BrailleType: Unleashing Braille over Touch Screen Mobile Phones

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Abstract. The emergence of touch screen devices poses a new set of challenges regarding text-entry. These are more obvious when considering blind people, as touch screens lack the tactile feedback they are used to when interacting with devices. The available solutions to enable non-visual text-entry resort to a wide set of targets, complex interaction techniques or unfamiliar layouts. We propose BrailleType, a text-entry method based on the Braille alphabet. BrailleType avoids multi-touch gestures in favor of a more simple single-finger interaction, featuring few and large targets. We performed a user study with fifteen blind subjects, to assess this method's performance against Apple's VoiceOver approach. BrailleType although slower, was significantly easier and less error prone. Results suggest that the target users would have a smoother adaptation to BrailleType than to other more complex methods.

Keywords: Blind, Braille, Mobile Devices, Text-Entry, Touch screens.

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. Yfantidis and Evreinov [4] 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 VoiceOver[1] 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. In a similar fashion, Bonner et al. system No-Look Notes [1], 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 VoiceOver'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.

In light of these problems, we present BrailleType, a single-touch text-entry system for touch screen devices. BrailleType 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. BrailleType 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. This paper details BrailleType as well as its evaluation through a user study with fifteen blind subjects.

2 BrailleType

The Braille system was devised by Louis Braille in 1825 as a method of writing and reading for blind people. Although its use is declining due to the use of electronic text in conjunction with assistive software such as screen readers, it is still a widely used method and paramount to the daily lives of blind people.

Each Braille character or cell is represented by combinations of dots on a 3x2 matrix (Figure 1). There are 63 possible combinations, making it possible to represent alphabet letters, accentuated letters, punctuation, numbers, mathematical symbols or even musical notes.

The use of the Braille alphabet, common knowledge for many blind users, to enter text on a mobile keypad device was already explored by Guerreiro et al. on BrailleTap [2]. In that system, the Braille cell was mapped to different keypad buttons (keys '2',

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[1] http://www.apple.com/accessibility/iphone/vision.html (Last visited on 07/04/2011)

‘3’, ‘5’, ‘6’, ‘8’ and ‘9’ on the mobile phone). Each press on those keys would fill the matrix with the corresponding dots, accepting the character through the press of another button (key ‘4’).

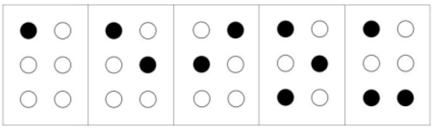

Fig. 1 - From left to right: the vowels: ‘a’, ‘e’, ‘i’, ‘o’, ‘u’ in Braille.

BrailleType comes as an adaptation of this approach to the now widely popular touch screen devices. Herein, the touch screen serves as a representation of the Braille cell, having six large targets representing each of the dots positions. These targets were made large and mapped to the corners and edges of the screen to allow for an easy search (Figure 2). Since they are also arranged accordingly to the known and expected Braille cell, the targets become spatially easy to find.

Fig. 2 - BrailleType main screen on the left (visual representation of the six target zones was added for illustration). Middle screen shows the letter ‘r’ marked and ready to be accepted. The image on the right shows a user writing the letter ‘r’ with BrailleType.

In order to keep this system simple and undemanding, multi-touch techniques were avoided. All interactions with BrailleType are made through single finger input. Whenever a user presses or drags a finger to a new target, the corresponding dot number is audibly announced, but the target is not immediately selected. A small timer was implemented to prevent involuntary selections from the user. This timer can be easily configured, allowing for a more experienced user to decrease or eliminate the waiting time.

To mark a dot in the Braille cell, the user must touch the desired target, and wait for an audio confirmation cue. Repeating the process on a dot already marked, would remove it and inform the user through audio feedback. After marking all the necessary dots for a Braille character, in whichever order the user desires, a double-tap in any part of the screen accepts it. A space is made by entering an empty Braille cell. If the user tries to accept an incorrect combination of dots, the Braille matrix is cleared and an error sound is played.

A swipe to the left clears the Braille cell if one or more dots were already marked or deletes the last entered character if the matrix was empty.

This method seeks to provide a less stressful first approach with touch screen devices by reducing the number of onscreen targets. By reducing the number of errors and enabling the user to succeed, we augment their confidence to go farther. Also, we intend to take advantage of the capabilities of those who use Braille on a regular basis, but also enable those who do not to learn or maintain Braille usage through simple daily interactions (e.g., writing text messages).

3 Evaluation

We conducted a comparative evaluation of BrailleType and VoiceOver with the target population. On two sessions, one for each system, participants first learned how to use both text-entry methods and had the opportunity to interact and practice with them. After this tutorial, participants were asked to write a set of sentences and end the session with a brief questionnaire. Any input made by the users during the evaluation was logged for later analysis. We focused both on the efficiency and effectiveness of the participant's writing, through the analysis of WPM and MSD error rates metrics.

