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The ENABLED Editor and Viewer – simple tools for more accessible on line 3D models

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Abstract

This paper reports on the ENABLED 3DEditor and 3DViewer. The software design is described, and results from user tests with end users are reported. Both the Editor and Viewer are seen to work quite well. It is possible for a developer to quickly start working with the editor. The Viewer was well received by the users who are able to use it to understand an environment, get an overview and locate a specific place on the 3D map.

1. Introduction

Research on presenting Web content through non-visual form is very active especially after the GUI interface has become one of the most prevalent interface types which exist today. Haptic, auditory and multimodal modalities have been used to provide novel methods for people with visually impairments to interact with computer systems. For instance, Ramstein et al [1] have proposed the PC-Access system that offers auditory information, reinforced by the sense of touch to enable blind users to be aware of what happens on the screen and where the pointer is. Rosenberg and Scott [2] have also carried out a study to prove that force feedback can enhance a user's ability to perform basic functions within graphical user interfaces. Using a haptic display in combination with audio feedback is one way to enable access. General guidelines to create and develop haptic applications and models are collected in [3]. Applications making practical use of non-spoken audio and force-feedback haptics for visually impaired people are e.g. applications supporting mathematical display [4], [5] & [6], games [7-9] and audio-haptic maps [7;10;11]. In [12], a CAD application is presented that enables users to create drawings with the help of audio and keyboard. In [13] an audio-haptic drawing program is described. The work described in this paper builds primarily on the previous work reported already in [10]

and later in where it was shown that the use of haptic 3D models together with spoken audio tags could be used to allow visually impaired persons to access also quite complex maps. We have also made use of the studies reported in [14] for the design of pan and zoom tools. Thus the design principles are not really new (although the zooming function has been enhanced with audio feedback) – but what is new is the way the developed software can make such environments easier to generate. The work has been part of a European project, ENABLED. One of the objectives of the ENABLED system is to provide an accessible end interface for people with vision difficulties to gain access to various types of graphics on the Web [15].

2. The ENABLED 3DEditor

The ENABLED 3DEditor is a program that can read an X3D 3D model and add haptic surfaces and speech tags to make the model more accessible to persons with visual impairments. The program is implemented making use of the open source api H3D for the haptics and Microsoft Speech - SAPI 5.1 for the speech. It is currently working with the PHANToM Omni, but could be extended for use with the Novint Falcon.
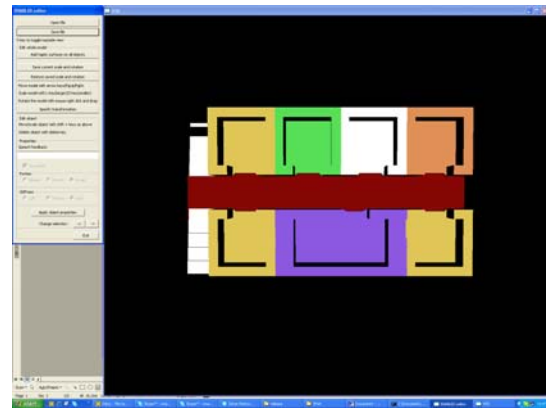

Figure 1. A Screen shot of the ENABLED 3dEditor.

To make the program as easy to use as possible it is quite limited in functionality. One can:

- scale and move the 3D model so that it fits well within the workspace (size and position is a common problem when exporting from e.g 3DStudioMax to put a model on the web)
- add haptic surfaces to the model
- edit friction (slippery, smooth, rough) and stiffness (soft, medium, hard)
- add speech tags to all objects
- switch between viewing objects from the side and from above (figure 1 shows the view of a map environment from above)
- save the results into a file that can be put on the web and which can be viewed using the ENABLED 3DViewer

The 3DEditor is primarily designed for sighted developers (although one blind reference user has also made use of it). The intention is that any developer should easily be able to make a 3D model accessible to visually impaired users by using this software. The users would then make use of the 3D Viewer described in the next section to actually access the model.

