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AHEAD - Audio-Haptic Drawing Editor And Explorer for Education

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Abstract – *We present the final evaluation of an audio-haptic editor and explorer for virtual 2D relief drawings that allow visually impaired users to create and explore graphical images. The application has been developed in collaboration with a user reference group of five blind/low vision school children, and has undergone final evaluation during spring in 2007. The AHEAD application has been used to create material that has been successfully used in school work.*

Keywords – *Haptic, Audio, Education, Editor, Explorer, Blind, Low-vision*

I. INTRODUCTION

Getting access to 2D graphics and especially computerized graphics is still a large problem for persons who are blind or have low vision. The traditional methods for enabling pupils access to graphic material in school is to make tactile drawings in advance, using swell paper, or to use prepared school material, so called "picture appendices" to the Braille books used in education. Furthermore, the reading of tactile pictures is a hard skill to master. Normally the teachers will describe the tactile pictures and sometimes help the pupils to feel the features in the pictures that are described by guiding their hands and fingers. A digital way of accomplishing a similar strategy is to use a touch screen with a tactile overlay, in which the pupil can point and click and then hear e.g. synthetic speech with descriptions of the marked feature in the picture[1]. However, this approach does not make it possible for the pupils to edit the drawings by themselves or make new drawings. Using a haptic display in combination with audio feedback is one way to solve those problems.

General guidelines to create and develop haptic applications and models are collected in [2]. Applications making practical use of non-spoken audio and force-feedback haptics for visually impaired people are e.g. applications supporting mathematical display [3], [4] & [5], games [6-8] and audio-haptic maps [6;9;10]. As described in [11] and [12], there are indeed people who are blind who have an interest in hand drawing. In [13], a CAD application is presented that enables users to create drawings with the help of audio and keyboard. In [14], a study on a haptic drawing and painting program is presented.

II. THE AHEAD APPLICATION

The Reachin 4.1 API for haptic interaction is needed to run the application, along with FMod Ex 4.04.30 used for non-speech sound and Microsoft SAPI 5.1 for speech synthesis. A PHANToM device is used for haptic feedback and control, and a mouse can be used for non-haptic control of the program.

The virtual environment consists of a virtual sheet of paper that is oriented in the vertical plane (standing up). The application can be used in two different modes: one for editing and one for exploring relief drawings.

In explore mode the users can explore text tagged relief drawings. The haptic image is produced as positive or negative relief. The drawing is represented on the screen as a grayscale image – a positive relief is seen as black, and a negative relief is seen as white. The paper color is grey. The users can select drawn objects by touching them with the PHANToM pen or hovering over them with the mouse cursor. When selected, the text tag for the line is spoken by the TTS engine. The mouse user can guide the PHANToM user by a pulling force that drags the PHANToM pen tip to the mouse cursor position. Similarly, the PHANToM user can drag the mouse cursor to the PHANToM position.

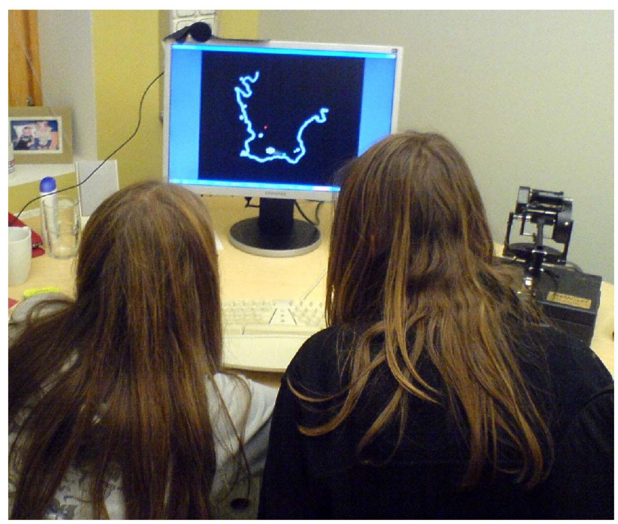

Figure 1 Two pupils collaborating using the AHEAD application making markings on a map of the Scanian region in Sweden

While in edit mode the PHANToM user can create and edit drawings. Drawing lines is done by pressing the switch when in contact with the paper. The mouse user draws while pressing the left mouse button. The PHANToM user can feel the lines while drawing. Drawn lines or figures (objects) can be manipulated in the different ways; moving, resizing, copying, pasting and deleting. Additionally, text tags for the lines and shapes can be changed, and shapes can be transformed into straight lines, rectangles or circles. The manipulation tools are fitted with feedback sounds designed to resemble a real world manipulation of similar nature. E.g. the copy function sound effect is a camera click.