3.1 Participants

Fifteen blind people (light perception at most) were recruited from a formation centre for the visually impaired. The evaluations took place in a quiet office room of this center. The participant group was composed of 10 males and 5 females, with ages ranging from 24 to 68 years old (averaging 45).

With more or less difficulty, the entire target group, with the exception of two subjects, writes text messages on their mobile phones with the help of screen readers. These two participants did not have mobile phones with screen readers and stated that they had never written a text message, restricting the phone use to placing and receiving calls. In terms of touch screen devices, only one user had made contact with this technology previously.

All of the participants knew the Braille alphabet and had had previous contact with a computer keyboard, thus being familiar to some extent with the QWERTY layout.

3.2 Material

For this experimental task we used the Samsung Galaxy S touch screen device, which runs on Google's operating system Android. This device has a 4 inch capacitive touch screen with multi-touch support, and although the screen does not occupy the entire device, since it has upper and bottom non-touch sensitive zones, no tactile upper and bottom boundaries were created.

BrailleType and a text-entry method identical to VoiceOver, in both keyboard layout and interaction methods, were implemented as Android applications. All audio feedback was given using SVOX Classic TTS. An application to manage both text-entry methods, user sessions and sentences required to type was also implemented. This application informed which sentence to type and logged all the participants' interactions (focus and entry), so it could be analyzed afterwards.

3.3 Procedure

This user study was composed of two sessions per user, each one focusing on one of the two text-entry methods, BrailleType and VoiceOver. The order in which the sessions were undertaken was decided randomly to counteract order effects.

In both sessions, with the help of the experimenter, participants started by learning the system and interacting with it for a minimum of 10 minutes and a maximum of 15 minutes. Each possible action was exemplified and taught to the participants and, as they trained, they were encouraged to ask questions and allay all doubts. If by the end of 15 minutes the participant was unable to write his name or a simple, common four-letter word, the evaluation was not continued. For the BrailleType method, two different timeout values for target selection were used. An introductory one of 1250 ms after entering the target zone, and a second one of 800ms. This last value was set when the experimenter felt the participant was confident enough and understood the basic actions of the method. All participants performed the test with the second value.

After the practice phase, participants were instructed to write a set of sentences as fast and accurately as they could, without the need to put any accentuation or punctuation. Each trial consisted of 5 phrases, each with 5 words with an average size of 4.48 characters. These sentences were extracted from a written language *corpus*, and each one had a minimum correlation with the language of 0.97. The sentences' selection was managed by the application and randomly presented to the user to avoid order effects.

All focused and entered characters were registered by the application during the evaluation. Since we wanted to focus on the number of errors participants made, the option to delete a character was locked. If a participant made a mistake or was unable to input a certain letter, she/he was told not to worry and simply carry on with the next character. It was made clear to all participants that we were testing the system and not their writing skills. When participants finished each sentence, the device was handed to the experimenter to load the next random sentence and continue with the evaluation. All sentences were read aloud by the experimenter and then repeated by all participants to ensure that they understood them correctly.

After writing all 5 test phrases, the session ended with a brief questionnaire to collect the participants' opinions on the text-entry method. All these steps were repeated for both techniques.

4 Results

Our goal in this study was to assess, in an exploratory evaluation, how BrailleType stands against a VoiceOver alike solution, in regards to speed, accuracy and preference.

4.1 Text-entry Speed

Concerning speed, we used the WPM text entry measure, calculated as *(transcribed text – 1) * (60 seconds / time in seconds) / (5 characters per word)* [3]. Time to input each sentence was measured from the moment the first character was entered to the last. Figure 3 shows the performance of each participant, speed wise, on both methods. Some participants had similar WPM on both methods, but VoiceOver was generally faster, with an average of 2.11 WPM against BrailleType's 1.45 WPM.

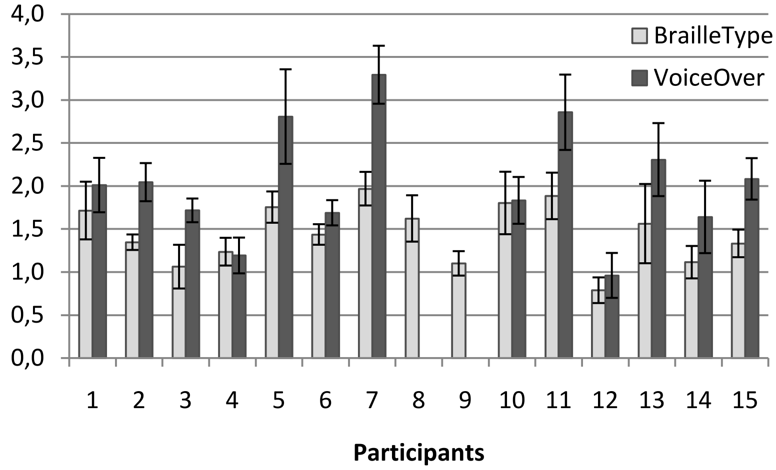

Fig. 3 – WPM (average) for each participant on each system.

