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Multimodal collaboration environment for inclusion of visually impaired children

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Deliverable D14: **Final User Requirements and Design Recommendations**

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Final User Requirements and Design Recommendations

Introduction

We chose to sum up the final design recommendations and user requirements as a set of guidelines. The input for these guidelines has been the user tests done and user feedback obtained throughout the MICOLE project. For initial requirements and a first preliminary set of guidelines we refer to the milestone report M3: “User Requirements and Design Recommendations (preliminary version)”. The analysis and structure of the guidelines was finalized during a workshop in Lund (5-6 February, 2007). During this workshop we analyzed the kind of problems users experience in audio-haptic collaborative environments and structured our guidelines to provide information for designers so that this type of problems could be avoided in the future.

The presented guidelines are a result of the work within the MICOLE project, although some guidelines of a more general nature have been included to make the list more complete. The MICOLE guidelines are intended as specific guidelines for audio-haptic interfaces and are to be complemented by general HCI guidelines such as

- Shneiderman’s “Eight Golden Rules”(Schneiderman, B. (1998) Designing the User Interface: Strategies for Effective Human-Computer Interaction. Addison-Wesley, Reading, MA. ISBN: 0201694972)
- Bruce Tognazzini’s list of basic principles for interface design (Tognazzini, B. (2003) First Principles of Interaction Design. http://www.asktog.com/basics/firstPrinciples.html)
- Nielsen’s “Ten Usability Heuristics” (Nielsen, J. (2002) Ten Usability Heuristics. http://www.useit.com/papers/heuristic/heuristic_list.html).

These guidelines overlap to some extent with earlier published guidelines such as

- the recommendations for the design of virtual environments for persons with visual impairments presented in Colwell, Petrie et al (Colwell C, Petrie H, Kornbrot D, Hardwick A, Furner S, The use of a haptic device by blind and sighted people: perception of virtual textures and objects. In Placencia-Porrero I, Ballabio E (eds). *Improving the quality of life for the European citizen: technology for inclusive design and equality*. Amsterdam: IOS Press), or
- recommendations in the thesis written by Calle Sjöström (http://www.certec.lth.se/doc/hapticinteraction/), or
- the more recent ones published within the ENACTIVE Network of Excellence (https://www.enactivenetwork.org/, Public documents:Deliverables: EI_D.RD3.1.1.pdf) .

Other relevant guidelines are guidelines on earcon design (http://www.dcs.gla.ac.uk/~stephen/papers/HCI95.pdf and http://www.dcs.gla.ac.uk/~stephen/papers/HCI2004_McGookin.pdf), guidelines for the audio enhancement of graphic widgets (http://www.dcs.gla.ac.uk/~stephen/papers/HCI2002-lumsden.pdf),

guidelines for the design of haptic widgets
(http://www.dcs.gla.ac.uk/~stephen/papers/HCI2002-oakley.pdf),
design guidelines for the audio presentation of graphs and tables
(http://www.dcs.gla.ac.uk/~stephen/papers/ICAD2003_Brown_Guidelines.pdf), and
some guidelines for tactile and audio
(http://www.dcs.gla.ac.uk/~stephen/papers/Nordichi2006_wall.pdf).

The main difference between our guidelines and the previous ones is that we have a more specific focus on collaborative work.

We chose to point out the main references of related scientific results in our guidelines, since it is often hard to know how well founded the advice of a specific guideline is. With references it is always possible to go into the details of the work to see where the guideline is derived from.

MICOLE guidelines, structure

The guidelines are split into two sections, one set of guidelines for interface design and one set of guidelines for the use of virtual environments for group work. The following structure has been used to organize the guidelines:

Interface design

- Exploration/navigation
  - General
  - Multimodality
  - Forces and constraints
- Overview
  - General
  - Multimodality
  - Reference system
- Object properties
  - General
  - Haptic 3D objects
  - Haptic 2D environments
  - Tactile applications
  - Audio
- Manipulation
  - Virtual environment
  - Physical device

Group work

- Context
  - Background knowledge
  - Shared workspace
- Awareness
- Guidance
- Role/initiative/empowerment

Guidelines, Interface design

1 Exploration/Navigation

1.1 General

1.1.1 Applications should support navigation and exploration.

For applications to be possible to use without vision, the interaction needs to be designed in such a way as to help users find and explore objects.

