ACCESS TO COMPLEX ENVIRONMENTS FOR BLIND PEOPLE: MULTI-MEDIA MAPS, PLANS AND VIRTUAL TRAVEL

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Abstract

In the introduction, some properties and use of tactile maps are considered. The paper then presents a new way for sighted and blind people to make tactile maps and plans: called **AudioCAD**, where **CAD** stands for Cant Anyone Draw? Then the reading of such maps and plans is considered, using the **TouchBlasterNomad**, multi-media audio-tactile system, incorporating the generic descriptor, **AudioPICTURES**. Audio-tactile maps and plans, a subset of all possible AudioPICTURES are then presented as elements in a static, interactive spatial information access system. Finally a dynamic interactive geographic information system for blind travellers is described, allowing real time, actual and **virtual travel**. The system is called **AudioTRIP** [1]. AudioCAD and AudioTRIP together form a package called Bumpy Pictures, compatible with the **TouchBlasterNomad** system. The information access system and AudioTRIP may be thought of as **remote sensing** systems for blind people.

1 Introduction: MAPS - the doorway to dreams and independent travel [1]

"We always knew that blindness was a nuisance!"
(Dr. Abraham Nemeth to R&D Committee of US NFB December 1994) [2]

"It is very difficult for them [blind people] to integrate individual geographic features into a coherent spatial representation and, generally, to comprehend the spatial relations of these features on a large scale [complex] environment"[2]. Philosophers of the 18th and 19th centuries, including Berkeley and Brown have proposed that 'if priority of sensation alone were to be regarded, the sense of **touch** might deserve to be considered in the first place; as it must have been exercised long before birth, and is probably the feeling with which sentient life begins'. Making maps for people who cannot see at all or who cannot see at all well with spectacles requires the creation of a world to touch in a world of touch. This is no mean task.

A **tactile** map or plan is one that can be interpreted by a person, without sight, using touch as a primary substitute to sight. An **auditory** map or plan is one that can be interpreted by a person, without sight, using hearing as a primary substitute to sight. An **audio-tactile** map or plan is one that can be interpreted by a person, without sight, using touch and hearing, simultaneously as substitutes to sight.

The TouchBlasterNomad audio-tactile system has been developed to enable synchronous reception of tactile and auditory stimuli for map making and for map reading.

It has been argued [3] that tactual perception, like visual perception, suffers from interference effects. These can either be intramodal, where another tactual stimulus interferes with the perception and encoding of a first; or inter-modal, where a stimulus from another sensory modality competes with touch for attention. Intra-modal interference is more disruptive to memory than inter-modal interferences [4, pp.

349-368]. An example of such disruption occurs when the processing of spatial information, points and lines for instance, is interrupted by the presentation of tactual verbal information (Braille) when labels are interspersed with such tactile graphical symbols. Dodds [3,5] has written that this is due to simple interference as well as attentional switching between the right and left hemispheres which are differentially suited to processing spatial and verbal information.

"In the case of a visual map the spatial information is available simultaneously to the eye due to the complementary activity of the two visual systems" [6], however in the case of a tactile map the spatial information must be gathered sequentially over time. This means that short term memory is therefore involved [3].

With a tactile map Braille is required not only to label features but sometimes also to explain the purpose of a symbol or a section of the map. Some of the associated problems have been alluded to above. In a statement to the R&D Committee of the National Federation of the Blind in the USA, December 1994, Abraham Nemeth [2] wrote as follows.

"It has for too long been assumed that blind people, in particular those who are congenitally blind, have no real ability to use maps, or more generally graphical information. For people with normal sight, pictures are the "native" means of communication. No one has to be taught to comprehend a picture. Children at a very early age can associate a picture of a familiar object with the real object and call it by name. Text is by no means a native method of communication. Learning to read and write is laborious and takes several years of learning and practice to acquire a creditable skill. Some people remain illiterate or semiliterate throughout their adult life, although they can perceive the content of a picture immediately. This is why pictures have so much more appeal than written text.

