BrailleKey: An alternative Braille text input system

Comparative study of an innovative simplified text input system for the visually impaired

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***Abstract* — This paper explores the efficacy of using an alternate text input system for the blind, based entirely on Braille alphabets for touch-screen mobile devices. A comparative study was performed wherein a prototype application developed by the authors was compared against the Voice-Over technology developed for iOS (Apple's mobile operating system. The study conducted on five blind subjects show that this system can be used as a viable alternative to the existing input methods that have been developed for this purpose.**

***Index Terms* — blind, braille, mobile devices, text entry, touchscreen**

I. Introduction

The use of mobile devices such as cellular phones and Tablet PCs has become an integral aspect of the lives of numerous people across the world. The use of these devices today, is no longer restricted to the making of voice calls or text messaging and encompasses a wide variety of daily functions including the storage and management of personal and important data. The stylish and more versatile devices that are being released in the market on a regular basis have transcended their original purpose and have become leisure and productivity tools, quickly looking to replace personal computers in this regard.

While most of the population enjoys the benefits of the state-of-the-art technology that comes with the mobile devices, the section of society consisting of the visually impaired is often unable to access these devices with the same ease as the rest of the population. While it is undoubtedly difficult to converge upon a 'best' possible solution, the existing research in this regard has attempted to solve this problem.

A blind person would definitely be able to access the traditional keypad–based phone to place a call, but it would be immensely difficult for him/her to do the same on today's phones which involve the touch screen interface [1]. Moreover, other functions such as the input of text messages would also be difficult. Many phone manufacturers offer voice-to-text functions. However, the area of speech recognition is relatively new and we are yet to see an immaculate means of converting voice to text [2].

In this paper, we attempt to study the existing technology that has been developed in this regard and to understand the principal features required for the building of an application that helps the visually impaired to input the desired text on a touchscreen device.

II. Related Work

There have been several types of input systems that have been developed to enable or enhance text entry for the blind – the most common means of input for the average user being the MultiTap system, where a mapping is done from one key to a group of 3-4 letters. However, this leads to obvious difficulty for a visually impaired person. In this regard, there have been systems developed exclusively for the Blind, among which the notable ones are Braillino, or the Alva Mobile phone organizer. [3] These devices use a braille keyboard for text input, a braille display for text output and certain other functionalities provided by cellular phone companies. However as one can comprehend, these devices are quite bulky and cannot be used as a suitable substitute for a mobile phone.

In order to circumvent this problem, there was the development of the screen reader technology which when combined with MultiTap replaces the visual feedback by its auditory representation. However, the offered feedback is restricted to the output as no feedback is provided with regards to position and displacement of words or letters [3]. A person acquiring blindness in an advanced stage of life is likely to face difficulty with the first contact of this approach, rejecting it before gaining the experience required to use it. That said, the use of auditory representation remains one of the most efficient ways of providing feedback to a visually impaired person with regards to the text being inputted on a mobile device [2].

In the recent past, many phone manufacturers have implemented this form of audio feedback in their phones in order to facilitate the blind. Apple's Voiceover is a successful example of this. Users can explore the interfaces' layout by dragging their finger on the screen while receiving audio feedback. To select the item, the user rests a finger on it and

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taps with a second finger (i.e. split-tapping [4]) or alternatively lifts up the first finger and then double-taps anywhere on the screen. This approach is application independent, allowing blind people to use traditional interfaces with minimum modifications.

Input methods for the touch screen device remains one of the biggest issues related to text-entry. It has been shown that users suffer from a lot of discomfort while dealing with touch interfaces [5]. Many researchers have developed various methods of inputting text, most common among which are by using gestures and by tapping.

Yfantidis and Evreinov [6] developed an input method designed as a pie menu with eight alternatives and three levels. Each letter is selected by performing a gesture towards one of the eight directions. The character is read and users accept it by lifting the finger. Navtouch also uses a gesture based approach wherein the users are asked to input text by gesturing towards one of the 4 directions [7].

Bonner et al. [8] developed the No-Look notes which involve the use of a split-tapping mechanism wherein each the user taps on a pie menu consisting of 8 segments which is read out. Each segment is divided into a set of sub-segments, which consist of the corresponding characters that are arranged in an alphabetical order.

Frey et al. [9] developed a system of input that mimics the Braille code. BrailleTouch consists of 6 buttons, which spatially correspond to the mental map of the six cells of a braille character. The system also provides audio feedback for each selected character. BrailleTouch was shown to be significantly faster and more accurate for the purpose of text entry [9].