3. The ENABLED 3DViewer

This program is to be launched by the Enabled architecture but it can also be run as an independent program. The program is implemented making use of the open source api H3D for the haptics and Microsoft Speech - SAPI 5.1 for the speech. It is currently working with the PHANToM Omni, but could be extended for use with the Novint Falcon. The 3DViewer is intended for a severely visually impaired user, and makes use of a keyboard interface together with the two buttons available on a PHANToM Omni. It has the following functions:

- H-key, speech information about the available functions
- Front PHANToM button, say the name of the object with the midpoint closest to the PHANToM pointer (when in move mode – see below – the front button is instead used to drag the model)

Back PHANToM button, drag you to the closest object (again it is the midpoint that is used)
L-key, enlarge. The PHANToM position relative to the object is the same before and after the operation.
S-key, make smaller. The PHANToM position relative to the object is the same before and after the operation.

0-key (zero) to restore the original size and position.
M-key activates/deactivates move mode. In move mode move the model either by click & drag using the front PHANToM button or with the arrow, page up and page down keys
Q-key to change between side view and top view.
A-key to switch audio on or off.
V-key to switch voice (speech) on or off.
Escape key to quit.

These key assignments are as much standardized as possible within the ENABLED system. The study [14] led us to add audio feedback to the zooming which tells you the size by playing a note on the windows synthesizer. To help users know which was the original size a different type of note was played for this size. We also made use of observations from [13] that indicated users felt higher frequencies should correspond to smaller sizes. In the move mode we have added a haptic intertial effect combined with a short "snap" to the PHANToM drag to make users understand better that they are moving the model. When using the arrow keys the user gets speech feedback which tells which kind of move has been done (left, right, in, out, up, down).

The guiding function implemented is very simple compared to what is described in e.g [16]. The reason for this was the wish to keep the interface of the editor as simple as possible. For the attractive force we made use of the force design recommendation from [17] and used a constant attractive force. Figure 2 shows a screen shot showing a map environment from above.

Figure 2. A screen shot from the ENABLED 3DViewer showing a 3D map from above.

4. User testing of the 3DEditor

Due to time constraints it was decided to focus on testing the Viewer, and the Editor test was done with only three developers (Nielsen [18] recommends 3-5 users to screen for serious design flaws). Two

developers were male and one female. All had experience from 3D development and VRML/X3D, two were familiar with assistive technologies and one was not, and one had some web developer experience (the other had also done some web work, but did not specify themselves as web developers). All were programmers (two experienced and one less experienced). One had long experience from haptic programming, one had a little and one had no experience at all from this type of programming. Two developers were in the age range 26-40 and one in the range 41-60.

The test persons were given a short introduction about what the program was expected to do. After this they were given the manual and were instructed to make use of it in case of problems. Then the users were asked to perform the following four tasks:

- Open the provided x3d file.
- Adjust the size and position of the model so that it fits well into the workspace.
- Make it possible to touch the model with the PHANToM.
- Add names to 3 objects on the map.

5. Results of the Editor test

All three users were able to complete all the tasks. There were two main problems:

1) The model was initially quite large and far away, and the users did not know initially what it was supposed to look like. Because of this it was not easy to understand the feedback given and it took a little time before they got things right.

2) The users did not look for a command to change the view, and needed a hint about this.

Otherwise the operations are easy to perform and no serious problems occurred.

6. User testing of the 3DViewer

Ten severely visually impaired users (5 in Sweden and 5 in Spain) participated in these tests (the age distribution is summed in table 1). 9 of the 10 were Braille readers. Two were adventitiously blind, five were congenitally blind and three were partially sighted. Four users were female and six were male. All had tested haptic technology before. Four of the five users in Sweden had used the PHANToM quite a lot, and can be considered more experienced PHANToM users. Also in Spain the users had some previous experience of haptics since they had all tested haptic applications before.