<u>Although I am congenitally and totally blind, many of my mental activities are visual.</u> When I read with the Optacon, the point appears in my mind's eye as black letters on white paper. I have to remind myself from time to time that my left index finger and not my eyes, is the input channel. When I deal with geometric figures, even with three-dimensional ones, they appear in my mind's eye as having been formed with white chalk on a blackboard. The figure in my mind is complete with labels for the points, lines and planes. When I discussed such figures with my students during my teaching days, I could read the labels off the image as surely as if I were reading them from an open page before me. No other mental process other than "reading" was involved. WE ARE "WIRED" THAT STRONGLY TO RECEIVE AND RESPOND TO VISUAL STIMULI.

That much having been said, a picture is meaningful only if the object which it depicts is familiar. An untrained [person] , for example, could not look at the picture of a double helix and recognise it as the basic structure for DNA. Therefore, a verbal explanation would have to accompany such a picture in a textbook where the double helix was first introduced. Would the verbal description alone enable you to comprehend this double helix? Probably not. The verbal description is intended to help you understand the picture better. On the other hand, the picture by itself would have no meaning without some accompanying explanation.......

Nemeth continues and makes repeated and emphasised reference to the dominance of graphical imagery and symbols and puts forward a strong plea for the development of a code for

[1] The oral presentation will be supported by a short video. Interested readers are invited to contact the author on Internet email "quant@peg.apc.org" or fax + 61 2 484 4717 for details about access to a copy.

[2] Dr. Nemeth's permission to quote this statement is greatly appreciated.

the classification of visual images. He quotes Tevye, the harried poverty stricken character in Fiddler on the Roof who turns his eyes toward heaven and pleads,

"Please, Lord, send us the cure; the disease we already have".

2 Making tactile graphics with AudioCAD system

Andrew Tatham, co-chair of the Tactual Mapping Commission made a similar plea some years ago when he wrote: "For blind and visually handicapped people to be able to fully participate in the 'graphical revolution' and benefit from the same knowledge and information as their sighted peers, systems must be developed in this century to provide access to graphically based data just as Braille was developed in the last century to give access to textually-based data..." [7] The accessible map may be one of the cures that Nemeth alludes to, through Tevye.

AudioCAD has been designed to enable blind and sighted people to prepare maps and plans, designs and other graphics that can be embossed or printed. The primary design objective has been to enable blind people to express their visual mental activities (as Nemeth has described them). When this involves map or plan related images it seems likely that everyone is going to gain a very great deal more understanding of the shape of the world as it might belong to blind people.