Oliveira et al. developed BrailleType [10], 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. It has been observed that it is much slower than existing systems like Voice-over, Multitap etc although it gives much fewer errors [1].

III. BRAILLEKEY

For the purpose of this study, the prototype application developed by the authors is referred to as BrailleKey. Its development was largely motivated by the design of BrailleTouch developed at Georgia Institute of Technology. BrailleTouch uses 6 buttons to mimic the six cells present on a braille character. Thus, it needs a support of multi-touch technology for tracking up to six fingers, a technological requirement that limits its accessibility in popularly purchased and available devices. Hence, it was decided that the designed system should not depend on advanced multi touch support. We decided to make it usable, with respect to the four discernible corners of the screen. To this end, we assigned the lower two keys to the functions of deleting and entering individual characters, and the upper two to be the left and right dot-marking buttons.

The primary reason for having decided to develop and test this application on a touchscreen platform is because there is a significantly greater flexibility in touch interfaces, and possibility of applications – as is visible in the convergence of all operating systems for touch interfaces. Hence there is a clear need for a suitable typing interface for the visually disabled, on mobile devices with touch screens.

Figure 1 illustrates the mapping that was designed for the purpose. The button on the left acts for the 3 cells on the left side of the braille character while the button on the right acts for the 3 cells on the right of the braille character. A single tap of a button activates the first cell, a double tap activates the second cell and a long press activates the third. This ensures that all six combinations can be created, by using the single tap, double tap and long press. A similar mapping is used for both left and the right button. For example, in order to access the letter O, a user would have to perform a single tap followed by a long press on the left button and a double tap on the right button.

Figure 1.a. The application in use

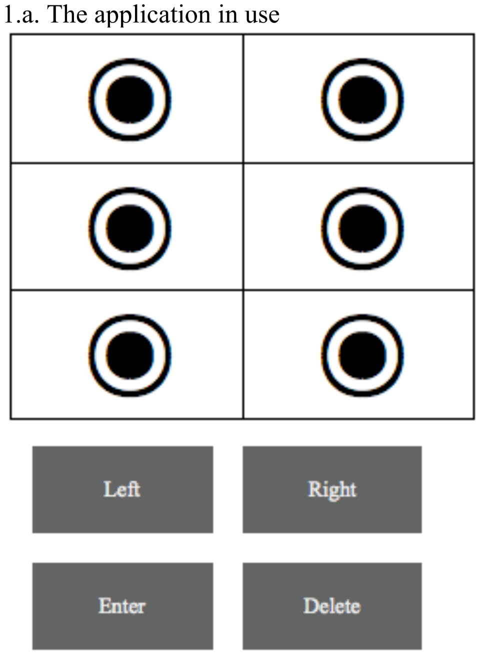

Figure 1.b. A representation of the Braille Type Application

This application also provides auditory feedback to the user as he is tapping. A single tap leads the application to speak the number 1, a double tap the number 2 and a long press the number 3. Once a person has performed the necessary taps, a press of the enter button inputs the letter onto the screen. A double tap of the enter button inputs a space character and a single tap of the delete button deletes the last entered character.

If the user wishes to replay everything that he has typed, a press of the volume key located on the top of the phone leads to the reading out of everything that has been typed.

Kane explored the challenges in gesture-based touch screen input for the visually impaired and suggested guidelines for designing these interface [5]. Table 1 shows the compatibility match between Braille-Key's features and Kane's guidelines.

TABLE I. COMPATIBILITY OF BRAILLEKEY WITH ACCESSIBILITY GUIDELINES [5]

Touchscreen Accessibility Guidelines	***BrailleKey Compatibility***
Avoid symbols used in print writing	No symbols, just taps and long presses
Favor edges, corners, and other landmarks	All the four buttons are at the four corners of the screen
Reduce demand for location accuracy	Each button/target location occupies approximately a quarter of the screen size
Limit time-based gesture processing	There are no time-based gestures
Reproduce traditional spatial layouts when possible	Not similar to any orthodox layouts, but the text entry is mapped to the layout of braille

IV. METHODOLOGY

In order to evaluate the effectiveness of the BrailleKey application, a comparative study was conducted with a well-established commercial application available for the purpose of text input for the blind; Apple's Voiceover technology developed for iOS devices. The Voiceover technology was used instead of a similar technology developed on a touch screen device to evaluate the efficacy of using BrailleKey as a text input system for the blind as the primary objective was to study how BrailleKey compared with one of the most widely used methods available on the market.

For the purpose of this study, a set of five participants was recruited from a school for the visually impaired. It was required that the participants have a functioning knowledge of Braille, the English language, and a familiarity with the QWERTY keyboard layout. The average age of the participant group was 17.