16 or under	17 - 25	26 - 40	41 - 60	61 - 80	Over 80	
1	2	4	3			

Table 1. Age distribution of the test users.

All users except one were used to Braille displays, and 8 had experienced stereo type sounds/3D sounds in the computer environment before. 8 of the users had also tested (or owned) mobile technologies (mostly phones or GPS/navigational devices). Seven users said they had received special training on reading tactile images.

The whole test session was maximized to two hours. During the test one test leader and one observer was present (apart from the test person). Test results were recorded in written form by both the observer and the test leader. Before the test session the user signed the informed consent form.

Due to the users previous experience of the PHANToM and of haptic applications, no special training was given beforehand. A short intro on the program was given where the main functions in the 3D Viewer was explained. In this intro the following functions were demonstrated:

- Front PHANToM button say the name of the object one is in contact with (when in move mode – see below – the front button is instead used to drag the model)
- Back PHANToM button drags you to the closest object (again it is the midpoint that is used)
- Press V-key to switch voice (speech) on or off. Pressing the front PHANToM button will still give "speech on demand" even if the voice is turned off.

Added to this the user was told that it was possible to perform panning and zooming operations, and that these could be demonstrated on demand. The user was also told that he/she could always press the H key to get help from the program (the program also says this by itself when it starts). The first test task was designed to provide some initial training, since it was an open task where the user was asked to explore and describe. The test environment can be seen in figure 2.

The test tasks were:
1. Explore the map. Give an overview description of it.
2. Start in the stairs, enter the lobby and then enter the corridor. Count the number of rooms at the right hand side. How many?

3. Start at the same place as in 2. Count the number of rooms on the left hand side. How many?
4. Find the largest room - which is it?
5. Describe the way from the stairs to the room 204.

7. Results of the Viewer test

All users except two were able to complete the final task. Of these two one was fooled by the speech feedback, while the other was not able to find the room at all. The descriptions generated are summarized in table 2 (the room 204 is the room just to the left of the purple open area with the four round red tables in figure 2).

Test person	Answer
P1	Second last on the right hand side
P2	Through the lobby, right side, 5th door just after the open area
P3	Go past the open area with tables and chairs. It is the next room on the right after that.
P4	Go into the corridor and past the open area with tables and chairs. It is the next room on the right after that.
P5	Fifth room on the right, just after the open area.
P6	Corridor after the coffee-room
P7	- (cannot find it)
P8	Follow the corridor straight, right until 4th door (She receives the speech feedback "room 204" on the left wall of the open-area, so she thinks wrongly she is in the room 2004).
P9	After the coffee-room, to the right
P10	By the corridor, just after the coffee-room

Table 2. Description of how to find room 204.

The overview descriptions (task 1) of the environment can be found in table 3. Task 2 presented some problems and six users did not get the number of rooms right. Task 3 presented less problems and all users got that number right. Task 4 was also easy and all users managed to find the largest room.

Test person	Answer
P1	A corridor with rooms
P2	A corridor with rooms
P3	Corridor with rooms
P4	A corridor with rooms on both sides
P5	On the left a long room followed by 3 shorter rooms. On the right two rooms and then an open area and after that 3-4 rooms (then you are back where you started)
P6	A large horizontal corridor, 4 doors at a side and a corridor in vertical
P7	Corridor with rooms that have tables
P8	Long Corridor with 7 rooms, open space with several tables
P9	Corridor with doors in both sides, lobby to right and another room without name to the left
P10	Horizontal corridor, rooms to both sides

Table 3. Overall descriptions.

