Autonomous Access to Graphics for Visually Impaired Learners

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Abstract

Learning material that relies heavily on the use of diagrammatical data or other visually intensive material remains predominantly inaccessible for visually impaired learners. If a learner is operating in a distance learning environment there is limited access to graphical material. This provides a barrier preventing those with a visual impairment from enjoying the autonomy of learning that is becoming commonplace in the modern E-learning climate. The aim of this ongoing research is to investigate techniques that will allow for the independent learning of graphical material by visually impaired learners .There are two important areas in this work, *independent access to graphics* and *user interaction with graphics*.

The first area to be investigated was *independent access to graphics*. This work was carried out as part of the AHVITED project. The aim of the work was to assess the usefulness of audio tactiles in a distance learning scenario. A list of requirements were produced that an audio tactile system would need to satisfy in order to be viable as a distance learning tool. These requirements were; the ability to identify a diagram without placing it on the screen, simple loading of diagram content, intuitive localisation of diagram content and an intuitive method of diagram authoring. A new system was created containing solutions to the above requirements. The system is currently being evaluated in various institutions across Europe.

An important issue has arisen during the course of the work. The non dynamic nature of paper is a barrier preventing real time independent learning. If a teacher changes course material the relevant tactile diagrams must be recreated. This is not ideal and a fully dynamic solution needs to be explored. For this reason the work has now progressed to phase two, *user interaction with graphics*. By investigating how learners are interacting with tactile diagrams, a list of requirements can be produced for a more dynamic solution. The type of information the learner receives from the diagram needs to be investigated. With this information a fully dynamic multimodal experiences can be provided that will allow the learner to receive the same information without the limitations of a static tactile.

This work will provide new methods and practices for visually impaired learners to interact with graphical material. It will be especially useful in making technical subjects that rely heavily on graphical material available to visually impaired learners in an autonomous fashion.

1 Introduction

Graphics play a vital role in education, especially in Science, Technology, Engineering and Mathematical subjects. The ability to understand graphics, known as graphicacy, is becoming expected of all educated adults [Aldrich and Sheppard, 2000]. It is difficult to gain an understanding of certain subjects from textual descriptions alone as human cognition is visually based. Visually impaired learners are therefore at a significant disadvantage when it comes to mastering technical topics. If a learner is operating in a distance learning environment there is limited access to graphical material. This provides a barrier preventing those with a visual impairment from enjoying the autonomy of learning that is becoming commonplace in the modern E-learning climate.

The World Health Organisation estimated that globally in 2002 more than 161 million people were visually impaired. The number of visually impaired people in Europe alone was 15.5 million. Currently, the National Council for the Blind of Ireland (NCBI) has 14000 people registered to use its services. In addition, a report in April 2008 commissioned by the Association on Higher Education and Disability(AHEAD) [AHEAD, 2008] found that visually impaired children are 50% less likely to progress from second level education on to third level and are significantly disadvantaged in comparison to their non-disabled classmates. A lack of access to graphical material is preventing a large number of visually impaired students from gaining an equal and complete education. The aim of this ongoing research is to investigate techniques that will allow for the independent learning of graphical material by visually impaired learners. There are two important areas in this work, *independent access to graphics* and *user interaction with graphics*.

2 Background

Over the years solutions have evolved that provide visually impaired learners with access to graphical material. The simplest solution is to present the student with a physical 3D model of the object in question. The learner can feel the physical object to gain an understanding of its shape and layout. The problems with this solution are portability and volume. It is difficult for a learner to have a physical model available if they wish to learn at home. Additionally, mass production of a physical model is difficult and costly. Consequently tactile diagrams have become the most common form of conveying visual data to visually impaired learners.

A tactile diagram consists of a raised image on a sheet of paper. The image can be felt with the finger and provides a medium to convey 2D graphics to visually impaired learners. Standard diagrams can not be directly copied into tactile form as the finger has a lower resolution than the human eye and cannot process as much information. Figures 1 and 2 below depict a cross section of the human eye in both visual and tactile form.

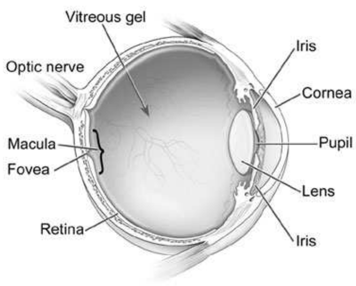

Figure 1: Diagram of the human eye

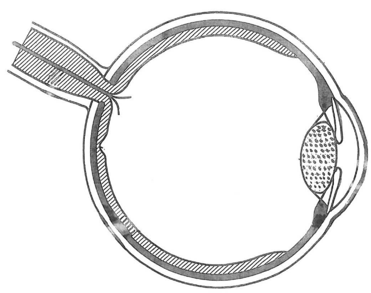

Figure 2: Tactile of the human eye

Various methods of tactile production exist. They range from manual methods such as collage, where a creator uses physical items to build a tactile diagram, to digital methods where diagrams are authored on a computer and printed onto Braille or swell paper. Further explanation of tactile production methods can be found in [Fitzpatrick and McMullen, 2008]. Tactile diagrams generally require supplementary information in order for a learner to understand them. This can be provided via a teachers audio description or more commonly with the use of Braille labels. The problems with the use of Braille are twofold. Firstly, there is limited space in which to place the label and thus limited supplementary information can be supplied. Secondly, not all visually impaired learners read Braille therefore Braille labels are useless to those learners. It is for this reason that audio tactiles are appealing.