For the purpose of this test, an HTC Wildfire running android OS version 4.0, having a screen size of 3.2 inches (measured diagonally) was used along with an Apple iPod Touch running iOS 5.

The user study was conducted in two sessions, one focusing on each of the two text entry methods. Initially the functioning of the two devices were explained to the participants and they were given 10-15 minutes to learn and get used to the applications. At this point, they were encouraged to ask any doubts they might have during the text entry. The iOS/Android devices were given to the participants in a random order to eliminate any order effect. Before the start of the test, the delete option was disabled from the android application. This was to ensure that the participants did not correct their mistakes. They were then asked to input two sentences that were dictated to them. The participants were clearly told that they were not required to worry about any errors that they commit as the test was not about their language or typing skills and were asked to continue typing even if they felt like they had made a mistake.

V. RESULTS

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

A. Text Entry Speed

Concerning speed, we used the WPM text entry measure, calculated as [11]

$$WPM = \frac{60\ \text{seconds}}{5\ \text{characters per word}} \times \frac{(\text{TranscribedText} - 1)}{\text{Time (in seconds)}} \quad \dots (1)$$

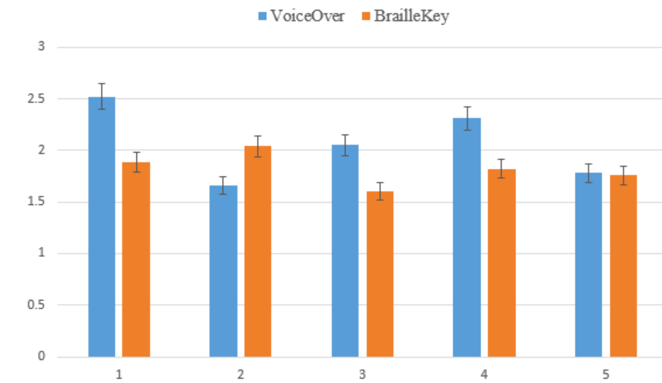

Figure 2. WPM for each participant
(X-axis holds the user index, and Y-axis has the WPM of each user)

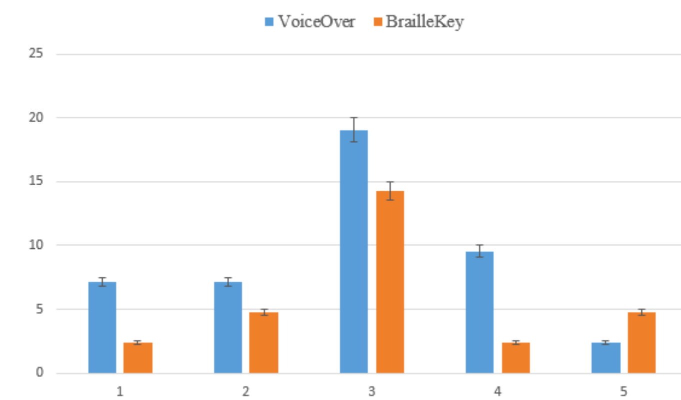

Figure 3. MSD Error Rate for each participant
(X-axis holds the user index, and Y-axis has the error rate of each user)

Time to input a sentence was measured from the moment the first character was entered to the last. Figure 2 shows the performance of each participant, speed wise, on both methods.

Given the normality of the data (as determined by the Shapiro Wilk test), a One-way ANOVA was applied ($F_{1,8}=1.897$, $p=0.2635$). The results indicated that the differences in mean values between the two groups were not significant. This can be attributed to the fact that only 5 participants were included in the study.

B. Text Entry Accuracy

To measure accuracy, the MSD Error Rate was used, calculated as [11]

$$MSD = \frac{(\text{PresentedText}, \text{TranscribedText})}{\text{Max}(|\text{PresentedText}|, |\text{TranscribedText}|)} \times 100 \quad \dots (2)$$

a) Given the normality of the data, (As determined by the Shapiro Wilk test and shown in Figure 3), a One-Way ANOVA was applied (F1,8=0.871, p=0.378). On comparison the mean values, the percentage of errors committed while using the voice-over method (Mean = 9.004, SD = 6.1605) are slightly higher than that committed by using BrailleKey (Mean = 5.712, SD = 4.9353).

VI. Conclusions and Future Work

As is evident from the Mean and Standard Deviation values of the two test groups, BrailleKey compares quite well with the commercial application developed by Apple. Though the one-way ANOVA provided results that indicated that the differences between the two methods could be as a result of pure chance, this is due to the low number of participants who were involved in the testing process. A comparison of the mean values for the two tests indicates that BrailleKey is very similar to the voice-over input method of apple (in fact, marginally better than).

