VBraille: Haptic Braille Perception using a Touch-screen and Vibration on Mobile Phones

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ABSTRACT
V-Braille is a novel way to haptically represent Braille characters on a standard mobile phone using the touch-screen and vibration. V-Braille may be suitable for deaf-blind people who rely primarily on their tactile sense. A preliminary study with deaf-blind Braille users found that, with minimal training, V-Braille can be used to read individual characters and sentences.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces – *haptic I/O*. K.4.2 [Computers and society]: Social issues- *assistive technologies for persons with disabilities.*

General Terms
Design, Experimentation, Human Factors

Keywords
Accessibility, blind, deaf-blind, mobile phone, haptic perception, touchscreen, vibration

INTRODUCTION
There are about 50,000 deaf-blind people in the US [7, 13]. Our goal is to provide this community with additional, alternate interaction techniques and devices that will fit in with the mainstream model. Since Braille is in wide use by deaf-blind people, we have created a novel way to present Braille on standard mobile phones, called V-Braille, using touch-screen and vibration capabilities. We have conducted preliminary evaluations of V-Braille with deaf-blind people who rely on tactile communication. Our evaluations show promise and excitement for the method itself as well as for its applications. This is a great opportunity to come up with new mobile interaction methods and include the users in the design process early.

1. BACKGROUND
1.1 Deaf-Blindness
Of the deaf-blind in the US, 50% have Usher's Syndrome [1], a hereditary condition that causes deafness at birth, followed by a gradual degeneration of the retina leading to eventual total blindness by middle age. Those with Usher's syndrome often learn sign language in their youth as part of the deaf community. As blindness sets in, they begin to receive sign language tactually and start to learn Braille. Regardless of the cause of deaf-blindness, Braille is their key to accessing information and gives us a compelling case to concentrate on this population.

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1.2 Deaf-Blind Communication
The communication methods of the deaf-blind vary, depending on the causes of their combined vision and hearing loss, their backgrounds, and their familiarity with technology. Most commonly used communication systems include sign language, adapted signs, tactile sign language, tracking, tactile fingerspelling, Tadoma (speech reading with fingers), face-to-face digital communication (DeafBlind Communicator), and Braille displays and notetakers [1, 2]. In our experience with the Lighthouse for the Blind and the Seattle deaf-blind community (which comprises around 80 people), most of those fully blind deaf-blind people use Braille and carry electronic devices (e.g., cell phones, Braille notetakers).

1.3 Related Work Using Haptics
Touch-screens on mobile devices are now accessible and usable by blind people [4, 6]. In 1971, the Optacon (OPtical to TActile CONverter) was invented, which enabled blind people to read text printed by raising the outlines of print letters [12]. Other projects, such as the Pantobraille, the Tsukuba University Braille cell phone, the Nokia 770 Mobile Internet tablet, and BodyBraille use specialized hardware to convey Braille [9, 10, 11]. There has also been work using online force feedback with a commercial mouse for reading Braille [3]. Rantala et al. [11] studied different methods of reading haptic Braille with a stylus on a tablet, and achieved high accuracy overall. The Nokia Braille Reader prototype [8] uses the vibrating touch-screen on Nokia phones to convey Braille temporally; the user holds their finger on the screen in any one static location and will feel a linear off-on vibration. This has been shelved because of a lack of accompanying accessible applications. This method could be compared to V-Braille as a different output method. V-Braille uses no extra hardware or devices; it can be used on mainstream phones. Using Bluetooth, V-Braille can connect to Braille notetakers as well, widening the breadth of potential applications.

2. V-BRAILLE
Braille is a method that is widely used by blind and deaf-blind people to read and write. Each traditional Braille character is made up of six dot positions, arranged in a rectangle with two columns of three dots each. V-Braille is a simple mechanism for conveying Braille using the touchscreen and vibration on a mainstream phone. The software was developed for the G1 under the Android platform. The screen is divided into six parts, to mimic the six dots in a single Braille cell (Figure 1). When the part of the screen touched (any point within the enclosing 1/6th region) represents a raised dot, the phone vibrates. Touching dot areas 2 and 5 present stronger vibrations (shown by the solid line in Figure 1), making it easier for users to differentiate between vertically adjacent raised dot areas. The screen can be tapped or

stroked in different sections and directions. We do not currently use multi-touch. Grade 1 Braille is currently used for testing.

3. DEAF-BLIND STUDY

We conducted a preliminary evaluation with local deaf-blind Braille readers to determine our systems' usability without any real training. We developed a simple application on which we built two tasks: reading random V-Braille characters and reading a short sentence presented as a string of characters.