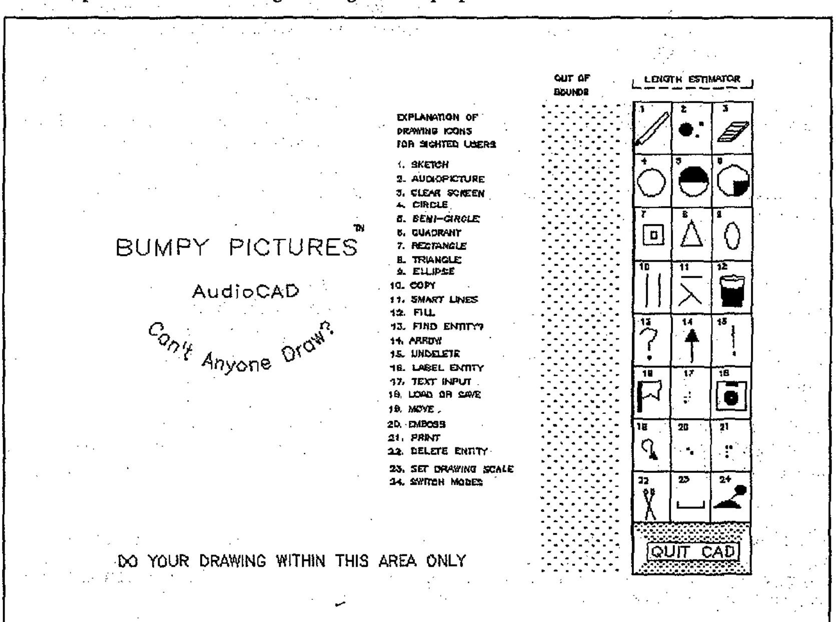

Figure 1: AUDIOCAD DRAWING TEMPLATE

The AudioCAD system uses either one of three touch sensitive surfaces, at A3 or A4 size, together with a voice synthesis system. The touch sensitive platform is serially connected to an IBM PC or compatible computer. The system is DOS based: the Windows environment still being a difficult one for blind people to handle.

An audio-tactile template (Figure 1) is placed on the surface of the touch sensitive platform (see Figure 2 for a diagram of the TouchBlasterNomad pad) and up 24 drawing functions may be selected, including orthogonal lines, lines of specified degree and length, gravity and snap facilities enable blind designers to produce precisely connected lines and circles, rectangles, and other geometric shapes may also be drawn. Entities may be copied, moved and deleted and Braille text may be added to any design, from the keyboard. A single switch transforms the design from an embosser based image to a vector graphic that may be printed directly, with a Braille text transformed to normal characters.

The blind designer, cartographer or artist is able to hear the shape and position of every item drawn. Immediate embossing of any stage in a design gives the blind designer additional feedback about the drawing, allowing editing and new versions to be developed. The completed, embossed drawing may then be enhanced as with synthetic speech labels or if a SoundBlaster card is installed, digital speech or environmental sounds may be added to the drawing, map or plan. If the map or plan that has been drawn is sent to a dot matrix or thermal printer with carbon ribbons, it is possible to print directly from the AudioCAD system onto a capsule paper, such as Flexi-paper and when heated the carbon black lines rise to form a strong tactile image [3].

3 Reading tactile graphics with the TouchBlasterNomad system

The system, generally referred to simply as "Nomad" is an integrated, interactive, multi-media and multi-lingual system that enables a wide range of map and plan scales to be presented at high resolution (in many instances in precisely the same form and scale as would be used by a sighted person). Like AudioCAD, the system works in the IBM and compatible environment, under DOS with serial connection between the Nomad pad and the computer. At the time of writing the system only functions on the high resolution Nomad pad , Figure 2.

Although designed for use with tactile images, print maps and plans may also be prepared for use on the system, without need for a tactual stimulus in cases where for instance shape is not important to the blind user. For blind users the relative position of map entities, say buildings is usually more important than the shape or even the size of the buildings. A map of a university campus for instance may be produced as a number of "layers", or **fragmaps**. Fragmaps are fragments of the total structure and one or more fragmaps may simply present the positions of buildings as sounds, another fragmap presenting paths of difficulty order A and so forth. Non tactile maps may be very helpful to recently blind people who have visual memory of the shape of places but require point information to enable reconstruction of the absolute and relative location of map entities. The TouchBlasterNomad system enables such access.

[3] Flexi-paper is a new product by Repro-Tronics of New Jersey. It has two outstanding qualities. The first is that the paper cannot be crushed with 'normal' rough handling. This has obvious advantages where a tactile image is concerned. The second property is that it is extremely responsive to a range of carbon based drawing tools, including the not so humble 3B pencil. Heating may be undertaken using the Repro-Tronics fuser or any other heat source to 130°C.