References: Deliverable D1

Aaronson D., Gabias P. (1987). Computer use by the visually impaired, Behavior Research and Methods, Instruments & Computers, 19(2), 275-282.

Colwell C, Petrie H, Kornbrot D, Hardwick A, Furner S, Use of a haptic device by blind and sighted people: perception of virtual textures and objects. In Placencia-Porrero I, Ballabio E (eds). Improving the quality of life for the European citizen: technology for inclusive design and equality. Amsterdam: IOS Press. 1998

C.Sjöström, PhD thesis (2002), http://www.certec.lth.se/doc/hapticinteraction/

1.1.2 Different interaction strategies (such as unconstrained exploration, constrained exploration, or fully guided tour) should be considered.

Different users have different preferences and abilities. Thus it has been found useful to provide an assortment of interaction strategies. It can be noted that these may result in differences in performance.

References: Deliverable D6, section 4.6

Loomis, J., Golledge, R. G., & Klatzky, R. L. (1998). Navigation system for the blind: Auditory display modes and guidance. PRESENCE: Teleoperators and Virtual Environments, 7, 193-203.

Pokluda, L, Sochor, J, Haptic exploration of buildings for visually impaired persons: Show me the map. In 3rd International Conference on Enactive Interfaces: ENACTIVE / 06 ENACTION & COMPLEXITY. Montpellier, France : Information Society Technologie, Universite Montpellier, 2006.

1.1.3 The interface should help the user in acquiring an effective interaction strategy.

Users do not always use effective interaction strategies. The interface should help them develop good strategies for navigation and exploration.

References:

Klatzky, R.L., S.J. Lederman, and C. Reed, There's More to Touch than Meets the Eye: The Salience of Object Attributes for Haptics with and without Vision. Journal of Experimental Psychology, 1987. 116(4): p. 356-369.

C.Sjöström, PhD thesis (2002), http://www.certec.lth.se/doc/hapticinteraction/

1.1.4 Choice of keyboard input versus the use of menus should be carefully considered

Using keyboard to control application tools may be considered, but it is important to note that it can give users too much memory workload. The advantage with the keyboard is that the user may stay in the same point in the environment, while haptic menus with a one point haptic device require that one moves away to interact with the menu. Another option is to use buttons on the manipulandum – but current designs (one or two buttons only) limit the amount of functionality possible to put here.

Use of keyboard :

- interesting because it enables parallel actions (10 fingers)
- a problem because user has to switch between keyboard and pencil

References: Deliverable D6, section 4.7

1.2 Multimodality

1.2.1 If multiple states can occur, state information should be provided in addition to the force feedback

Kinesthetic feedback is quite limited and when state change information is needed this is best provided via some other modality

References: Deliverable D6, section 4.7

Magnusson, C, Rassmus-Gröhn, K, Eftring, H
A virtual haptic-audio line drawing program, 3rd International Conference on Enactive Interfaces, 20-21 November, 2006, Montpellier, France

1.2.2 Combining haptic and tactile feedback should be considered

Visually impaired users can successfully integrate force feedback cues and tactile cues presented to different hands. Static tactile cues provide better performance than dynamic tactile cues when working in a two handed navigation task.
Active tactile exploration provides better performance than passive interaction.

References: Deliverable D6, section 4.4

Crossan, A. Brewster, S. Two-Handed Navigation in a Haptic Virtual Environment, in Extended Abstracts of CHI 2006, Montreal.

1.2.3 Audio feedback may be added to a dragging force

Combining audio with haptic trajectory feedback can improve users' performance in learning and recreating trajectories.

Pitch works well for one dimension, while pitch and pan together can cause problems since pitch tends to dominate over the pan feedback.

References: Deliverable D7, section 2.4

1.2.4 3D sound feedback may be applied with the ears of the listener attached to the PHANToM position ("ears in hand").

This type of feedback can help users to get an understanding of a spatial environment and possibly also increases the sense of immersion within the environment. "Ears in hand" can also be used as a tool for navigation, but the efficiency of this depend on the size of the objects within the environment.