Drawings can be saved and loaded with the application, using the applications customized MICOLE file format ".mcl". The format includes the objects and the text captions for them. A ".png" import function is available. The files imported must be grayscale and exactly 256*256 pixels.

III. EVALUATION

The AHEAD application is in itself a multi-purpose application that can be used both for exploring prepared relief drawings and to create them in any school subject needed. Teachers and researchers have collaborated in planning and preparing a task and the material for a school subject fitting both the curriculum and the individual pupil. The tasks and the application have then been evaluated at school. Evaluation data has been collected with automatic logging of the user events (e.g. PHANToM and mouse movement samples, TTS events, file load events etc.), video recording and situated observation, and post-test interviews of pupils and teachers.

A. Participants

A reference group with 5 participants aged 11 to 17 years has participated in the entire project. The pupils are fairly well trained using the PHANToM, having used it at 3-6 reference group meetings, and have also participated in the iterative design of the AHEAD application. The iterative deign work is described in [15]. Four of the pupils participated in a qualitative evaluation with a prototype of the AHEAD application very similar to the final application. For the final evaluation, the teachers and teaching assistants of each pupil have participated in the planning and in the evaluation lesson at school. In three of the evaluation cases the pupil collaborated with a class mate, and in two cases the teaching assistant used the collaborative feature of the application to instruct the pupil.

Three of the five pupils in the reference group have residual vision. Only one of them used it while working with the evaluation task.

Visually impaired pupils and their previous experience of PHANToM use:

Pupil	Age	Residual vision	Total PHANToM use experience prior to test
1	11	Used	30 minutes
2	12	Not used	30 minutes
3	12	No	1 hour
4	15	Not used	1 hour
5	17	No	> 3 hours

B. Test procedure and tasks

The tasks were planned by teachers and researchers in collaboration. The teachers were invited to try the AHEAD application and to discuss possible subjects and tasks that would fit both the pupil and the curriculum. Since it is quite a challenge to try to envision the possible use scenarios for the teachers, the researchers had prepared a couple of demonstrators showing map use and geometry use, but the application was also showed in the mode where you can create a drawing from scratch.

The preparation of the material was done in different steps. First ordinary graphic material was prepared. In 3 of the cases this implied downloading and using some graphical material as base material, e.g. free maps on the Internet. For the school yard, the map was made from scratch, visiting the school yard and making first a hand drawing and then a drawing in Adobe Illustrator. The graphics were converted using Adobe Photoshop to line drawings in grayscale, and then inverted to make the lines white (in the AHEAD white lines are rendered as negative relief). The graphic images were also cropped to 256*256 pixels. Then the prepared grayscale files were loaded into the AHEAD application as a background picture and the outlines and figures that were important were filled in using the edit mode and text tagged. When the copying part was done, the background file was removed, and what remained was the important features with text tags that the text-to-speech (TTS) system can read.

Task for pupil 1. For pupil 1 the test was conducted in a fifth grade class in the subject geography. The learning task chosen was to learn to interpret maps and learn about the geography of the European part of Russia. The task for all pupils in the class was to draw a simplified map of the country, featuring the most important parts such as mountains, rivers and major cities. The sighted pupils worked with a regular map book and an outline map where they were supposed to fill in the important features.

Figure 2 Map of the European part of Russia. All borders, cities (circles), the river Volga and the major lakes have text captions spoken by the TTS.

The test setup for the visually impaired pupil consisted of a PHANToM OMNI, a laptop running the program and acting as screen and keyboard for the pupil. The teaching assistant used the mouse for guiding and showing the pupil features on the map when needed.

The AHEAD application was loaded with a customized map of the European part of Russia (see figure 2). The pupil used this map as a substitute for looking in the map book through the CCTV, which is the way the pupil usually performs the task, inducing problems such as glare and problems with overview. The pupil had a tactile map of the outlines of European Russia to make a simplified map from, using markers and crayons to draw and write on the paper map.

Task for pupil 2. For pupil 2 the test was conducted in a sixth grade class in the subject geography. The learning task chosen was to learn to interpret maps and learn about the geography of South America. The task in the lesson for all pupils was to make a simplified map by hand of the continent, with major mountain ranges, lakes, countries and capitals.