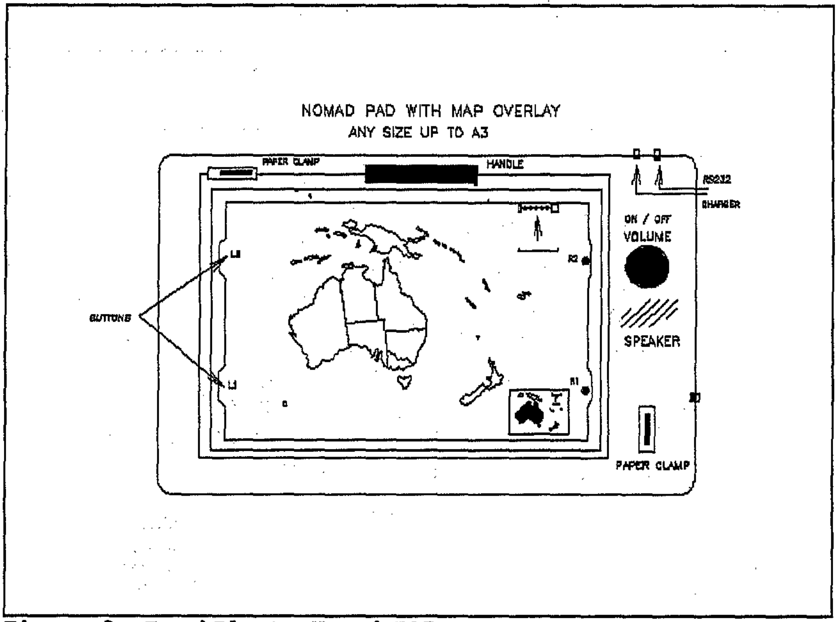

Figure 2: TouchBlasterNomad PAD

The system is **integrated** because touch and hearing are synchronised such that almost any part of a map or plan has a speech or other sound associated with it, when touched. The system is **interactive** because the user can ask the system questions about the map or plan, relating directly to compass or egocentric direction, absolute and relative location, straight line and route distances, perimeter and area. The user also **interacts** by editing the map or plan, adding information to any one of about 9000 addressable points at three levels and adding real world environmental sound to features on a map, maximising the possibility for sensory substitution and reducing the effects of intra-modal interaction, as would be present if Braille were used to carry the same level of information.

The system is **multi-media** because it combines a number of independent channels for the presentation or transmission of information: <u>touch</u> where tactile surfaces carry detailed information, <u>hearing</u> where synthesised speech and digitised sounds including speech can be used, independently or synchronously. In other words, it is possible to touch a feature on a map or plan and listen to the digitised sound at that location, perhaps the sound of a great waterfall on a contour map while <u>at the same time</u> listening to a synthesised speech description and explanation of the feature and the associated process.

The system is **multi-lingual** because any language can be used to place information on a map using the