References: Deliverable D6, section 4.6

Magnusson, C., Danielsson, H., Rassmus-Gröhn, K., Non Visual Haptic Audio Tools for Virtual Environments,Workshop on Haptic and Audio Interaction Design, University of Glasgow, 31st August - 1st September 2006

1.2.5 Sound feedback may be used to identify objects from a distance.

Although general navigational sounds could be useful, if possible one should make use of the fact that sound will allow for object identification from a distance.

References: Deliverable D6, section 4.6

Magnusson, C., Danielsson, H., Rassmus-Gröhn, K., Non Visual Haptic Audio Tools for Virtual Environments,Workshop on Haptic and Audio Interaction Design, University of Glasgow, 31st August - 1st September 2006

1.2.6 The borders between different object spaces may be used to provide important information.

With one point haptics it takes time to actually locate objects in the environment. If suitable information can be provided when the space surrounding an object is entered this can shorten exploration times. If general navigational sounds are used, these may provide information about when a new object space is entered.

References: Deliverable D6, section 4.6
Magnusson, C., Danielsson, H., Rassmus-Gröhn, K., Non Visual Haptic Audio Tools for Virtual Environments,Workshop on Haptic and Audio Interaction Design, University of Glasgow, 31st August - 1st September 2006

1.2.7 Directional-predictive sounds may be used for identification of graphs.

The sounds are also usable without the haptic feedback.

References: Deliverable D6, section 3.2

1.2.8 Number of sounds in grid navigation should be optimized.

In grid navigation with sound feedback the mapping and the number of sounds influences the difficulty of the task. Small number of sounds facilitate learning, while more sounds improve target acquisition. The objective is to favor the learning process but also to avoid "noise pollution" and thus minimizing as possible the user's fatigue.

References: Deliverable D6, section 4.2

1.2.9 Rhythm feedback may be considered.

Results show that several users thought tactile rhythms were more pleasant. Regular rhythms appear to be easier to recognize.

References: Deliverable D5, section 2

Kosonen, K. & Raisamo, R. (2006). Rhythm perception through different modalities. Proc. EuroHaptics 2006, 365-370.

1.2.10 Haptic bumps may be considered

Haptic bumps may be used to code information. Users can recognize easily 6 directions guided bumps and 4 directions half-guided bumps Using several amplitudes for the bumps doesn't disturb the direction discrimination. Two amplitudes are discriminable, but if we add a third one there is an ambiguity.

References: Deliverable D6, section 3.7

Thomas Pietrzak, Benoît Martin, and Isabelle Pecci. Information display by dragged haptic bumps. In ENACTIVE 05, The 2nd International Conference on Enactive Interfaces, Genoa, Italy, November 17-18, 2005, 4 pages, published on CD-ROM.

1.3 Forces and constraints

1.3.1 Forces to constrain the user to specific regions or paths within the environment may be used.

It has been shown that forces attracting the user to the goal or constraining the user to a path can be useful. But since such forces can also disturb the haptic experience one has to take care when designing them.

References: Deliverable D6, section 4.6, deliverable D7, section 2
Wall, S.A., Paynter, K., Shillito, A.M, Wright, M., Scali, S. (2002) The Effect of Haptic Feedback and Stereo Graphics in a 3D Target Acquision Task, In Proc. Eurohaptics 2002, Univeristy of Edinburgh, 8-10th July, 2002, pp. 23-29

Magnusson, C., Danielsson, H., Rassmus-Gröhn, K., Non Visual Haptic Audio Tools for Virtual Environments,Workshop on Haptic and Audio Interaction Design, University of Glasgow, 31st August - 1st September 2006

1.3.2 A box constraining the available workspace may be used

A box restricting the user within the workspace can prevent the user from getting lost, or from confusing the physical limitations of the device with virtual objects. Such a box also provides reference points that can help the user understand the environment. On the other hand, such a box also restricts the available workspace, and in cases where there is no risk of confusion between device constraints and object it can be better not to use it.

