Transitory Graphical Displays for the Blind

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There is a need for hardcopy and transitory graphical displays for the blind. However relatively little is known about the optimum presentation of graphical information in a non-visual form, particularly for multi-modal displays.

Most computer-related aids for the blind are for conveying textual or numerical information by tactile or auditory displays. These displays may be time invariant such as braille embossed on paper, or be transitory such as a refreshable braille display of raised pins. However there is much information which sighted people have presented in graphical form which is difficult to present clearly in textual form to the visually handicapped.

The conventional approach is to use an embossed map or diagram, with the text displayed as braille. Variation in the type and elevation of point, line and areal symbols can facilitate the tactual reading of a graphical display. For instance Schiff, Kaufer and Mosak (1966) showed that a line saw-tooth in cross-section can be useful for conveying directional information since the line is smooth in one direction and rough in the other.

Of the thirty systems that have been developed for producing embossed maps and diagrams for the blind (Gill, 1974), most are very labour intensive and therefore expensive if paid staff are employed. The problem is exasperated by the optimum conversion from a visual presentation to a tactual one being more of an art than a science. At present this conversion requires human intervention in all but the simplest graphical representations.

Here is an obvious application for computer-aided design; the task has similarities to the preparation of artwork for integrated circuit masks or a multi-layered printed circuit board. One such system was developed some years ago (Gill, 1973), and it has been further developed by Clark and Balsam (1982) and Fries (1983).

This system uses conventional interactive graphics on a visual display unit for the design stage, and the computer then controls an engraving machine to produce a negative master. A positive is made in epoxy, and plastic copies are vacuum formed from the positive master.

This system produces good quality tactual output but it would be improved if the computer could directly generate the embossed map or diagram. However this would only "solve" part of the problem. There is an increasing requirement for a refreshable non-visual graphics display.

There are about six paperless braille devices commercially available (Gill, 1984), but they all have a single line of braille display. Maure (Foulke, 1981) and Rose (1979) are developing page braille displays which will have advantages over line displays for tabular material and simple graphics. However there is a limit to the amount of graphical information that can be displayed with evenly-spaced single-elevation dots.

This problem will become more acute with increasing use by the blind of digital information systems. For instance the British Telecom Prestel viewdata system can now be output in braille (Gill, 1981); this is just the alphanumeric data with the graphics being ignored. This type of system will be much easier to use when page braille displays are commercially available at a reasonable price.

The problem is not only one of hardware but also software since the optimum conversion is likely to require a complex algorithm.

If the text is displayed in braille it does not mean that the graphics must be in a tactual form. For instance one could consider a display which uses both auditory and tactual stimuli. Such a proposal is not new but little research has been done in this area. One possible configuration would a x-y plate which when touched gives an audible signal which varies in frequency and amplitude according to two dependent variables at that x-y coordinate.

Before designing such a display it is important to ascertain the factors which determine ease of use by a blind person. This is a far from trivial task which has received comparatively little attention.

Research has been mainly concentrated on audio displays partly because they are much easier to design and build. Pollack and Ficks (1954) studied multi-dimensional auditory displays in which each variable had only two states. They found that, in general, multiple stimulus encoding is a satisfactory procedure for increasing the information transmission rate associated with such displays.

Roffler and Butler (1968a) found that listeners could locate auditory stimuli accurately in the vertical plane when the stimulus was complex and included frequencies above 7kHz. Roffler and Butler (1968b) then found that subjects tended to place the audio stimuli on a vertical scale in accordance with their respective pitch. Higher-pitched sounds were perceived as originating above lower-pitched sounds.

A variety of two dimensional auditory displays have been built; for instance Black (1968) developed a display where the horizontal coordinate was represented by time delay and amplitude of the signal and the vertical coordinate by frequency (100-400 Hz). Fish and Beschle (1973) also used frequency (200-7000 Hz) for representing the vertical position of the scan but interaural differences (up to 40 dB) for the horizontal.

Phillips and Seligman (1974) developed a multi-dimensional auditory display in which frequency, amplitude and timbre are all utilised. Robinson (Gill, 1975) also developed a two dimensional display, where the frequency of the signal depends on the vertical coordinate and time delay for the horizontal. However there has been little systematic comparison of the various types of auditory displays even though Kramer (1962) mentioned the need for this nearly two decades ago.

Davall and Gill (1975 & 1977) developed two performance parameters for assessing displays but they would be difficult to apply in practice to multi-modal displays.

That the foregoing has been more a catalogue of problems rather than solutions reflects the lack of research on computer-generated graphics displays for the blind. It is important that the next generation of displays are scientifically designed to be optimum for the user and not just the easiest to manufacture.

References

Black W L "An Acoustic Pattern Presentation". Research Bulletin of the American Foundation for the Blind, No 16, May 1968, pp 93-132.

Clark L L & Balsam M "The Baruch College Tactual Graphics Facility: A Progress Report". Braille Research Newsletter, No 13, June 1982, pp 34-37.

Davall P W & Gill J M "A Method for the Comparative Evaluation of Visual and Auditory Displays". Research Bulletin of the American Foundation for the Blind, No 29, June 1975, pp 9-21.

Davall P W & Gill J M "A Comparison of Human Operator Transient Response to Visual and Auditory Displays". American Foundation for the Blind Research Report, ISBN 0 89128 952 6, 1977, 27 pp.

Fish R M & Beschle R G "An Auditory Display Capable of Presenting Two Dimensional Shapes to the Blind". Research Bulletin of the American Foundation for the Blind, No 26, June 1973, pp 5-18.

Foulke E "Braille Research in the Perceptual Alternatives Laboratory". Braille Research Newsletter, No 12, 1981, pp 17-20.

Fries P "A New CAM System for Tactual Graphics". Braille Research Newsletter, No 14, July 1983, pp 14-17.

Gill J M "Design, Production and Evaluation of Tactual Maps for the Blind". PhD Thesis, University of Warwick, 1973.

Gill J M "Tactual Mapping". Research Bulletin of the American Foundation for the Blind, No 28, Oct 1974, pp 57-80.

Gill J M "Auditory and Tactual Displays for Sensory Aids for the Visually Impaired". Research Bulletin of the American Foundation for the Blind, No 29, June 1975, pp 187-196.

Gill J M "Microprocessor Braille Systems". Computers and Braille Conference, Toulouse, France, Sept 1981.

Gill J M "International Survey of Aids for the Visually Disabled". Research Unit for the Blind, Brunel University,