is simple yet powerful, as any character, including accentuated letters, can be made through the combination of six or less dots. Brailler takes advantage of this knowledge to allow the user to input text, resorting to a single screen composed of 6 targets representing the Braille matrix.

2. Motivation

The emergence and success of touch screen devices, which are gradually replacing the traditional keypad ones, can pose a daunting future to the blind, as several challenges arise. Interaction with touch screens is even more demanding from a visual standpoint, as familiar and more easily identifiable input methods, such as keyboards, are replaced by their virtual onscreen counterparts. The lack of tactile feedback and the physical stability offered by keypads can turn selection of targets much harder, or even render the blind user virtually lost. Besides the fact that these devices are usually devoid of physical buttons, the interface is constantly changing from screen to screen, depending of context, making it hard to navigate and access the desired content.

In light of the problems faced by the visually impaired, we present Brailler, a single-touch text-entry system for touch screen devices. Brailler allows the blind user to enter text as if he was writing Braille using the traditional 6-dot matrix code. The Braille system is simple yet powerful, as any character, including accentuated letters, can be made through the combination of six or less dots. Brailler takes advantage of this knowledge to allow the user to input text, resorting to a single screen composed of 6 targets representing the Braille matrix.

The accessibility to smart phone devices by visually impaired users has recently significantly improved. This was obtained by adopting an interaction paradigm that

---

*Corresponding author: **Vinay Harish Gaba** couples the touch screen with a speech synthesizer: in a nutshell, the visually impaired user can touch the screen to explore the interface, and can touch twice to activate an interface object (e.g., by touching an icon twice, the corresponding application is run). As a result of these improvements, most of the applications developed for sighted users can also be used by the visually impaired.

Despite these achievements, there are still some operations that require a longer time or higher mental workload to be completed by a visually impaired user. Our goal is to provide the visually impaired community with additional, alternate interaction techniques and devices that will fit in with the main stream model. Since Braille is in wide use by blind people, we have created a novel way to present Braille on standard mobile phones using touch-screen and vibration capabilities. This is a great opportunity to come up with new mobile interaction methods and include the users in the design process.

3. Existing Technologies

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. 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 Voice Over, which comes standard with their latest generation of mobile products including the I-Phone 4 ($200 with plan). Unfortunately, at 0.66 words per minute (wpm), it is impractical.

Table 1 Comparing existing solutions

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

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.

Work Bonner, Burdick et al. recently developed a system called No-Look Notes. 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, Voice Over. Visually impaired users were able to input an average of 1.32 wpm with No-Look Notes, as compared to 0.66 wpm with Voice Over 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. 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, Brigham, and Wobbrock at the University of Washington's DUB group. 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 Braille chorded input system, are areas for future research.

Yfantidis and Evreinov developed an interface based on simple unidirectional single-finger gestures, regardless of position, to select characters.

Although this method eliminates the need to search for targets, it is very dependent on the gesture-finger orientation, which can become troublesome since there is not a standard way to hold devices and maintain orientation as it was envisioned. Apple's VoiceOver1 text-entry solution, relies on a soft keyboard in which the users focus the desired key by touching it, and enters it by split-tapping or double tapping anywhere. On the strong side, it enables the blind user to input text similarly to a sighted person with a simple screen reading approach. On the other hand, Voice Over typically uses a QWERTY soft keyboard layout, hence it features a large number of targets, making it difficult to find a specific letter especially if the user is not familiar with computer keyboards. In a similar fashion, Bonner et al. system No-Look Notes also uses targets and selection through multi-touch techniques like split-tapping. However No-Look Notes minimizes the number of targets on screen by dividing it into eight sectors containing groups of characters, just like the standard 12-key phone keypad. Split-tapping one of these segments brings another screen, with the corresponding letters arranged in new segments, for the user to select the same way he did previously. This solution improves on some of Voice Over's problems, but still presents users with an unfamiliar and inconsistent layout, changing from a circular pie menu layout in the character group screen, to a vertical list in the character selection screen. Furthermore, the use of split-tapping among other gestures, as simple as they are, can be quite difficult to people with dexterity and coordination problems.

4. Braille Script

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 = 26-1). 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 Fig. 1).