References: C.Sjöström, PhD thesis (2002),
http://www.certec.lth.se/doc/hapticinteraction/

1.3.3 An attractive force may be used to locate objects non-visually in a 3D space.

It is important that the attractive force is weak enough to allow the user to resist it, while at the same time being strong enough to attract the user to the target once the grip is released.

References: Deliverable D7, section 2.1

1.3.4 For dragging users to a specific location, constant or slightly increasing snapping forces such as 1/sqrt(r) should be used.

Forces increasing with distance become too strong at long distances, while forces decreasing with distance can become too weak far away. Thus we recommend fairly constant dragging forces. Some snapping behavior towards a point can be useful to make sure the user reaches the point (one can tolerate larger forces by the end of a gesture compared to the strength one can handle at the onset of the force).

References: Deliverable D7, section 2.1

1.3.5 Dragging forces should not appear or disappear unexpectedly

The sudden and unexpected onset of dragging forces can jerk the device out of the hand of the user (disturbing the exploration). The unexpected and sudden disappearance of a dragging force, forces the user to suddenly compensate – something which also can disturb the navigational experience.

References: Deliverable D7, section 2.1

1.3.6 You should make it possible for the user to adjust the strength of a dragging force

Users have different motor skills, and will need different dragging force strengths

References: Deliverable D7, section 2.1

1.3.7 You should be aware that user actions will influence the trajectory felt by the user during dragging

During force playback users will not feel the exact path that is played to them. Perturbations from the users force on the device and gravitational effects can alter the trajectory. The effect will be less for smooth transitions than sharp transitions.

References: Deliverable D7, section 2.4

2 Overview

2.1 General

2.1.1 Applications should help the users to build a mental representation of the virtual environment.

Users need to be able to build a mental representation of the environment. Be aware that user expectations influence the result, and that serious problems may occur if the user expects things to be organized or oriented differently than it actually is.

References:
Magnusson, C, Rassmus-Gröhn, K, Sjöström, C, Danielsson, H,
Navigation and recognition in complex haptic virtual environments -
reports from an extensive study with blind users, Eurohaptics 2002, Edinburgh, UK, 8-10 juli, 2002

Magnusson, C, Rassmus-Gröhn, K, A Dynamic Haptic-Audio Traffic Environment, Eurohaptics 2004, Munich, Germany June 5-7 2004

2.1.2 Haptic models or environments should be presented in their context of use.

The context will help users form an understanding of the virtual environment. Context information can significantly improve user performances.

References: Magnusson, C, Rassmus-Gröhn, K, Sjöström, C, Danielsson, H, Navigation and recognition in complex haptic virtual environments - reports from an extensive study with blind users, Eurohaptics 2002, Edinburgh, UK, 8-10 juli, 2002

Magnusson, C, Rassmus-Gröhn, K, A Dynamic Haptic-Audio Traffic Environment, Eurohaptics 2004, Munich, Germany June 5-7 2004

2.1.3 The applications may provide contextual information from different starting points.

Since users have different preferences and abilities it is recommended to provide contextual information via multiple channels.

References: Deliverable D1

2.2 Multimodality

2.2.1 Applications should provide feedback via the appropriate senses.

It is not suitable to rely on one modality alone for all information (this can lead to information overload). Consider using a short text message such as a caption to an image or model, provided as speech or Braille. Combine haptics with sound labels, a Braille display and/or synthetic speech for text output. Environmental sounds can also help the user to form an understanding of the environment.

References: McGee, M.R., Gray, P.D. and Brewster S.A (2000). The effective combination of haptic and auditory textural information. In Proceedings of the First Workshop on Haptic Human-Computer Interaction, pp 33-38

2.2.2 You may try environmental sound to aid in getting an overview.

Use audio (both sound labels and environmental sound) to provide a context. The sound feedback can also be used to get information about the program mode. One should consider how complicated and expensive the setup is (large number of loudspeakers, advanced audio card, etc.). Alternatively, an HRTF-based auditory display can be used instead (it simulates the presence of a sound-emitting object in any position within the listener's environment), which requires only a pair of headphones but the main drawback of that approach is that the 3D auditory environment around the listener, which is reproduced on the headphones, appears to be moving when the listener's head moves.

