A Multimodal, Computer-Based Drawing System for Persons Who are Blind and Visually Impaired

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ABSTRACT
Many individuals who are blind or visually impaired are interested in drawing tactile pictures, and some have already done so with static raised-line drawing kits. However, static raised-line drawing kits are problematic as they are non-erasable. Various computer systems, with or without accompanying device interfaces, have been designed to allow these individuals the ability to both perceive and construct their own drawings on a computer, but each with various drawbacks. A focus group was conducted to gain input from blind and visually impaired computer users on a new design. Based on these results, a new multimodal device design concept has been generated which will improve upon previous solutions and give graphic editing and viewing to blind and visually impaired individuals at a low cost.

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

General Terms
Design, Human Factors

Keywords
Haptics, drawing system, visually impaired, tactile graphics

1. INTRODUCTION
Pictures are conventionally thought of as visual entities; however, what is important about a picture is not the perceptual modality involved, but the spatial arrangement of information. For individuals who are blind and visually impaired, this information must be rendered in a form accessible though non-visual means. Words alone are insufficient to do this. To communicate, individuals who are blind and visually impaired should be able to create pictures that they themselves can access as well as sighted people. Many blind individuals already make tactile drawings with raised-line drawing kits. Thus drawing is not a foreign concept to them, but technology like that which enables sighted individuals to render computer-based drawings is still lacking.

Several such drawing systems have already been developed in research settings. Kurze [1] developed a system called TDraw in which a graphics tablet is overlaid with swell-paper to provide both digitization (tablet) and tactile rendering (swell-paper) of the drawing. This system enables object labeling and the saving of digital copies, but no erasure is possible. While Kurze's TDraw produces a haptic picture, Kamel and Landay [3] have developed a drawing system which communicates solely through the auditory modality and keyboard input. The IC2D Grid-based Drawing System does not use any external devices (except for a standard keyboard). Users appreciated the recursive grid-based system; however, this method does not provide any immediate, dynamic haptic interface through which to feel the drawing. Watanabe & Kobayashi [2] developed a drawing system that would enable users to freely erase any portion of their drawings. This was achieved by using a refreshable Braille display (64 by 48 pins) to display the drawing and a 2-axis arm coupled to a stylus to sense the user drawing on the display. This display allows digital copies to be haptically perceived, but the resolution of the display is 3 mm, the drawing field is limited, and the large refreshable Braille display is likely expensive.

2. FOCUS GROUP
In order to gain input from the blind and visually impaired population on a new design for a computer-based drawing system, a focus group was conducted at the Virginia Department for the Blind and Visually Impaired as part of their "Issues of Blindness" class, one of several classes offered as part of the Department's rehabilitation program. This class contained approximately thirty people; active participation was observed from many of the participants and a variety of experiences and degrees of blindness were represented.

Participants reported a variety of experience with computers, both before and after becoming blind, including using them for data entry, Internet shopping, selling items, accessing e-mail, and composing flyers. One individual who is blind reported drawing pictures and having a friend scan them into the computer. JAWS ™ seemed to be preferred as the screen reader of choice; no other assistive technology was mentioned. Experience with graphics included use of Microsoft Word ™ and PowerPoint ™ for the production of charts and flyers, although the latter was used when the participants were sighted. Some individuals also reported experience with digital photo enhancement and manipulation.

The individual who reported drawing also stated that she would sometimes outline her drawings with fabric paint so that other blind individuals would be able to feel them. She related that while creating copies of larger drawings was not a problem,

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making smaller ones proved difficult. Others stated difficulties in drawing objects to scale or matching halves of drawings.

When asked what they would expect in a computer-based drawing system, one participant expressed a desire for verbal guidance to aid drawing of precise dimensions. Other features included a simple saving method and the use of key commands to switch between drawings. Participants reacted enthusiastically to the suggestion of allowing verbal labeling and description of parts of an image. A desire for a large variety of tools and options to suit individual preferences was also echoed repeatedly. Not surprisingly then, participants expressed a desire for access to be redundantly available through both touch and audition.

When queried, the idea of an audible grid was accepted by the group. However, there seemed to be a strong preference for the grid system to inform the user which grid area they are in rather than alert that a gridline was crossed. A warning signal indicating the user was outside of the field of the workspace was also requested. When asked whether a free-handed drawing method (such as Kurze's device) or one with predefined shapes (such as the IC2D device) would be preferred, participants wanted the option of both. One individual also requested the ability to choose line thicknesses, a feature often found in visually-based computer drawing programs.

Some individuals stated they would prefer to draw with one hand (preferably with a stylus) and feel with the other, while others felt that it may be confusing to perform the two tasks with two separate hands and preferred to draw and feel with the same hand. Overall, the participants were very enthusiastic and felt that such a device would be very useful in their lives, with applications ranging from making birthday cards to education, research, orientation and mobility.

3. NEW DESIGN CONCEPT

Based on the feedback from the focus group and design inputs defined by Kurze [1], a new computer-based drawing system has been designed, consisting of a multimodal display able to engage the user's visual, haptic, and/or auditory sensory systems. The variable-amplitude haptic distributed display device developed in the Haptics Laboratory at Virginia Commonwealth University, which includes a Braille cell tactile display with an absolute positioning system [4], will be used as the haptic display for sensing what is drawn and potentially also as the drawing tool itself: the user will have the option of either using a graphic tablet stylus to draw in one hand while actively moving the haptic display device on the drawing surface to sense in the other, or to use the device to both draw and sense the haptic rendering of the drawing. This system will compensate for the drawbacks inherent in previous designs described above: the drawing will be able to be erased and edited, digital copies will be immediately accessible, an affordable and refreshable haptic display will be provided, and the active accessible surface will cover an entire graphics tablet. The system will be able to be operated solely through the haptic system, making it accessible to individuals who are deaf-blind, as well as those that prefer this method. An added auditory portion of the display with both auditory labeling and sonification will enhance the user experience. Vision will be included for those who are partially sighted and to aid potential sighted users of the system such as educators of blind students who wish to create haptic diagrams.

As per the focus group results, a grid system will be implemented in which the user can select the grid size, which will divide the drawing surface into m x n sections. Keyboard commands will elicit a verbalization of grid location, enable the user to record a verbal label or description of what is contained in the grid, or play back what has been recorded in the grid. The grid will also be able to be rendered haptically, making use of the capability of the haptic display device to achieve multiple pin amplitude levels, using the smallest level as the grid, the intermediate level as the established and saved drawing, and the highest level for new edits being drawn. Since the system concept inherently supports free-handed drawing, no additions are needed to fulfill that function. However, a library of predefined shapes will be included, as requested, which can be placed using a select, click, and drag method. Through the software interface, the drawing will be able to easily be saved, switched, reviewed, edited, and distributed.

Most uniquely, this system will allow the user to "paint" in textures, analogous to colors, which can be tactually distinguished. Virtual textures have been developed in conjunction with the haptic display device, whose capability for multiple pin amplitudes enables the rendering of textures that can vary in amplitude, temporal frequency, and spatial arrangement. Many different textures can be rendered, and a large selection will be available for the user to fill lines, shapes, and areas of the drawing as he or she desires.

4. CURRENT IMPLEMENTATION

To date, a limited version of the new design has been implemented in MATLAB using the haptic device. A more complete embodiment is being constructed in C#, with plans to incorporate Microsoft ™ SDKs which enable the use of multiple pointing devices. The completed version will be subjected to user testing.

5. ACKNOWLEDGMENTS

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