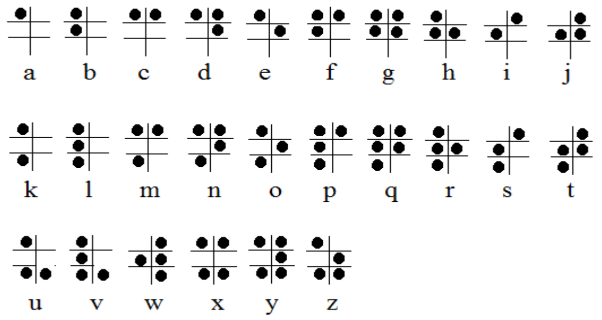

Fig.1 English to Braille Script Mapping

This code progresses in a logical and expanding pattern of neighbourhoods 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. Braille was inspired by a system of communication called Night Writing that was developed for French artillery personnel during the Napoleonic Wars. 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.

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. Users of traditional Braille writers achieve 3 to 7 keystrokes per second, which roughly converts to 36 to 84 words per minute. This is well within the range of traditional full-sized QWERTY keyboards, where expert users can reach speeds of 70 – 100 wpm.

The application interface is based on simple unidirectional single-finger gestures, regardless of position, to select characters. Although this method eliminates the need to search for targets, it is very dependent on the gesture-finger orientation, which can become troublesome since there is not a standard way to hold devices and maintain orientation as it was envisioned. Apple's VoiceOver1 text-entry solution, relies on a soft keyboard in which the users focus the desired key by touching it, and enters it by split-tapping or double tapping anywhere. On the strong side, it enables the blind user to input text similarly to a sighted person with a simple screen reading approach.

On the other hand, Voiceover typically uses a QWERTY soft keyboard layout, hence it features a large number of targets, making it difficult to find a specific letter especially if the user is not familiar with computer keyboards. Furthermore, the use of split-tapping among other gestures, as simple as they are, can be quite difficult to people with dexterity and coordination problems.

5. Proposed System

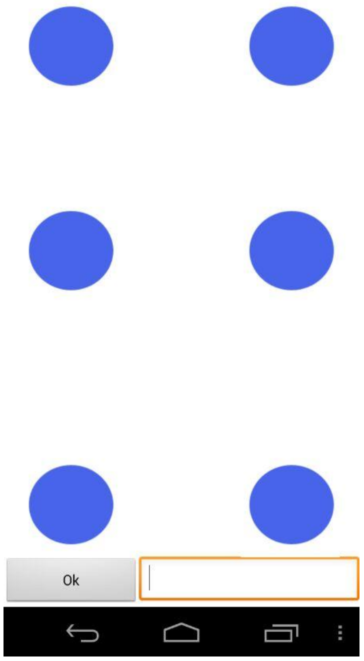

Fig.2 Braille Text Input Screen in Brailler app

Brailler will allow the visually impaired to use Braille and gestures for using their smartphones. The user needs to select dots depending on which character the user wants to enter, as different characters are represented by different combinations of dots arranged in the 3 X 2 Matrix form. Once selection is done the user confirms by pressing an OK button after which the character will be read so as to inform the user, thus acting as an acknowledgement after which user can do the following: Send a Text message, Search Contacts List and Make a call or Chat with a friend using Braille as input method.

There is also one more pain point that we had to address. The pain point is that since it is an app built on top of the existing Android platform, how will a visually impaired user find/open the app? To address this issue, we are using Broadcast Intents which starts the application automatically whenever the phone is started. This way, the user does not need to find the mobile application and the application presents itself automatically along with a welcome message. The following features are supported by the system:

A. Making a Phone Call

1) A visually impaired person will be able to make a call using the Braille keypad.
2) The user will enter the number in Braille.
3) Then user has to Double Tap on the screen to setup a call.
4) To disconnect, user will Press the lock or Power button.

B. Text Messaging

1) User will input text using Braille script, with which the visually impaired users are well acquainted.
2) Gestures will also play an important part here.
3) For e.g. - In order to leave a space, user will swipe right, for deleting the previous character, user will swipe left.
4) When the user swipes downwards, the audio mechanism will read the message for user.
5) Also, whenever user enters a character, an audio feedback will be given to him.

C. Music Player

1) Music Player will be accessed by the visually impaired through gestures.
2) For e.g. If he wants to play a song, he will double tap on the screen. If he wants to pause it, then again he will double tap on the screen. If he wants to play the next song, he will swipe left, etc.
3) Also, whenever user enters a character, an audio feedback will be given to him.

D. Battery Information

1) The visually impaired will also be informed about the battery usage.
2) For e.g. - If battery is too low, then he will be informed immediately to charge his phone in order to avoid his smartphone getting discharged.

