Banning a Chimera with the Hyperbraille Display

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Abstract
The Hyperbraille system has been developed together with more than 50 blind people and improves access to window systems and everyday applications such as a browser or spreadsheet software. The system consists of a large tactile and touch-sensitive display as well as software supporting braille reading and writing, tactile graphics editing, and experiencing tactons. Each haptic modality has its advantages and we demonstrate some of the limitations as well as applications requiring them specifically.

1 Introduction

Braille has many facets; it may be used for plain text, but also music and mathematics to name a few notations. Braille becomes a chimera and shows its three heads when considering dots as text, as graphics, or as a tacton on a refreshable large pin matrix display.
We present the design of the Hyperbraille display (see Fig. 1) from the view of operating graphical user interfaces such as MS Windows with those haptic modalities. Unlike the fire-breathing monster in Greek mythology this display is touchable and can be controlled by single or multi-touch gestural input (Völkel, 2008).

The Hyperbraille display consists of 60 rows, each with 120 pins arranged equidistant in 2.5 mm distance. Each pin is driven by piezoelectric actuators, and even a larger or smaller display size is feasible through a modular mechanical design. The height of the tactile display is approximately 7cm. Two sets of four large keys are on the top towards the rear side of the display for braille input and four keys in between these two groups can be controlled by the thumb. Users may explore a larger canvas by cursor keys (up, down, left, right), two more extra keys, as well as a navigation bar at the front. Cursor keys are duplicated on the right and left side of the display.
When working with haptic displays blind people know firsthand about the specific haptic interpretation of dots. We have iteratively developed an approach with users to grasp the contents of the display, and to manipulate them through touch, gestures, keys, braille input, and navigation. More than 50 blind users have completed typical tasks with simple mock-ups (Schiewe, 2009) and more complex editing of diagrams. This revealed many ergonomic conflicts and showed the need for efficiency. For example, crossing one's hands must be avoided by duplicating keyboard components.

2 Dots on a Large Tactile Display

2.1 Braille

Initially Louis Braille wrote his new notation by pressing dots into soft wood through a pointed instrument. He quickly learned from his classmates (and agreed in this sense with Barbier's method) that raised dots are better perceivable and appropriate gaps must be made between lines and characters. As important as braille code is the ability of braille notation to create a multi-line layout and structure text into paragraphs and pages.

Reading braille on a multi-line display is new to most users, as the distance between each character makes up exactly one lowered braille pin as well as the distance among two lines of text is made up from one lowered braille pin. Early pilot systems have demonstrated the feasibility of this approach (Schweikhardt, 1985).

We have conducted a reading test with 20 blind people (Prescher, 2010) and analysed efficiency and effectiveness of reading braille text. For comparison, users had to read braille on paper, on a single line braille display, on a single line of a prototype of the BrailleDis 9600, and on the full size display (12 lines of 40 braille characters). Materials were presented in randomised order to avoid any learning effects. We counted the number of words users were reading within five minutes. Users were asked to read out aloud in order to be able to count the number of errors.

The analysis of mean values shows, paper is the fastest, followed by regular braille display, the full size BrailleDis 9600 and finally a single line within a large display. However, the reader's individual reading capabilities were too different to conclude such findings for every user; some readers were very fast on the large display. A more detailed analysis within a post-test among 4 readers revealed expert users are slowed down slightly on our large braille display but they can quickly become faster. Inexperienced braille readers seem to make less reading errors on BrailleDis 9600.

Most text is still much longer than what fits on the BrailleDis 9600. Browsing books or editing text is dependent on the particular interaction techniques built into an application programme and a screen reader. The horizontal and vertical layout of braille is not only important for books and magazines, but also for reading electronic documents. Although standard screen readers support editing many types of documents, it is often difficult to understand where text appears. The main work within the Hyperbraille project has focussed on developing solutions for better access to typical software used at the workplace including PowerPoint, Word, Excel, Outlook, browsers and PDF forms.

2.2 Graphics

Sequences of dots may be perceived as a graphical shape, if the distance is set appropriately. In general, tactile graphics require some production method and material appropriate for merging labels with shapes and textures of graphical elements. Graphics and braille may be merged easily, if braille dots are used for producing tactile graphics. In contrast, this reduces the kind of shapes and textures suitable for such an approach.

Clearly, it is not intended to present photographs on a large braille display. But snapshots of computer screens may be interpreted successfully. One of our studies with blind users indicates, some blind people can recognise the shape of

ink print character very well and distinguish different font styles such as bold or italic style. These features are typically hard to convey in braille and need extra time and effort to be edited properly.
Coloured pixels require further processing, in particular if it is unclear what pixel makes up background and foreground information. A novel approach developed by Taras (2009) is rendering each pixel by multiple dots. Each pixel results in a unique shape which represents its colour. Readers perceive both an overall texture (such as a bar graph) and detailed elements making up the texture (such as red) while sweeping across the display. Combined with appropriate scaling this is a promising, highly interactive method for in-depth analysis of some graphical information.
Finally, the BraillDis 9000 has been used for presenting OpenStreetMap data (Zeng, 2010). This very demanding domain requires a combination of roads, buildings, areas, and braille labels while zooming and panning through the map. Often information appears to be overlaid. Users were easily able to locate points of interest in three cities (Dresden, Leipzig and Chemnitz) based on live geographical data.

2.3 Tactons

Dots may move and the BrailleDis 9600 supports a frequency of up to 5 Hz for the complete display. This type of animation is well known on single-line braille displays: either all 8 dots are blinking or dots 7 and 8 are flickering periodically and indicate the position of the cursor. Tactons are made from graphical symbols and may be vibrating. They are often designed to find something on a tactile display easily and without the need for auditory feedback. They may alert the user and inform about an input mode. On a large tactile display arbitrary shapes may be blinking.
Icons are indispensable in graphical user interfaces to tell sighted users which kind of operations a particular user interface element allows. Text boxes allow for text input, circled radio buttons may be triggered to change their state. We converted the visual outline of many elements found in forms into tactons and evaluated them informally. It appears users can link labels and form elements (text fields, boxes, etc) without additional mark-up. Future work will have to show if this requirement for accessible web pages may be dispensable. In particular, using appropriate layout of braille and graphics worked well with PDF forms. Many authors are not aware of accessibility requirements in this domain and hence a large display may help to overcome many of the existing deficits.
The design of tactons is very demanding as readers may recognize a shape incompletely. Flickering dots lead to perceiving some movement, they create a sequential impact. We applied the concept of flickering tactons to teaching graphical shapes (Schmidt, 2009). Gestures may be simple and consist of a click or a swipe, but may have a complex shape if drawn. Often the direction and dynamics of such gestures needs to be communicated to the user as the type of information changes. For example a circle may zoom in if drawn clockwise or counter clockwise otherwise. A study on teaching gestures showed good results in training blind-folded people. Future studies will be needed with blind people training our systems with their own gestures.

3 Outlook

We have shown the three main meanings of braille dots applied within the Hyperbraille project. Braille, tactile graphics and tactons form each a unique modality for novel types of haptic user interfaces. Mastering these modalities as an artist, author, teacher, or proof-reader of accessible graphics may even create new job opportunities for blind people.
While braille has opened the world of text for blind people, it may be a touch-sensitive graphical tactile display that is needed to allow blind people designing, editing and exchanging graphics with other blind people. Collaboration with sighted people requires more efforts in designing appropriate software interfaces. Our experiences to link graphical data from standard applications with a graphical screen reader show similar deficits like in the early days when access to window systems was unknown. Future work on standardisation may raise the floor and increase the opportunities for braille and its siblings.

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