3.1 Methodology

We recruited nine users for our study in the field (six deaf-blind, three blind). There were six males and three females. The average age of the participants was 47.4 years, with 25.8 average years of Braille experience. After 10 minutes spent familiarizing the users with the phone and our V-Braille application, we started by asking users to read 10 random V-Braille characters. We recorded the amount of time it took users to read each character. The next task was reading a short sentence of 21 characters. We verified the understanding of the sentence by asking a detailed question about the content of the sentence. We also timed the results. After the tasks were completed, we conducted a semi-structured interview about the users' experience with V-Braille. We asked them how they felt about the system, if they had any suggestions for improving V-Braille's functionality, and what situations this sort of interaction could be useful for. We also discussed the interaction techniques users tried out.

3.2 Task Results

The average time it took for a participant to read a V-Braille character ranged between 4.2 and 26.6 seconds. Five out of nine users were able to read a character in less than 10 seconds. Together, our nine users had a 90% accuracy rate. Experienced blind Braille readers can read about 7 print Braille characters a second. Deaf-blind Braille readers are usually much slower [5]. The BodyBraille study showed a rate of about 1 second per Braille character [9]. With more experience it may be possible to reach one character per second with V-Braille. More than one Braille cell displayed on the screen at once might increase the speed further. The time it took to read a 21-character sentence ranged from 130 to 781 seconds. Six of nine participants successfully understood the sentence, with the other three understanding individual characters but forgetting some along the way. Four participants preferred tapping the screen, instead of sliding their finger across it. Two participants moved their finger in a smooth "U" shape. Three other participants moved their fingers in 2 smooth, quick vertical strokes of the finger. One user increased his speed by predicting letters during the second task (reading a sentence) using context. If he had an idea of what letter was next, he would quickly tap those dots for verification. Four participants mentioned that having a tactile dividing overlay on the phone would help them differentiate between the six dot areas. Our nine participants, even those with lesser technical experience, all seemed very enthused about V-Braille, and were excited to discuss potential applications.

4. FUTURE APPLICATIONS

Some of our users explicitly expressed a desire to use mainstream devices with phone sensors (e.g., a camera) instead of having many specialized devices. V-Braille could also be used as part of a communication device, similar to the DeafBlind Communicator, using V-Braille on a mainstream cell phone instead of using a Braille display. We are also researching Braille input techniques, some using V-Braille. Our preliminary study indicates that V-Braille has potential as an alternate method for deaf-blind people to interact with the world using mobile, cheap, sustainable mainstream devices. More study and development is needed.

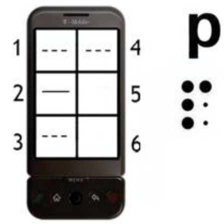

Figure 1: V-Braille representation of the lowercase letter 'p' on a smartphone touchscreen, simulating localized vibration on Dots 1 through 4. Dots 2 would vibrate more strongly in this case, as would 5 if it was raised.

REFERENCES

[1] American Association of the Deaf-Blind http://aadb.org

[2] Clarridge, Christine. New device lets deaf-blind people converse with anyone. Seattle Times. August 12 2009.

[3] Jeong, Wooseob. Touchable online Braille generator. ASSETS Poster, ACM SIGACCESS Conference on Computers and Accessibility (ASSSETS '05).

[4] Kane, S., Bigham, J., and Wobbrock, J. Slide Rule: Making mobile touch screens accessible to blind people using multi-touch interaction techniques. ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '08).

[5] Legge, G., Madison, C. and Mansfield, J. Measuring Braille Reading Speed with the MNRead Test. *Visual Impairment Research*, Volume 1, Issue 3 December 1999, 131 – 145 (VIR 99)

[6] McGookin, D., Brewster, S., and Jiang, W. 2008. Investigating touchscreen accessibility for people with visual impairments. 5th Nordic Conference on Human-Computer interaction: Building Bridges (NordiCHI '08).

[7] National Consortium on Deaf-Blindness. http://nationaldb.org/index.php

[8] Nokia Braille Reader. 2009. http://betalabs.nokia.com/apps/nokia-braille-reader

[9] Ohtsuka, S., Sasaki, N., Hasegawa, S. and Harakawa, T. BodyBraille System for Disabled People. Computers Helping People with Special Needs (ICCHP 08).

[10] Ramstein, C. Combining Haptic and Braille Technologies: Design Issues and Pilot Study, ACM SIGACCESS Conference on Assistive technologies, 37-44 (ASSETS 96).

[11] Rantala, *et al.* Methods for Presenting Braille Characters on a Mobile Device with a Touchscreen and Tactile Feedback. *IEEE Transaction on Haptics*. Vol. 2. No 1, 2009

[12] Stein, D. The Optacon: Past, Present, and Future. *The Braille Monitor*. Vol. 41, No. 5 May, 1998.

[13] Watson, D., and Taff-Watson, M., eds. A Model Service Delivery System for Persons Who Are Deaf-Blind, Fayetteville: University of Arkansas. 1993.