An Improved, Low-cost Tactile "Mouse" for Use by Individuals Who are Blind and Visually Impaired

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ABSTRACT
Although tactile mice, such as the VT Player by virTouch, have been developed to enable access to 2-D graphical information by individuals who are blind and visually impaired, they have yet to really be adapted by the community. We suggest that this is due to the significant lack of accuracy in the haptic position information, which is critical for individuals to haptically piece together a 2-D graphic. In addition, the VT Player suffers from a noticeable lack of spatial and temporal concordance between the kinesthetic and tactile information. In this paper, we present a low-cost (<\$400 US) alternative that avoids these problems. Furthermore, the dynamic response of the pins of our improved mouse can range from 0 to > 300Hz. This will facilitate the use of vibration and texture, which our preliminary results show improves the saliency of graphical information.

Categories and Subject Descriptors
K.4.2 [**Computing Milieux**]: Social Issues - *Assistive technologies for persons with disabilities, Handicapped persons/special needs.*

General Terms
Performance, Design, Experimentation, Human Factors

Keywords
Haptic mouse, VT Player, Braille, raised line drawings, embossed graphics, visually impaired, tactile graphics

1. INTRODUCTION
Traditional methods of presenting graphics to individuals who are blind or visually impaired involve creating physical raised line or embossed drawings. However, these types of drawings can be cumbersome to make, use and store, particularly when one considers dynamic environments such as analyzing data on a computer. One proposed alternative is to use a device having mechanical actuators that produce refreshable sensations on the skin [2]. Interfaced with a computer, this allows graphics to be made, stored and disseminated electronically. Several mouse-like devices have been created to do this [1,3]. These work by sensing the position of the device as it is moved, and then displaying local geometric information on its tactile display, typically by raising and lowering individual pins in a matrix. The only such device to be commercially available is the VT Player by virTouch.

However, the VT Player, and all other tactile devices that use an optical mouse sensor, suffers from a significant lack of accuracy in the haptic position information (which can be several cm). This information is critical for individuals who are blind and visually impaired to interpret tactile graphics as they are unable to obtain spatial information from the visual display. In addition, the VT Player has a significant delay in the pin response (approximately 200 msec) and a noticeable position error between the optical sensor and tactile pins, when the device is rotated. Some of these issues have been solved to varying extents [4,5]. This paper presents an alternate, low cost device that avoids all the problems mentioned above, as well as being more ergonomic and with a significantly larger temporal bandwidth than the VT Player.

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2. DEVICE DESIGN
The developed device has four components: (1) a tactile display component which utilizes a Braille cell (P16, Metec AG) and laboratory developed electronic driving circuitry, (2) an absolute position sensing component which utilizes a graphics tablet (VisTablet) and a laboratory developed RF transmitter tuned to the tablet, (3) an inexpensive digital input/output (DIO) hardware interface (National Instruments USB-6501) to interact with the Braille cell and the buttons on the mouse, and (4) a commercially purchased mouse case. The tactile display component of the device is controlled in software via a dynamic link library file (DLL) created in LabVIEW (National Instruments). The DLL can be used, along with the screen pointer position information, in any computer language to control the device.

For the tactile display component, the DIO interface was used to drive 8 relays in parallel, each controlling a pin of the Braille display. Solid state MOSFET relays were chosen for this application due to their excellent switching speed, lack of switching noise, and longevity when subjected to an extremely high number of cycles. The relays were a single pole double throw type. They function by switching their output between 200VDC and ground, effectively charging and discharging the capacitive piezo-bimorph benders to displace the Braille cell pins. Parallel drive of the Braille cell pins enables high vibration frequencies (> 300 Hz) to be obtained.

For determining the absolute position information, a radio frequency oscillator (made with a 555 timer circuit) and coil were used to create a small RF transmitter tuned to the graphics tablet. The transmitter and corresponding circuitry that came with the graphics tablet were not used due to their bulky size. Size was important as the RF transmitter needed to be directly beneath the Braille cell to ensure spatial collocation between the tactile display and position sensor.

The Braille cell of the tactile display, with the RF transmitter beneath it, was placed in between the buttons of a low cost, commercially available mouse case, replacing the scroll wheel. This provided a low-cost ergonomic design for the overall shape of the device. All other driving circuitry was contained in a box connected through cabling to the mouse (Figure 1).

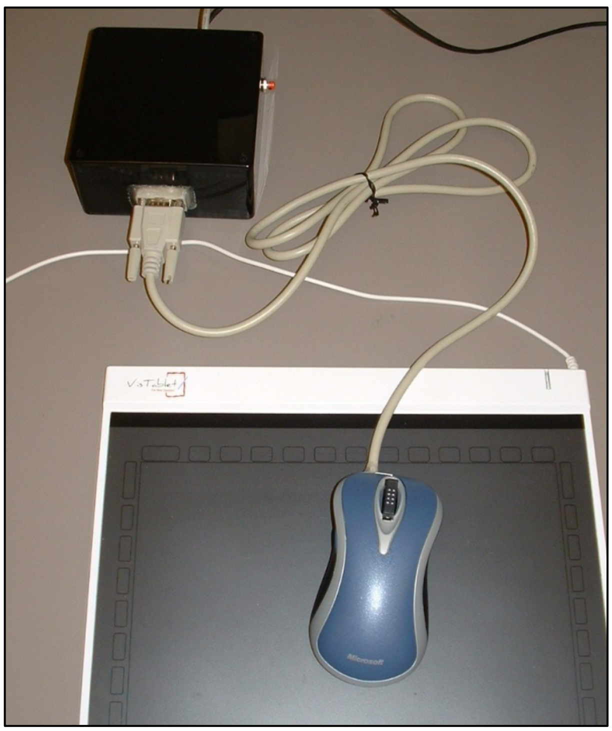

Figure 1: Final device prototype showing the graphics tablet, the mouse device, and the associated circuitry.

3. MATLAB INTERFACE

A MATLAB function was developed that uses the device DLL to haptically display up to three lines on a line graph. As the device is moved around, the pins are vibrated individually to indicate the presence of a part of a line at the corresponding pin position on the graphic. Each of the lines is represented by its own vibrating frequency (between 0 to greater than 200 Hz); at a given moment, different pins of the display may vibrate at different frequencies depending if they belong to one or another line. In addition, one of the mouse buttons can be used to obtain the coordinate position of the cursor on the graphic.

The lines were chosen to vibrate as it is hypothesized that vibrating lines are more salient, and therefore, more easily interpretable than static ones. In fact, the performance with vibrating lines may even be better than using raised line drawings/embosser graphics. This is, in part, expected as all the mechanoreceptors in the human hand are more sensitive to vibrating stimuli than to a static indentation. This hypothesis, as well as the most salient frequencies to use for multiple lines, is currently being examined experimentally.

4. PRELIMINARY RESULTS

Initial tests using the whole system show an imperceptible time lag between positioning the device over a line and pin activation. The spatial information obtained was also found to be highly accurate compared to optical mouse based devices. The dominant factor determining the spatial accuracy of the whole system was the time lag of the software. The actual time lag was approximately 40 msec, which, at typical hand movements of 60mm/sec or less, produces a spatial accuracy less than 2.5 mm.

Qualitative, preliminary results from an ongoing study evaluating a prototype system have shown that participants, including some who were blind, were able to analyze parts of a line graph, such as maxima and minima, and to point out these characteristics within pixels of the exact point. These individuals have also noted the ease of use of the device in tracking lines. So far, the results also show that participants were able to distinguish between two lines, each vibrating at a different frequency.

5. ACKNOWLEDGMENTS

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