References: Deliverable D6
Savidis, A., Stamou, A. & Stephanidis, C. An accessible Multimodal Pong Game Space. 9th ERCIM Workshop "User Interfaces for All", Bonn, September 2006

2.3 Reference system

2.3.1 Changing the reference system or the size of the environment should be done with care.

If the reference system changes the user has to be able to know his/her position relative the environment after the operation. Thus either one needs to make sure the user is in the same relative position before and after the change, or the change is done in such a way as to allow the user to follow what happens during the changing operation.

References: C.Sjöström, PhD thesis (2002), http://www.certec.lth.se/doc/hapticinteraction/

Magnusson, C, Rassmus-Gröhn, K, A Dynamic Haptic-Audio Traffic Environment, Eurohaptics 2004, Munich, Germany June 5-7 2004

2.3.2 Applications may use reference points to help the users locate objects.

Fixed reference points like walls, floor, ceiling and fixed objects like shelves are important in an environment in order to support overview. Virtual reference points can also be added to facilitate navigation.

References: C.Sjöström, PhD thesis (2002), http://www.certec.lth.se/doc/hapticinteraction/

2.3.3 If the application adds new reference points, it should make sure they are accessible and that they do not disturb the exploration.

It is important to make any added reference points easy to find and to get back to. They should also provide an efficient pointer to whatever they are referring to.

References: Deliverable D6, section 4.6, Deliverable D7 section 2

2.3.4 Directional references in the virtual environment should be the same as in the physical environment.

Referencing depends on the physical location of the participants during the interaction in the virtual environment, since forwards, backwards left, right etc depend on the way you are facing. Thus it is hard to talk about directions in the environments if participants are in the same room facing each other.

References: Deliverable D8

3 Object properties

3.1 General

3.1.1 Context should be provided to support haptic object identification

Object identification in haptics alone is difficult. Feedback can be provided through other modalities to give context and aid identification. Eg spoken introduction, relevant non-speech audio or cue triggered information.

References: Deliverable D6.

C.Sjöström, PhD thesis (2002), http://www.certec.lth.se/doc/hapticinteraction/

Magnusson, C, Rassmus-Gröhn, K, Sjöström, C, Danielsson, H, Navigation and recognition in complex haptic virtual environments - reports from an extensive study with blind users, Eurohaptics 2002, Edinburgh, UK, 8-10 juli, 2002

3.1.2 Objects should be designed to be haptically simple and not just visually simple

Don't just adapt a visual object to a haptic form, start from scratch when designing the haptic object to avoid any visual bias.

References: Deliverable D6
Challis, B. and Edwards, A.D.N. Design Principles for Tactile Interaction. Haptic Human-Computer Interaction. Brewster, S.A. and Murray-Smith, R. (Eds.), Springer LNCS, Vol 2058, pp17-24

Magnusson, C, Rassmus-Gröhn, K, Eftring, H, User evaluations of a virtual haptic-audio line drawing prototype, Workshop on Haptic and Audio Interaction Design University of Glasgow, 31st August - 1st September 2006

3.1.3 Objects should be usable without vision

Ensure that the user can get all of the information required about an object without requiring sight. Other modalities can be used to present complementary information.

References: Deliverable D5
C.Sjöström, PhD thesis (2002), http://www.certec.lth.se/doc/hapticinteraction/

3.1.4 Rhythm may be presented in either an audio or tactile form

Auditory and tactile rhythms can be used in cross-modal interaction interchangeably, as the recognition rate remains high. When visual rhythms are involved, the cross-modal recognition rate is clearly lower.

References: Deliverable D7

Kosonen, K. and Raisamo, R. Rhythm perception through different modalities. In Proceedings of Eurohaptics, France, (2006).

3.2 Haptic 3D objects

3.2.1 Objects with small scattered surfaces should be avoided

It is difficult to recognise and explore small scattered surfaces. Objects with large connected surfaces are easier to identify and explore. Use of such objects is therefore unsuitable but if they are required it is preferable to provide feedback via other modalities to support use.

References: Deliverable D6.
C.Sjöström, PhD thesis (2002), http://www.certec.lth.se/doc/hapticinteraction/

3.2.2 Objects with sharp convex corners should be avoided

Sharp convex corners are difficult to follow and it is easy to lose contact with the object surface. Rounded corners (and concave ones) are easier for users to stick to. This is due to the limitations of current single point force-feedback devices (e.g. PHANTOM).