Audio Tactile diagrams [Landau and Wells, 2003][Gardner and Bulatov, 2006] are tactile diagrams that can be placed on top of a touch sensitive screen that is connected to a computer. When a learner presses on regions of the diagram, information relating to that region is spoken. If the user continues to press the same region, more detailed information is spoken. This provides the learner with more supplementary information than Braille labels can achieve. A learner using an audio tactile diagram can be seen in Figure 3.

The problem with all solutions to date are the reliance on sighted guides to aid the learner when exploring the diagram. All of the above solutions work best in a classroom setting. This excludes visually impaired learners from the autonomous learning environments enjoyed by non visually impaired learners. In turn this impacts on learners confidence and social development.

Figure 3: Learner using audio tactile

3 Work To Date

Work to date has concentrated on the first area of the research, providing *independent access to graphics*. This phase of the work was carried out as part of the AHVITED [AHVITED, 2009] project. The aim was to assess the usefulness of audio tactiles in a distance learning scenario. Through a combination of user survey and expert review a list of requirements were produced that an audio tactile system would need to satisfy in order to be viable as a distance learning tool. These requirements were; the ability to identify a diagram without placing it on the screen, simple loading of diagram content, intuitive localisation of diagram content and an intuitive method of diagram authoring [McMullen and Fitzpatrick, 2008]. A prototype system was produced containing solutions that satisfy the requirements.

The ability to identify a diagram without placing it on the screen was satisfied by using a tactile pin system. Each diagram is given a four digit pin number. This number is represented in a tactile form and can be used by the learner to identify the diagram. The pin can be reused to enable simple loading of relevant audio content. The learner can press on each part of the tactile pin in order to inform the system which diagram they wish to interact with and thus which audio content to load. Diagram content can also be loaded using a variety of menu options. A more in depth discussion of these and other solutions can be found in [McMullen and Fitzpatrick, 2008].

One of the most important features of the system is the ability to deliver audio tactile content over the Internet. When a diagram is authored and exported for delivery, a package of that diagram containing all relevant digital material is produced. This package can be placed online, either directly on a website or embedded as a learning object in a Virtual Learning Environment. When a learner selects the package, it is automatically downloaded and opened by the system for the learner to interact with it. This provides teachers with the ability to deliver audio tactile information to their students using environments such as Moodle. As the material can be placed alongside mainstream content, it fosters a sense of inclusion and autonomy that was unavailable to date. The first phase of the work is currently being evaluated in learning institutions across Europe.

4 Future Work

An important issue has arisen during the course of the work to date. The non dynamic nature of paper is a barrier preventing real time independent learning. If a teacher changes course material the relevant tactile diagrams must be recreated. This is not ideal and a fully dynamic solution needs to be explored. For this reason the work has now progressed to phase two, *user interaction with graphics*.

By investigating how learners are interacting with tactile diagrams, a list of requirements can be produced for a more dynamic solution. The type of information the learner receives from the diagram needs to be investigated. With this information a fully dynamic multimodal experiences can be provided that will allow the learner to receive the same information without the limitations of a static tactile.

Various technical solutions are being explored the most prominent of which being haptics, a technology that has already been shown to aid the learning of visually impaired students [Pietrzak et al., 2007]. Haptics refers to a method of communicating information to a user by applying a variety of forces and vibrations. This can be used to convey the shape and texture of virtual objects. Additional technologies being investigated are surround sound audio and gesture recognition. Ultimately a combination of these technologies may be required to provide a multimodal experience to the learner.

5 Summary

This paper has outlined research that aims to provide visually impaired learners with independent access to graphical material. A background was provided outlining historical methods for delivering graphical material to visually impaired learners. Work to date was discussed and a prototype system containing solutions to common problems was described. The paper concluded with a description of current and future work.

This research will provide new methods and practices for visually impaired learners to interact with graphical material. It will be especially useful in making technical subjects, that rely heavily on graphical material, available to visually impaired learners in an autonomous fashion.

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References

AHEAD. Seeing ahead: a study of the factors affecting blind and vision impairedstudents going onto third level. 2008.

AHVITED. http://www.ahvited.org. 2009.

F Aldrich and L Sheppard. 'graphicacy' the fourth 'r'? *Primary Science Review*, 64:8 – 11, 2000.

Donal Fitzpatrick and Declan McMullen. Distance learning of graphically intensive material for visually impaired students. *LNCS*, 5015: 219–225, 2008.

John A. Gardner and Vladimir Bulatov. Scientific diagrams made easy with iveo. *LNCS*, 4061:1243 – 1250, 2006.

Steven Landau and Lesley Wells. Merging tactile sensory input and audio data by means of the talking tactile tablet. *Eurohaptics*, 2003.

Declan McMullen and Donal Fitzpatrick. Tactile diagrams at a distance: A multimodal e-learning prototype. *Proceedings of the Irish Human Computer Interaction Conference*, pages 109–112, 2008.

Thomas Pietrzak, Benoit Martin, Isabelle Pecci, Rami Saarinen, Roope Raisamo, and Janne Jarvi. The micole architecture: Multimodal support for inclusion of visually impaired children. *The Ninth International Conference on Multimodal Interfaces*, 2007.