For this type of task, the visually impaired pupil would usually work with the teaching assistant, who would describe the geography verbally with a tactile map for reference. On the tactile map used there would be code letters that marked important features, and the pupil would usually type the code letter and the names that the code letters marked into the computer.

Figure 3 Map of South America. All borders, capitals (circles) and the surrounding oceans have text captions than are spoken by the TTS.

At the test session, however, the pupil was instead instructed to work with a sighted classmate, collaborating on the task using the AHEAD application. The classmate would make the markings on the tactile map, while the visually impaired pupil was exploring the map (see figure 3) and telling his class mate what to write down.

Task for pupil 3. Pupil 3 was the only one who did not use the AHEAD application in class. Instead it was used for navigation training. The pupil, who does not have any residual vision, is normally integrated in a sixth grade class with sighted children. Usually the navigational training would be performed by using a tactile map and by walking repeatedly the paths that the pupil needed to learn. At the test session the pupil instead used the AHEAD application for the training.

As the test task a kind of treasure hunt was implemented. 3 detailed maps of the path from school to the bakery were prepared with the AHEAD application. The bakery was selected as the goal of the exercise, since all the sighted pupils used to go there and the visually impaired pupil had expressed a wish to be able to go there too.

The pupil was to explore every map step by step. When the first map (see figure 4) was explored and the treasure on that map was found and the pupil felt confident enough to remember the route, the pupil was supposed to travel by foot unaided by the assistant to the treasure in the real environment. The teaching assistant followed and was allowed to give verbal hints referring to the map, but the assistant was instructed not to help in other ways (by leading the pupil for example). After the pupil succeeded with finding the first treasure, the other 2 maps were explored. Because the time was running out, both maps were explored and then the next treasure was searched.

Figure 4 Map of the school yard of pupil 3. All permanent ground obstacles were modelled and the details described by the text captions spoken by the TTS.

Task for pupil 4. The test for pupil 4 was conducted in a ninth grade class in the subject mathematics. The learning task in the particular lesson was to practice using geometrical mathematical language, i.e. words like “rectangle”, “sphere”, “angle” and “diagonal” to describe a composite geometry figure to a fellow pupil. The sighted pupils were instructed to use paper, pencil and a ruler, and the visually impaired pupil and a fellow pupil were instructed to use the AHEAD application. The test setup consisted of a laptop running the program and acting as screen and keyboard for the sighted pupil who also was using a mouse for input. The visually impaired pupil had a separate keyboard attached to the same computer, a screen, headphones and the PHANToM OMNI. Half of each screen was blinded by a piece of cardboard to prevent the pupils from seeing the drawing the other person made.

The AHEAD application was loaded with a file with a subtle grid in positive relief, and a middle line with the spoken caption “Stop, middle line” (see figure 5). The pupils were supposed to use one part of the virtual paper/screen each to draw on and the middle line was not to be crossed until the last phase of the task. There were three parts to the task; first, one pupil would design a composite figure in the drawing application (without showing it to the other pupil); second, the same pupil would describe the figure to the other pupil who would try to make a copy based on the description; third, the pupils would together compare the copy to the original figure.

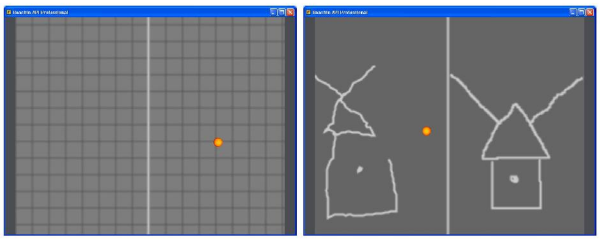

Figure 5 The left picture shows the empty grid for the mathematic task. The right picture shows a picture from the test (with the grid removed for better clarity).

Task for pupil 5. The test was conducted in a high school second grade class in an aesthetic program. The learning task was to, on the basis of an image of a traditional Shakespearean theatre (i.e. The Globe), place the actors on different parts of the stage and balcony etc. in every scene of a Shakespeare play which they had read in advance. The image was marked with the different parts of the theatre – e.g. formal stage and balcony.