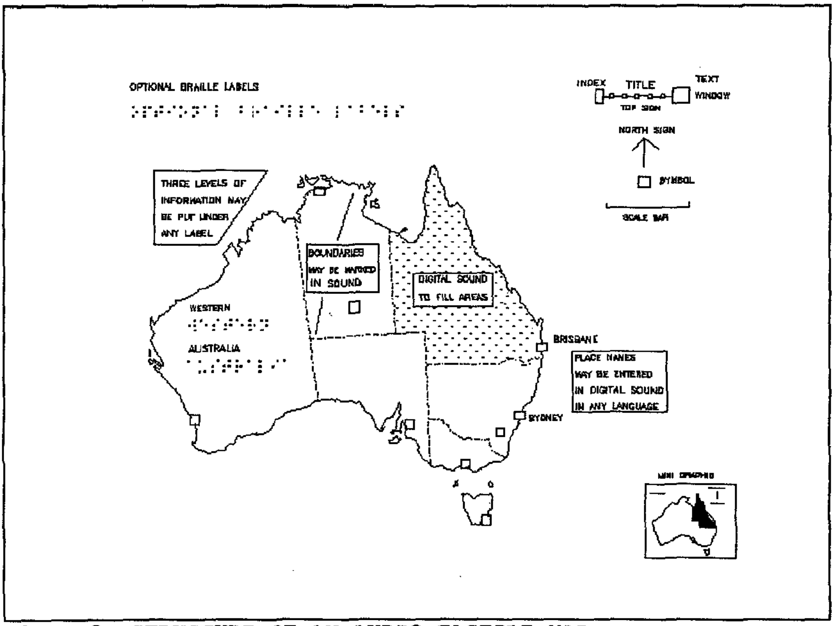

Figure3: STRUCTURE OF AN AUDIO-TACTILE MAP

digitised speech input facility. Limited only by hard disk storage space there is for most practical purposes no limit to the amount of speech that can be used. Speech synthesisers[4] in any language may be used to generate spoken output from maps and plans in the absence of a digital SoundBlasrter card. The speech synthesiser built into the Nomad pad will handle English, Spanish, Portuguese and Brazillian[5] . Figure 3 above shows the key elements in the structure of an audio-tactile map prepared for use on the Nomad system.

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[4] The internal synthesiser in the Nomad pad is programmed for English, Portuguese and Spanish and it is hoped that this capability will prove an advantage when the system is used in a project proposed by cartographers and members of the the tactual mapping commission of the ICA for production of a tactile electronic atlas of Latin America, through a project of the Pan American Institute of History and Geography (PAIGH). Key persons in this initiative are Dr. D.R.F.Taylor (President of ICA) and Dr. Regina Vasconcellos, University of Sao Paulo, Brazil. Further details of this project may be obtained from Dr. Taylor at Carleton University, Ottawa or Dr. Vasconcellos,.

[5] The Portuguese language for Nomad has been developed by Maria de Lourdes Braga Pereira of CENTEC, Porto and the Brazilian (Portuguese dialect) has been developed by Marrey Perez of Sao Paulo. Both were delegates to the 4th ICA International Tactual Mapping Symposium at the University of Sao Paulo, Brazil, in February 1994.

With the Nomad system the tactile map or plan is enhanced by inter-modal information in the form of sound. The views of Dodds and Brooks referred to in the introduction are further supported by recent controlled experimental study in Australia [8]. It was found that haptic retention was enhanced by the addition of auditory signals to tactile shapes. In other words, intermodal stimuli enhanced the legibility of the raised image.

3.1 Materials and methods

Any sort of tactile material may be placed on the pad's surface. Typically the tactile information will have been embossed, printed with puff inks through screen printing or copied using capsule paper, a recent outstanding development of this material being Flexi-paper, an uncrushable paper by Rero-Tronics of New Jersey.

To give the graphic greater durability, in some instances it is possible to use a low micron lamination, taking care not to cause "tenting", especially between any Braille symbols. Art gloss sprays can also be applied to completed graphics to encourage durability and cleanliness. Thermoform and colour, preprinted, as undertaken most exquisitely by Professor Joe Wiedel, co-Chair of this Commission, are also easily adapted to the TouchBlaster System. If the embossing is greater than 3 millimetres or so it is advisable to fill the back of the graphic with a polystyrene foam or other material. The Swedish and Norwegian mapping authorities have recently collaborated to produce tactile maps for the Winter Olympics in Lillehammer, and it is hoped that through the innovative work of Mats Dahlberg they will continue to produce exciting tactile maps for blind people.

It is also possible to use three dimensional objects on the system surface, topographic features for instance and with the use of 1:200 scale models as used in model railways for instance, complex 3-D scale urban or other environments may be created, on which vehicles and people, also to scale, may be moved, with appropriate digitised sound files to enhance the spatial information.

3.2 Digitised sound multi-media graphics

With multi-media available and no requirement for Braille code, tactile maps and plans can take on new and exciting properties. These are now briefly outlined. Though they are not essential to the functioning of the system, they are recommended components in the design of graphics that use this system. See Figure 3 for some details.

