Displaying Braille and Graphics with a "Tactile Mouse"

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ABSTRACT

Refreshable tactile displays that move with the hand, such as those that resemble computer mice, can be utilized to display tactile graphics faster and more cost effectively to individuals who are blind and visually impaired than traditional paper methods of creating tactile diagrams. However, in tactile diagrams, the word labels can be as important as the diagram itself and so it is important that these displays can present Braille. In this work, we present and discuss findings from a study which used three methods of displaying Braille and tactile graphics simultaneously with a tactile mouse: Braille and graphics at the same amplitude level, Braille and graphics at different amplitude levels, and Braille with a box around it, The simplest method, Braille and graphics at the same amplitude, surprisingly proved to be the most effective.

Categories and Subject Descriptors

K.4.2 [**Computing Milieu**]: Social Issues – *Assistive technologies for persons with disabilities, Handicapped persons/special needs.*

General Terms

Design, Human Factors

Keywords

Haptics, haptic mouse, visually impaired, tactile graphics, Braille

1. INTRODUCTION

Visual graphics are used in a variety of applications at work, school, and in daily living to effectively communicate a wide range of information. Unfortunately, individuals who are blind and visually impaired cannot directly access this information. While word descriptions can be used to summarize graphics, certain advantages of using graphical information, such as the ability to discover patterns and spatial relationships, are lost. Tactile diagrams can be used instead or in addition to word descriptions so as to fully present the information to individuals who are blind and visually impaired. Particularly if many diagrams are needed, refreshable graphics displays can be more cost-effective, faster, and less cumbersome than traditional methods of creating tactile diagrams.

Currently, two types of mechanical refreshable displays exist. One type is a "full page" pin display which consists of a large matrix of pins that can move up and down (e.g., hyperBraille, Metec AG). Rotard and his colleagues (2005) have considered displaying Braille and graphics on these types of displays. However, these displays are expensive due to the large number of pins needed and can be difficult to maintain, while still covering a relatively small total area. Their pin spacing (i.e., 2.5 mm for the hyperBraille) can also be limiting for presentation of tactile graphics. The other type of display consists of a small tactile display which move with the user's hand over a virtual diagram (e.g., [1-3]). These are less limiting for presentation of graphics since the span of the diagram is limited only by the position tracking system used. These systems are also more cost effective and easier to maintain because they contain less pins. In addition, these devices have the ability to resolve significantly finer position information, through motion of the hand.

The use of Braille is important for tactile graphics as the word labels used can be as important in interpreting a diagram as the graphics themselves. Currently, labels are commonly presented in multimedia systems through audition (e.g. Talking Tactile Tablet, Touch Graphics; [3]). However, there are few limitations to the use of speech: (1) it precludes access to labels for individuals who are deaf-blind, a small but underserved group; and (2) it presents social issues associated with the use or non-use of headphones. Therefore, being able to clearly interpret Braille on graphics displays is an important issue. In addition, for small moveable displays, if Braille is easily read, these devices can be used to access virtual, full pages of Braille at a much lower cost than traditional Braille.

Although small, moveable tactile display systems are beneficial in several ways, two key problems exist for presenting Braille on these smaller tactile displays. One difficulty is that if treated simply as a part of the diagram, the contact with the Braille is too quick to easily be interpreted. In a previous paper [6], we presented a method that modified the presentation method so that users could effectively interpret Braille. Another concern was that, even for paper tactile graphics, it can be difficult to separate the Braille from textures used in the graphic. However, textures are a very effective means of conveying information and so it is not desirable to exclude them from the diagram.

2. DEVICE

In this work we used a haptic display system previously developed in our laboratory that uses relays to select one of four possible amplitudes for each actuated pin [1]. Although displays that can vary continuously in amplitude do exist (e.g., [3]), they require expensive amplifiers to work. This low cost device has four main components: a Braille cell (P15, Metec AG) which houses a 2x4 pin array constituting the tactile interface, the electronics to drive it, an RF transmitter directly underneath the pin array to keep track of absolute position with a graphics tablet, and a mouse casing (Figure 1). The maximum amplitude level and the minimum amplitude level are fixed, but the middle two amplitudes can each be adjusted using a potentiometer.

