A CASE STUDY IN THE DESIGN OF SOFTWARE THAT USES AUDITORY CUES TO HELP LOW VISION STUDENTS VIEW NOTES ON A BLACKBOARD

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This ongoing project investigates the interplay between educational technology, pen-based computing, and auditory displays with respect to the design of assistive technology for low-vision students in a classroom setting. Specifically, we report on the design, implementation, and evaluation of a software system named v-VIS (Viewer for Visually Impaired Students) that addresses the problems low-vision students have in seeing material which may be written on a blackboard or overhead projector in a traditional classroom setting. Instead of writing extemporaneously on a blackboard or overhead projector, the instructor in a v-VIS enabled classroom uses an electronic stylus to write and sketch material freehand on the surface of an electronic video tablet. Material written on the video tablet is input into a computer projection system which displays it on a screen at the front of the room, thereby allowing fully sighted students to view the material much as they would if the instructor was writing on an overhead projector. The instructors writing is simultaneously transmitted to a computer located at the low-vision student's desk where this material is displayed using color adjustment, zoom, and audio cues. Several distinct auditory cues are used to inform the low-vision student when new material begins to arrive on the screen, how long this material continues to arrive, and which region of the screen the material is being displayed on. Work on the v-VIS system has been informed both by a formal user study comparing several different audio cue designs, and by gathering feedback from a low-vision student who used the system in a semester-long statistical methods course.

SONIFICATION OF DYNAMIC CHOROPLETH MAPS: GEO-REFERENCED DATA EXPLORATION FOR THE VISION-IMPAIRED

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Interactive data visualization tools are helpful to gain insight about data, find patterns and exceptions, but are usually inaccessible to vision-impaired users. In the case of geo-referenced data where users need to combine demographic, economic or other data in a geographic context for decision-making, we designed YMap, a dynamic choropleth map tool that visualizes data attributes on the choropleth map and enables slider-based dynamic queries. User studies show that YMap can help users find specific geographic regions that match a query and retrieve details, find trends and patterns or detect the correlation between attributes. As our first step to design a multimodal (audio+haptic) counterpart exploration tool for the vision-impaired, we created a virtual spatial sound display for the interactive map by synthesizing 3-D sounds of various timbres and pitches using head-related transfer function (HRTF) and tying these sounds to map regions and interface widgets. The 3-D sounds create the effect of a virtual map hung on the surface of a large virtual sphere with the user sitting in the center. Three audio interactions have been implemented: (1) gliding the cursor over the map to examine the sound of individual regions; (2) adjusting dynamic query sliders and hear the sounds of regions being filtered-out / filtered-in; and (3) using sweeping lines to scan the map and hear the sound patterns. We designed an interface using either keyboard or tablet. Our research goals are to identify effective sonification mechanisms, especially as applied to dynamic choropleth maps, explore coupled use of tactile perception with sound for maps, and examine the effectiveness of our tool in helping vision-impaired users in large geo-referenced data set exploration. We also want to investigate the sonification of maps for sighted users to use over the telephone or as a complement to visual modes.

SONIFICATION OF SQL CONSTRUCTS IN MULTI-MODAL DATABASE INTERACTION

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This work integrates sonified output of database queries with screen reader (SR) technology, to provide visually impaired users with an efficient means of reviewing results of SQL queries. A further goal is to develop effective sonifications of standard SQL constructs.

SRs provide access to results of database queries, however, problems in efficiently assessing tabular information ar well documented. We have employed sonification [1] to provide visually impaired students and workers with a rapid overview of query results, both as an end in itself or prior to more detailed review with an SR.

SQL was chosen as it is a widely used database language, the development of effective sonifications of standard SQL constructs will itself be valuable. CSOUND was used to render the sounds, as it enables the parameters of realtime sonifications to be data driven. JAWS was used as the SR.

Standard user queries wer supplemented by "sonification queries," which extract and format data to be sonified. These data values are used to vary parameters of notes rendered by CSOUND. Parameters that have been examined include start time, duation, frequency, amplitude, wave-shape, and panning.

The approach has been used in educational and commercial settings. Task completion times reduce significantly when understanding the results profile is important, and as the numbers of output rows and columns increase.

Sonifications have been developed for gropuing, ordering, UNION, INTERSECTION, and RESTRICT queries. These, and the comparative effectiveness of spatial and/or temporal presentations of results will be demonstrated at the workshop.

[1] Rossiter, D. "Using Csound for sonification," additional chapter 15 on second accompanying CDROM for *The Csound Book: Perspectives in Software Synthesis, Sound Design, Signal Processing, and Programming*, R. Boulanger (editor), MIT Press, 2000.

WYSIWIH — WHAT YOU SEE IS WHAT I HEAR: GIVING BLIND USERS ACCESS TO VISUAL COLLABORATION

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The goal of this project is to investigate how collaboration between blind and sighted users can be facilitated using computers, and to what extent sound can be used as the only means of output for the blind user.

One of the main assumptions of this work is that it is important not only to find a solution that is accessible, but also that it mimics its graphical counterpart both in the presentation of and the interaction with the information. The reason for this constraint is the belief that an important part of the collaboration is the sharing of not only the goal but also the means of achieving that goal. In a collaborative setting, this enables the users to share their work, to give and receive help, to exchange ideas and workarounds to common problems etc.

In a collaborative study of cross-modal collaboration, a blind and a sighted user played a game taking turns in moving towards a shared goal. The subjects did not share any of the presentation, the sighted subject did not hear what the blind subject heard in the headphones, and the blind subject did not see what was presented on the sighted subjects screen, but the underlying model of the game was the same.

This collaboration involved mutual understanding of the locations of the objects, negotiating the strategy for solving the game, collaborative error recovery, and effective turn taking.

The results suggests that for the blind subject, the auditory interface was used as an added resource rather than being the primary means of understanding the game. Sound together with memory, interaction with the other subject, and gestures was used to understand and play the game. Additionally, sound was used differently whether it was the blind or the sighted subject's turn to move.

A GAME FOR VISUALLY IMPAIRED CHILDREN WITH A 3-D VIRTUAL AUDITORY DISPLAY

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To those who are blind or visually impaired, it is extremely important to make the most of auditory and tactile perception as an alternative to the lost or weakened sense of sight. These senses can provide them with many cues to recognize objects' positions, configurations, sizes, velocity, and other crucial pieces of spatial and temporal information. The recent advancement of virtual auditory systems (VAD) will prove to be very useful for the education and training in developing the ability to gain spatial information through alternative paths of recognition. Moreover, the idea of VAD systems could also be applied to daily entertainment equipment, i.e. computer games which entertain players only with sounds may be developed on VAD. In this study, therefore, we attempted to develop an "edutainment" system with which visually impaired children can improve their capability of space recognition by playing a game as application software of a hand-made 3D VAD. Moreover, perceptual characteristics for sound localization were measured both for visually impaired and for sighted subjects. Results show some differences between impaired and sighted subjects. The game was named "Hoy-Pippi." In this game, a monster appears in a random 3-D position and shouts "Hoy-Pippi." The player's objective is to attack the monster using a short rod with a position sensor at its end. If the attacked position agrees well with the acoustically prescribed position, he/she gains a point. Results show that players generally enjoyed the game and that a gradual increase in points was observed for most participants, suggesting a positive effect of this type of training on spatial recognition among visually impaired subjects.