3.2.1 The size of the graphic image on the TouchBlaster System

In principle the graphic, map or plan should aim to be as <u>small</u> as possible. More specifically, the less the importance of shape, and the greater the importance of relative position, the smaller the graphic should be. Recall that a Braille cell is also <u>rather small</u>, and not <u>rather large</u>! The special needs of the user should also be borne in mind . Young children have small hands and fingers. Their span is small, the graphic should be small. Of course, users will not always be small children and a sensible decision needs to be made, where possible taking into account the biographical and physical characteristics of the user. Perhaps the most important biographical factor being the period of blindness. Established guidelines should be followed wherever tactual discrimination, as such, is critical. This is especially so in the separation of lines and symbols. Essentially Braille dot spacing is a minimum. With some methods of tactile line printing, such as high mesh screen printing, very narrow lines can be produced and this further enables higher resolution drawings, with lines closer together [9].

3.2.2 The Top sign symbol and its contents

Please refer to Figure 3. The top sign has three components and one purpose. The purpose is to identify the correct positioning of the graphic. Braille is no help here if one cannot read Braille. The components are a box on the right. This contains an ASCII text file or a digitised real speech file. The feature itself is known as a text window. This particular window will usually contain a description of the graphic and its purpose. The speech may be input by microphone. It should be the first point sought on a Nomad graphic. The "string of beads" contains the title. The left hand box contains an index to the entire graphic. This index may be printed or translated to Braille as it is an ASCII file.

3.2.3. Scale bar and direction arrow

A linear scale and north arrow provide tactile cues to the map scale and the orientation of features. The "arrow" is not usually a good tactile symbol. It is used here because its "meaning" is immediately understood, upon touch. The system enables calculation of linear and irregular route distances, areas of any shape, perimeters and directions, as compass or egocentric readings. The latter are most helpful in a building. If scale has been set when the graphic was created, the system undertakes all further calculations when two or more points are pressed according to need. A linear scale can be set and reset at any time.

3.2.4. The mini graphic

This feature should appear in the lower right of the graphic (Figure 3). It is a simplified miniature of the main graphic, **intended as a pictorial index to the main graphic** giving the user an idea of the distribution of tactile information. When the mini graphic idea was first developed it was my intention that it should be a literal miniature of the main graphic, enabling a sense of shape to be acquired. In some cases this is still possible, but the constructive comment or many teachers and blind users has been that it should be as simple as possible, emphasising the "fragments" or main components of the map or plan, thus providing relative location information; a map of the map if you like. Speech and other sound can be added, of course.

3.2.5 The preparation of sound related information for a map

Once the map or plan has been drawn, by whatever means, and transformed into a tactile format, it is then necessary to "write" information onto it. In terms of TouchBlaster graphics this means putting sound into the map space.

There are essentially three sound types that can be placed onto a graphic: synthesised speech in a range of languages: nine computer generated frequencies for "painting" onto lines and into areas: digitised sound, including speech in any language or any real world sound, recorded in situ and transferred by microphone or jack to the map. Digitised sound and synthetic speech can be entered using either the **direct** method or the **indirect** method of data input.

The direct method involves typing or recording information into the graphic and touching the appropriate areas into which that information is to be placed, one item at a time as each is entered on the keyboard. The indirect method, available with version 6.0 (1994) allows the creation of all levels of information[6] including text windows as a file with the extension INP, using a text editor such as DOS EDIT or a word processor in ASCII mode. Nomad takes control of the input and prompts the map or plan maker for the appropriate response. The sound information may be entered into a "single" point or into a large area such as an ocean. It may be placed onto horizontal and vertical lines and onto lines of any other shape. The sounds may be retrieved from files recorded "on location" .

It is also possible to create text windows at any desired point or points on a graphic. Such a text window will be given a tactile signature, perhaps no more than a box with a hatch pattern in it. When

[6] Lower level information usually expands on the information at the level above. It may also be used to ask questions and provide answers though this would not be usual in its use with maps and plans.

the box is touched, a synthesised or digitised speech message can be heard, as can other sounds. If digitised speech is used it is possible to listen to synthesised speech at the same time. With judicious placement and file size design it is possible to set up a dialogue between the synthesised sound source and the digitised sound source.