Users were also asked about the best and worst features of the Viewer. The best features were:
⇒ That you get an image in your head and know where the rooms are
⇒ Easy to find the rooms
⇒ That you see it from the top
⇒ That you can hop over the walls - this way you can really check the layout. Good that tables are shown. After a while it is better to turn the speech off (but initially the automatic speech is good)
⇒ Easy to get an idea of the map layout. Good that you get the room names already out in the corridor (you don't have to enter the rooms).
⇒ Audio help with the names
⇒ She likes the final goal of the application that allows her to explore the different levels of an indoor environment, although she considers it can be improved a lot
⇒ Spatial representation (3D). This would be great for railway stations and airports
⇒ 3D Representation

while the worst features were:
⇒ The pen did not always work (the back phantom button had stopped working so the attractive force did not work)
⇒ Don't know

⇒ That the names of the rooms were said out in the corridor - should only say it at the door
⇒ Hard to say - maybe harder walls.
⇒ Hard to say - the pen is hard to hold - would prefer thimble eg.
⇒ Voice synthesis is not good. You go out through the floor
⇒ Voice synthesis is not good.
⇒ Voice synthesis is not good.
⇒ Bad sound quality
⇒ Continuous audio feedback is annoying (useful to be able to deactivate it). Sound quality bad.

It is encouraging that the worst features are things which are not really features of the viewer, but rather things like the voice (which depends on which voice the user has installed in his or her computer), non-working hardware and the fact that you get room names on the outside walls (which depends on how you design your map).

Improvements suggested are:
⇒ Give a verbal overview in the beginning
⇒ Don't know
⇒ Remember to check it does not collide with Jaws (comment: this has been done)
⇒ Maybe one should use textures more to differentiate different objects.
⇒ Don´t go out. Listen the name of the room without need of coming in (he deactivated the automatic audio help and when he requested this information at the wall of a room, at the corridor, he did not receive the name of the room)
⇒ No 3D. 2D is enough to explore the layouts of the different floors
⇒ The voice. Include textures to delimite/differenciate spaces
⇒ The voice. Omni forces are soft. Don´t jump walls.
⇒ Textures in the big rooms, rest room,..

These improvements can all be taken into account by improved design of the 3D model (even the 2D one, since it is possible to do a more 2D-type design if this is requested), or by installing a better voice for the speech feedback.

8. Discussion

The Editor test showed that developers who have had no tutorial and uses the program for the first time are quite able to do the tasks required to prepare a 3D model exported from 3D StudioMax for use with the 3D viewer. All users think the program is good, and would like to use it for doing this type of maps. While there is room for improvement, the important functions "add haptic surfaces" and the ability to annotate objects are very easy and intuitive. A little practice (e.g with the existing tutorial) can be expected to further improve things.

If we look at the Viewer test, the users were in general able to explore and understand the environment. The program was easy to use despite the very short introduction and the absence of training (confirming that it is a program that is easy to use). We had some hardware problems with the second Omni button which unfortunately caused problems during the first testing Sweden (the attractive force that should drag the user to the objects could not be activated because of this).

It was interesting to observe that for the more experienced PHANToM users the absence of a limiting box was not really a problem – even if they lost touch with the object they were usually able to get back to it quickly (usually they just reversed the gesture that made them lose contact). This leads us to believe that a limiting box is mostly a beginner feature – experienced users are not that dependent on it – this is in contrast with the recommendation in [3].

The map design generated some problems – to indicate endpoints in the corridor these doors were designed to be jumped over. This was not a good idea, and this design needs to be improved. The outside walls said the name of the rooms which generated problems for some users while others liked it. Design guidelines needs to be generated to improve the usability of this type of models.

Still, all users are able to get some kind of overview of the environment, and 8 out of ten were able to find the requested room in the final task (9 out of ten if we count the person who was fooled by the speaking walls). This is a clear indication of the usefulness of this type of maps (further confirming the results from [10]).

9. Conclusion

Both the Editor and Viewer are seen to work quite well. It is possible for a developer to quickly start working with the editor.

As could be expected from earlier studies such as [8,10] the Viewer was well received by the users who are able to use it to understand an environment, get an overview and locate a specific room (only one user

failed completely on this task). User comments show the importance of the design of the 3D map and care should be taken when designing this type of environments.

10. Acknowledgements

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