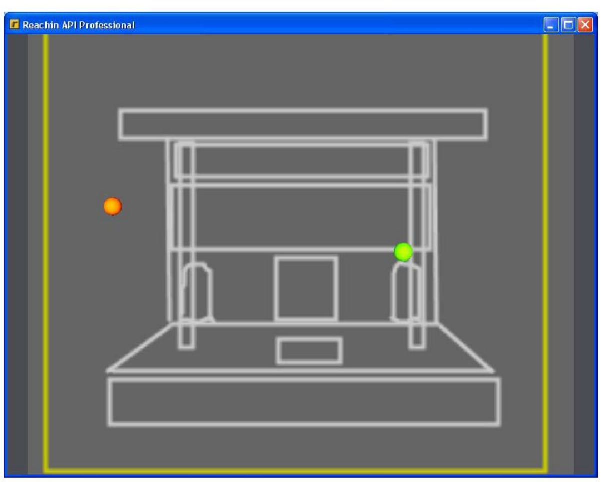

Figure 6 A simplified drawing of a Shakespearean theatre. The major parts such as pillars, main stage, balcony, trap door, valves etc. were marked with captions.

The pupils worked in pairs and were allowed to spread out anywhere at school during the group session. The blind pupil did not want the classmates (except the collaboration partner) to see the test arrangement, therefore a small room adjacent to the classroom was used for the AHEAD test.

The AHEAD application was used to load prepared drawings of the Globe Theater. There were 4 different files with stage information to choose from. One drawing was a simplified variant of the tactile picture that the assistant had previously prepared for the pupil. There was also a simplified cross-section from above and then a view in front of the stage (see figure 6). Both the latter drawings were also included into one file with somewhat smaller details.

The pair of pupils could choose freely between the files, using the one that suited them the most. Pressing a shortcut on the keyboard would start a standard Windows file load dialog that was supported by JAWS to enable text-to-speech outside the AHEAD application.

IV. RESULTS

Most of the data collected is still being analyzed, and in this paper we only report the overall results that do not depend on the more detailed analysis.

The first thing to note is that in all the above described test cases the pupils were able to carry out the test tasks, and according to the teachers they also performed well. Four of the pupils were very pleased with the applications functioning, and would like to experience such an interface for other school subjects and/or for leisure activities. One pupil did not like to use the AHEAD application and would rather do the tasks the usual way. This particular pupil also has some problems with fine motor skills, which makes handling the PHANToM device harder. Even so, also this pupil was able to complete the tasks.

Two of the students that liked the applications commented particularly that the AHEAD type of environment made 2D graphical material more accessible compared to the tactile graphics that they normally used (made with swelling paper).

The fact that the AHEAD environment allowed for collaboration, by giving a mouse user and a PHANToM user access to the same material was generally appreciated. The guiding function where the mouse user guided the PHANToM user was well liked by two of the students while one did not like being guided at all. The guiding function where the PHANToM user guided the PHANToM was not used except by accident.

Some qualitative results concerning the usability of the application have been collected. There is e.g. the case of learning geographical names that is a challenge when using only text-to-speech systems. A Swedish TTS engine simply will not pronounce e.g. “Buenos Aires” or “Georgetown” correctly, and even if it did it might be hard to learn the names. Finally, pupil 3 who performed the navigational task would rather have the map displayed in the horizontal plane, since it would help understand the directions better.

V. DISCUSSION AND CONCLUSIONS

In general the results of this tests show that programs like the AHEAD application could be a useful complement to the materials already used by visually impaired children at school. Despite the single point haptic interaction provided by the PHANToM, pupils found that the AHEAD application provided good overview of the displayed 2D graphics, and two pupils in particular commented that this was actually better than the raised line images normally used (despite the fact that these can be explored by all fingers simultaneously).

The fact that the environment allowed for both a mouse user and a PHANToM user to have access to a common workspace was seen to be important, and to increase the usefulness of the application. The guiding function where the mouse user guided the PHANToM worked well when the mouse user used a guiding motion to lead the PHANToM user to a target or show a shape. The result of the guiding depended on how the mouse user used it – and the test results indicate that one should advice the mouse user on how to use the guiding efficiently. Still, it is important to note that some users may not like being guided (these results agree with the observations made in collaborative haptic environments with multiple PHANToMs [16]).

Also, the usability problems observed suggests that a Braille display should be connected to the system and that the user should be able to change the orientation of the virtual paper.

VI. FURTHER WORK

The described evaluations are aimed at foreseeing use scenarios in school in a not too distant future. There are still challenges, aside from the problem of expensive hardware and software. The next step will be to investigate if and how a teacher or teaching assistant will be able to use the AHEAD software in school, preparing the material and using it without technical help.

VII. ACKNOWLEDGEMENTS

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