4 The integrated spatial information access system

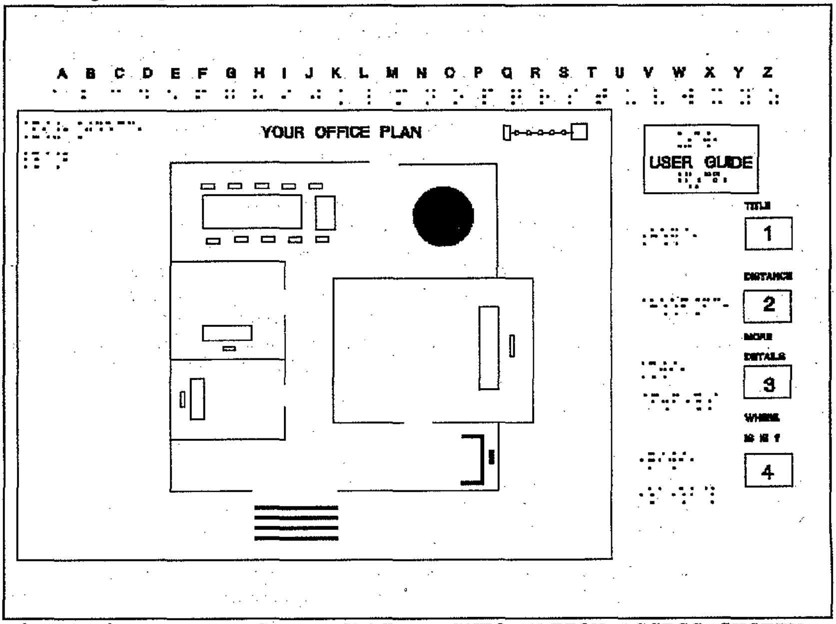

Figure 4: AUDIO-TACTILE SPATIAL INFORMATION ACCESS SYSTEM

The information access system, is designed as a self-contained system that could be situated in a public place allowing blind users (and others) to obtain information about their immediate environment. Typically this system would be used to provide detailed information about a building. An example based on a hotel floor plan initially prepared by the American Printing House for the Blind is distributed with the system. It is composed of two tactile components. A permanent template sheet, at A3 size, that includes a Braille alphabet (to date only the English language alphabet has been prepared) an in-built user guide and four "buttons", each providing a particular function, to be outlined in a moment. On to this template is placed a map or plan, up to A4 size. Guide lines are drawn on the template for accurate positioning of the plan or map. Any point on the plan or map may be touched and the user will hear an explanation or description of the feature. As the map or plan is likely to be "dedicated" to a particular establishment, for instance a bank [7] or a hotel, a public building or a campus

[7] The National City Bank in Louisville was the first large organisation to install the system for use by its blind customers. The tactile graphics and Nomad information were prepared by the American Printing House for the Blind.

map, real speech can be used and if required a number of different languages can be prepared for the same plan.

The user touches the Braille labelled button 1 and listens to a user guide. Touching button 2 allows the straight line distance between any two points to be given to the user. Another button, number 3 gives the user lower level information if touched after a feature on the plan or map has been touched. Such lower level information could be train or bus times from a particular platform or "station", for example. Touching the lowest button will give the user access to a guidance system leading to any feature on the plan or map. After this button is pressed, three Braille characters at the top of the template must be touched. These three characters are no more than a part of the name of a feature on the plan or map. For instance, "T O I" might be typed for direction to the toilets. If the plan designer has distinguished between male and female toilets, then this is accommodated by the system. Don't worry! Instructions then guide the user to the wanted feature.