A significant limitation of the testing was the fact that a comparative study was not conducted between similar Braille typing applications. The authors did attempt to contact the makers of both Brailino, and BrailleType, but did not receive any conclusive response, especially a prototype of either application, to test alongside ours. Thus, we chose the most prominently available interface made to help visually disabled people to type, as a comparison parameter.

As this is in a very early stage in its developmental process, the user testing was conducted on a relatively small scale with only five users. During the future course of research, the authors plan to test the feasibility of using the application on a much larger scale after testing it on a larger group of users

When asked to provide their feedback, the users mentioned that while they were satisfied with the currently existing methods, they wished for some sort of a tactile feedback. The participants also felt that while BrailleKey was quite easy to use, the audio feedback provided by the system which currently provides an output of 1, 2 and 3 on both sides should be replaced by 1, 2 and 3 on one side and 4, 5 and 6 on the other. They were of the opinion that BrailleKey was quicker to input each character, as they did not have to spend much time searching for the character on the keypad. This was despite the fact that all the participants had had prior experience with QWERTY keypads. It is also possible that if the participants were provided with a longer time to practice, they would be able to get used to the system much quicker.

The tap codes were chosen seeing that one could process the top, middle, and bottom dots as numbered 1,2, and 3. Three taps were then replaced with a long tap, to fasten the gesture. As a part of further explorations, an alternate design is being developed with incorporates directional gestures – drag upwards, downwards, or tap, for the top, middle, or bottom dot respectively. During the course of further testing, the applications feasibility will be evaluated.

BrailleKey is highly advantageous as users who have minimal experience with QWERTY keypads can use it. It's only prerequisite is a knowledge of Braille. As part of future studies, we plan to implement some of the suggestion offered by the participants and also have a larger number of participants for testing. We also plan to reduce the number of buttons involved and to incorporate a larger number of gestures in our system.

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References

[1] J. Oliveira, T. Guerreiro, H. Nicolau, J. Jorge, D. Gonçalves: "Blind people and mobile touch-based text-entry: acknowledging the need for different flavors." In Proceedings of the 13th Int. ACM SIGACCESS Conf. on Computers and accessibility. ASSETS '11, ACM (2011).

[2] A.R Fernandes, H. Paredes. "Exploring Alternative Devices for Blind Users." In Proceedings of The Sixth International Conference on Virtual Systems and Multimedia, 2000.

[3] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[4] T. Guerrero, H. Nicolau, J. Jorge, and D. Gonçalves. "Navtap: A long term study with excluded blind users." In ASSETS'09, pages 99–106. ACM Press, 2009.

[5] S.K. Kane, J.P. Bigham, and J.O. Wobbrock. "Slide Rule: Making mobile touch screens accessible to blind people using multitouch interaction techniques", pp. 73-80, 2008. In Proc. ASSETS '08. New York: ACM Press.

[6] G. Yfantidis, and G. Evreinov. "Adaptive Blind Interaction Technique for Touchscreens." UAIS, 4, 328-337, 2006.

[7] T. Guerreiro, P. Lagoa, H. Nicolau, D. Gonçalves, and J. Jorge. "From tapping to touching: Making touch screens accessible to blind users." IEEE Multimedia 15, 4 (2008), pp. 48-50.

[8] M. Bonner, J. Brudvik, G. Abowd, and K. Edwards. No-Look Notes: "Accessible Eyes-Free Multi-Touch Text Entry." IEEE Pervasive Computing '10. Heidelberg: Springer, 2010, pp. 409-426.

[9] B. Frey, C. Southern, and M. Romero. "BrailleTouch: mobile texting for the visually impaired." Universal Access in Human-Computer Interaction. Context Diversity, 2011, pp. 19–25.

[10] J. Oliveira, T. Guerreiro, H. Nicolau, J. Jorge, and D. Gonçalves. "BrailleType: Unleashing Braille over Touch Screen Mobile Phones, in Human-Computer Interaction." INTERACT 2011, P. Campos, et al., Editors, Springer Berlin / Heidelberg: Lisbon, Portugal, 2011, pp. 100-107

[11] S. Kane, J. Wobbrock, and R. Ladner. Usable Gestures for Blind People: Understanding Preference and Performance, in CHI '11, 2011, pp. 413-422.

[12] I. MacKenzie, and K. Tanaka-Ishii. "Text entry systems: Mobility, accessibility, universality." Morgan Kaufmann, San Francisco (2007).