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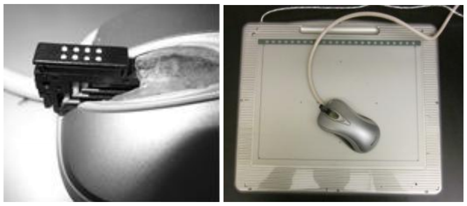

Figure 1. Tactile Mouse for Tactile Graphics Display

3. METHODS

We evaluated three different methods of presenting Braille in combination with graphics that used texture. Each map contained five 3 letter country abbreviations (where the letters were notrepeated between labels of a single diagram), borders between countries, and several textured areas which represented various features of the countries. Method 1 presented both the features and Braille at equal amplitude (the highest possible level). Method 2 also presented both the features and Braille at the highest possible amplitude level but with a box surrounding the 3 letter Braille abbreviation. Finally, method 3 presented the Braille at the highest possible amplitude level and the features at approximately half the amplitude.

Braille was presented using our previously developed method [5], where, within a 100x100 pixel area, a single Braille character would be presented independent of mouse movements. Stringing these boxes together with different Braille characters was used to form words. Textures were presented as either spatial square wave gratings or evenly spaced dot patterns. Borders of countries and states were presented with temporal square wave vibrations of 20 and 71 Hz, respectively.

Participants were asked to find the Braille labels on the diagram and then explore the respective country using the borders to determine which features it contained. Once the participant completed finding the Braille, reading the Braille, finding the features, and determining the features for each of the five countries on each map, the map was completed. The subject then answered a short questionnaire regarding that map and the ease of both finding and identifying the correct Braille letters and the map's features. The total time to complete the map was recorded for each map.

For this study, participants were required to be proficient in reading grade one Braille. For each method, questions were asked about two maps drawn in a counterbalanced manner across subjects from a pool of six. The two maps for each method were presented in blocks, counterbalanced across subjects. A training map was given before each block so the subject was familiar with the method being presented and using the device for that particular method.

Because of the small sample size, non-parametric methods, such as the related-samples Friedman's two-way analysis of variance by ranks, were used for the analysis.

4. RESULTS

There were nine participants, ages 19-59, approximately half of whom were completely blind and half with low vision, with the age of onset being from birth to only a couple of years.

In terms of performance, the number correct for finding and reading Braille, performance was 100% and close to 100% respectively. No statistical difference was found between methods. However, there was a statistical difference between methods for finding and identifying the graphical features ($p=0.048$). Further analysis showed that method 3 did significantly worse than other methods ($p=0.042$ for method 1 and $p=0.017$ for method 2), but there was no significant difference between methods 1 and 2. Finally, in terms of total time taken, there was no difference between the three methods.

In terms of usability, there was no statistically significant difference between the methods in terms of ease of finding the Braille ($p=0.508$) or ease of identifying the Braille ($p=0.368$). The method used did have an effect, however, on the usability of finding features ($p=0.020$) and correctly identifying them ($p=0.006$). It was found that Method 3 was significantly more difficult to find features than Method 1 ($p=0.006$); however, no other differences were significant. Method 3 also did statistically worse than Methods 1 ($p=0.007$) and 2 ($p = 0.041$) in identifying the features, although there was no significant difference between Methods 1 and 2.

5. DISCUSSION

While finding Braille with the tactile mouse was successful with all methods, displaying Braille and graphics alongside one another created difficulty for certain methods of presentation. In contrary to our original expectations, when Braille and graphics were displayed at different amplitudes (Method 3), it performed the poorest and subjects found it difficult to find and identify features. This could be because the lower amplitude level was insufficient stimulation for identifying graphics (however, higher amplitudes were difficult to discriminate from the maximum level). We had expected Method 1 to be the poorest performing and most difficult method as we expected, like for paper graphics, the user could easily confuse the Braille letters for textures. Contrary to what we expected, Methods 1 and 2 were much better in terms of performance and ease of use. This may be because there was already a large difference between the presentation of Braille, which was static over a small area, from that of graphics, which created vibrations as the mouse moved across them.

Thus, it recommended that the simplest method to use, Method 1, be used to present Braille. This is also more cost-effective, as it does not require the additional electronics needed to present the multiple amplitudes.

6. ACKNOWLEDGMENTS

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