Participants 8 and 9 after the 15 minutes of the practice session were still struggling with the VoiceOver alike method, so they did not perform the test. Given the normality of the data (according to the Shapiro-Wilk test), a One-way ANOVA was applied to confirm that VoiceOver-alike was significantly faster than BrailleType ($F_{1,143}$=43.15, p<.001).

Both methods' WPM increased from sentence to sentence, however BrailleType's showed a larger improvement, with an increase from the first sentence to the last of 46.15%, against the VoiceOver's alike smaller 29.4%.

4.2 Text-entry Accuracy

To measure accuracy, the MSD Error Rate was used, calculated as *MSD(presentedText,transcribedText) / Max(|presentedText|,|transcribedText|) * 100* [3]. Since the data did not present a normal distribution, the non-parametric Friedman Test was used. The VoiceOver alike method, with an average MSD error rate of 14.12% against BrailleType's 8.91%, was significantly more error prone (X^2 (1)=81.94, p<.01). This difference can be observed on Figure 4, where the majority of participants made fewer errors with BrailleType. In terms of progress along the five test sentences, results showed that when using BrailleType participants made between the first and the last phrase 5.42% less errors, while with the method identical to VoiceOver 6.7% less errors. Even though the last one had a slighter better performance increase, it still showed on average, almost twice as much errors as BrailleType (9.7% against 5.2%).

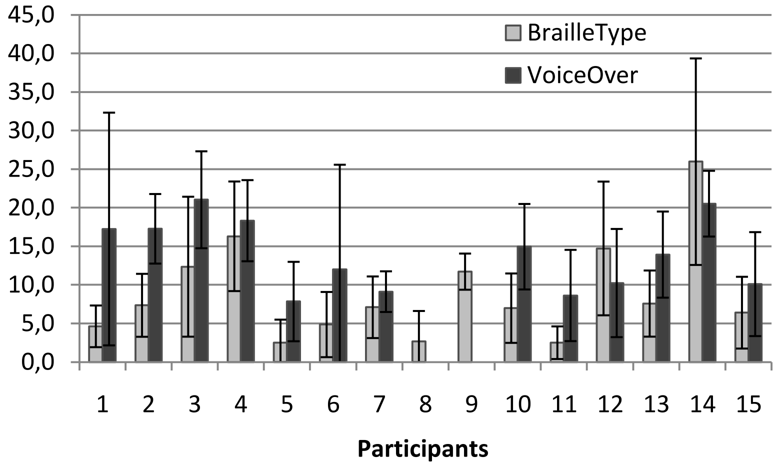

Fig. 4 – MSD Error Rate (average) for each participant on each system.

4.3 Users' feedback

Upon finishing each session, participants completed a small questionnaire about the text-entry method. This questionnaire was composed of a five-point Likert scale with four sentences and an open question about the perceived difficulties and general opinion on the method. Table 1 shows the participants' ratings to both methods.

	Easy to comprehend. *	Easy to use. *	Quickly write text.	Would use this system.
BrailleType	5 (0)	5 (1)	3 (1)	3 (2)
VoiceOver	4 (2)	4 (2)	4 (3)	3 (1)

Table 1 – Questionnaire results for each system (Median, Inter-quartile Range). The '*' indicates a statistically significant response.

Users strongly agree that BrailleType is much easier to understand and to use than a system identical to VoiceOver (X^2 (1)=4.72, p<.05 and X^2 (1)=4.92, p<.05 respectively). Even though BrailleType was significantly slower in the tests, the participants' opinion is that they can write almost as fast as they do on VoiceOver's alike. However, the fact that BrailleType is a slower system weighted on the response to whether they would use the system, as the VoiceOver method was marginally preferred. In terms of perceived difficulties, the major complaint about the system identical to VoiceOver was that keys were too small and close to each other, making it hard to select and enter the intended letters. Another problem worth mentioning is that most users made involuntary errors due to split-tapping, as they would accidently touch/rest fingers on the screen and enter unwanted letters. BrailleType was touted as a simple and easy system but slow. Most users wanted to select targets faster, which sometimes resulted in errors as they would not wait for the confirmation cue and continue without actually selecting them.

4 Conclusions and Future Work

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.

BrailleType 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 VoiceOver's approach. This does not come as a surprise since the presented method features timeouts and requires multiple inputs per character. On the other side, users commit far fewer errors with BrailleType. 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. These difficulties reached a pinnacle with two of the participants who were unable to write their names or a simple four-letter word, after the practice session with the help of the experimenter.

BrailleType 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, BrailleType 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.

As future work we intend to delve further into the target selection process and test the method with progressively smaller timeout intervals or completely remove them, as we believe BrailleType can be a much faster method while keeping the errors to a minimum. A long term study with the target users will be fundamental to understand the impact of experience and the full potential of this eyes-free method.

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