When the feature is found, further detailed information, perhaps describing the layout of the "toilets" can be heard by touching button 3, labelled "More details". The real, practical value of this sort of map based information may lie in its function as a preview device, enabling a blind person to get to know the general spatial structure and opportunities provided in a building or other complex environment. In essence it becomes a tool for remote sensing of the environment.A multi-media sound environment can be built into the plan by good design and using high quality sound recording the aural essence of the real world can be incorporated as completely as colour and print on a sighted person's maps and plans. The system is very well-suited to development of locality travel maps and will be helpful in O&M training, especially when used in conjunction with AudioTRIP.
This system is now outlined.

5 AudioTRIP: a virtual travel system in real time

Space does not permit detailed description of how to use the system, but an outline of its purpose and functions should be of interest, not only to blind people but also to those involved in training for orientation skills and greater, safer mobility.

There is no restriction on language or the range of real environment sounds and digitised speech that can be incorporated into the AudioTRIP system. It is a software package that runs with the Quantum touch sensitive pad, a Concept keyboard Informatrix pad and the Edmark Personal Touch pad.. The system requires a map or plan with scale included. For a blind person to use the map or plan it must be tactile. For a sighted person to prepare an AudioTRIP actual or virtual journey, to be undertaken by a blind person, the map does not have to be tactile.

The essence of the system is that a route is traced with the finger on the map that has been placed onto the Nomad pad or other suitable platform, for instance the Concept Informatrix A3 keyboard or the Edmark Personal Touch screen. The AudioTRIP system transfers the information that has been touched and that is located on and adjacent to the route, onto a computer disk. Keyboard entry of the speed of travel in metres or yards per second, default is 0.85 metres per second, enables replay of the entire journey in real time, including detailed lower level information.

Replay of the trip or journey, in real time, gives the notion of virtual travel. A well-designed AudioTRIP virtual travel experience would incorporate actual environmental sounds that will be heard in the "real world journey". The trip may be experienced (sensed remotely) either by listening to the replay of the disk information, directly from the computer or by downloading the information to a cassette player. Unlike traditional verbal maps, which require the map maker to travel the route in detail, with an AudioTRIP map the information can be drawn directly from a map or plan. Of course it will always be helpful if the route can also be travelled by the person making the map in order to update information and include real environmental sounds. However, this is not a necessary factor to the making of an informative map.

Three different information orders are available to the blind traveller. **1.** - The lowest information order simply provides a sound at each feature that is to be passed on the journey and with which the traveller may have wish for contact. The idea is that the traveller can gain an idea of the "density" or "frequency" of significant items along the proposed route, in real time. If the journey is to take 10 minutes, and there are 20 items on the route, evenly spaced, the virtual traveller will hear a "beep" sound every 30 seconds. Normally the distribution of items will not be regular and the "beeps" will occur at varying intervals. A frequency difference will distinguish right from left. **2.** - The middle information order gives the name of the feature, usually a single word, and this is effected in the real time of the journey. The information is, like that used in the lowest order, taken directly from the path that is to be followed and the map or plan must have been prepared for this "AudioTRIP" function. **3.** - The highest order gives not only the name of the feature on the route, but also allows detailed information about the feature to be presented. This information cannot be accessed in strictly real time, though sequence is maintained.

5.1 Virtual Travel

In traffic-safe environments such as shopping complexes, educational establishments, offices, convention centres, hotels, stations and so forth, the opportunity to listen to real time previews of a journey is likely not only to be of practical value but also of general recreational value. Just what is it like to "walk down The Strand, down Fifth Avenue, along the Champs Elysees, and so on. What is it like in such and such a part of the office complex where I work?" In schools, colleges and universities the applications are likely to be very quality-of-life enhancing, and are also therefore likely to improve learning efficiencies..The system is not designed as a real time guidance system, per se, except for use in safe environments such as buildings or other areas where there is no danger of impact with wheeled traffic. It is a secondary travel aid, but one which will provide much needed preview information that is easily and cheaply produced.

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