E. Location

1) As the user will be visually impaired there will often be a need to know the location.
2) Location will be made available on a click in the form of text as well as voice with an error of around 300 meters as we are fetching the location through mobile network and not through GPS which saves battery and makes location available in a closed environment.

F. Date and Time

1) Scheduling the tasks helps planning the things better but for that one needs to have the current status of the time.
2) Our application also allows the user to get information about date and time.
3) On clicking this option, date and time will be conveyed to the user by voice.

G. Network Information

1) This is one of the important features because the actual use of a mobile phone is not justified without network.
2) User will come to know the Network power in terms of percentage which will be helpful in determining whether a call can be made or whether it can text someone successfully.

H. Alarm

1) People used to get up by alarm clocks; now mobile does this work.
2) Almost every person is dependent on its mobile so that one can have a timely start of the day.
3) On setting the alarm according to the 24 hour clock the user will be notified by voice that the alarm is set.

Fig.3 Brailler app main screen

Conclusion

As we move towards a future where touch screen devices threaten to replace their keypad counterparts, an effort to make them accessible to everyone is paramount. Blind people, in particular, have an added difficulty due to the absence of tactile feedback. Available solutions feature unfamiliar layouts, many targets/sub screens and/or multi-touch gestures, which although appear to be simple, can still be quite tricky to accomplish by many people.

Brailler, as an assistive technology for the visually impaired, offers advantages over comparable technology that is currently available. Compared with existing solutions available today, Brailler has the potential to be considerably less expensive than the hardware options, while offering superior performance to the software options. In addition, Brailler does not need to carry an additional piece of hardware while on the go.

Brailler tries to overcome these limitations by featuring a familiar layout, the Braille cell, with few and larger targets. This approach proved to be slower than some other systems. This does not come as a surprise since the presented method requires multiple inputs per character. On the other side, users commit far fewer errors with Brailler. The large number of soft keys along with the difficulty in split-tapping, a keyboard layout with small and close targets, and errors due to involuntarily touching the screen with multiple fingers were the main reasons to this difference. Brailler showed promise by being an easy to comprehend, simple to use, albeit slower, text-entry method. As Braille is being less practiced due to new technologies, Brailler could bridge these two worlds and reach out to people who would normally shy away from these devices due to unfamiliar concepts, while giving others an incentive to use Braille, as it should not be forgotten.

Acknowledgement

We wholeheartedly thank Mr. Sanjay Kumar Pandey, Assistant Professor(Senior Scale),Department of Information Technology, Thadomal Shahani Engineering College, first for letting us choose the project of our interest and secondly, for co-operating with us in every possible manner. He has also provided us with encouragement and he has been the motivational force for us.

We would also like to thank Mr. Arun Kulkarni, Head, Department of Information Technology, Thadomal Shahani Engineering College, for providing us with a wide range of domains to choose our project from.

We would like to thank Mr. G.T.Thampi, Principal, Thadomal Shahani Engineering College, for providing us with the infrastructure and the facilities in the college.

We would also like to thank all the faculty members of Department of IT as well as non-teaching staff of Thadomal Shahani Engineering College, for giving us their valuable time and for being co-operative.

References

Bonner, M., Brudvik, J., Abowd, G. Edwards, K (2010) No-Look Notes: Accessible Eyes-Free Multi-Touch Text Entry, *The Eighth International Conference on Pervasive Computing*, LNCS, vol. 6030, pp. 409--426. Springer, Heidelberg

Kane, S.K., Bigham, J.P., Wobbrock, J.O (2012) Making Mobile Touch Screens Accessible to Blind people using Multi-Touch Interaction Techniques, *Proceedings of the 14th international ACM SIGACCESS Conference on Computers and Accessibility*, pp. 73--80

Yfantidis, G., Evreinov, G. (2010) Adaptive Blind Interaction Technique for Touchscreens, *Universal Access in the Information Society*, 4(4), 328-337.

João Oliveira, Tiago Guerreiro, Hugo Nicolau, Joaquim Jorge, Daniel Gonçalves (2011) BrailleType: Unleashing Braille over Touch Screen Mobile Phones

Southern, C., Clawson, J., Frey, B., Abowd, G., Romero, M (2012) An Evaluation of BrailleTouch: Mobile Touchscreen Text Entry for the Visually Impaired. *Mobile HCI 2012*