References: C.Sjöström, PhD thesis (2002),
http://www.certec.lth.se/doc/hapticinteraction/

Yu, W. and Brewster, S.A. Evaluation of multimodal graphs for blind people. Journal of Universal Access in the Information Society (2003), 2(2), pp 105-124.

3.2.3 Objects should be haptically complete

Ensure that objects do not have holes or gaps that users could fall through.

References: G. Jansson, H. Petrie, C. Colwell, D. Kornbrot, J. Fänger, H. König, K. Billberger, A. Hardwick and S. Furner, Haptic Virtual Environments for Blind People: Exploratory Experiments with Two Devices, International Journal of Virtual Reality, 1999

Magnusson, C., Rassmus-Gröhn, K., Sjöström, C., Danielsson, H.,
Navigation and recognition in complex haptic virtual environments -

reports from an extensive study with blind users, Eurohaptics 2002, Edinburgh, UK, 8-10 juli, 2002

3.3 Haptic 2D environments

3.3.1 Negative relief may be used to support force-feedback line following

Negative relief allows users to fall into the groove of a line and follow a shape. It stops users slipping-off the shape when exploring.

Positive relief may also be used for contour following in closed objects

It can be noted that this guideline differs from a guideline applicable to embossed pictures explored with real finger pads; in that case embossed lines are preferable.

References: Deliverable D6
Yu, W. and Brewster, S.A. Evaluation of multimodal graphs for blind people. Journal of Universal Access in the Information Society (2003), 2(2), pp 105-124.

Magnusson, C, Rassmus-Gröhn, K, Eftring, H, User evaluations of a virtual haptic-audio line drawing prototype, Workshop on Haptic and Audio Interaction Design
University of Glasgow, 31st August - 1st September 2006

3.4 Tactile applications

3.4.1 Tactile icons should be clear and easy to recognise

Tactile icons (Tactons) can be distinguished by using different spatial and temporal patterns. The amount of information that can be presented via a tacile icon can be increased by increasing the number of independent parameters used. For example for pin arrays:

Blink speeds of 0.04 and 0.5 seconds are easy to differentiate
Eight patterns (the four cardinal points plus main diagonals) are easy to differentiate
Height may also be a good way to distinguish patterns

Pattern size is not efficient for small (4x4) arrays of pins.

References: Deliverable D7

Benali-Khoudja, M. Hafez, M. Sautour, A. Jumpertz, S. (2005). Towards a new tactile language to communicate emotions. Mechatronics and Automation, 2005 IEEE International Conference. 29 July-1 Aug. 2005. Volume: 1, On page(s): 286- 291

3.5 Audio

3.5.1 Sonification of objects may enable identification at a distance

Both non-speech and speech sound cues can help users identify an object at a distance

References: Deliverable D6 and D7

Magnusson, C., Danielsson, H., Rassmus-Gröhn, K., Non Visual Haptic Audio Tools for Virtual Environments,Workshop on Haptic and Audio Interaction Design, University of Glasgow, 31st August - 1st September 2006

3.5.2 Sound effects may be used to give additional feedback

Non-speech sounds can be added to a haptic application to give extra feedback when tools or different modes are selected. Such sound may also motivate users.

References: D7

Magnusson, C, Rassmus-Gröhn, K, Eftring, H, User evaluations of a virtual haptic-audio line drawing prototype, Workshop on Haptic and Audio Interaction Design
University of Glasgow, 31st August - 1st September 2006

4 Manipulation

4.1 Virtual environment

4.1.1 Forces associated with objects should be adjustable by the user

Different users have different strengths and capabilities, so it is suitable that they should be able to adjust the forces associated with objects to suit their personal preferences. Different force-feedback devices allow very differing levels of forces, some devices cannot support strong forces, for example.

References: Deliverable D7, section 2.1

4.1.2 Objects should have predictable behaviours to simplify control

Predictable, natural behaviours, such as gravity or friction, make objects easier and simpler to control.

References: C.Sjöström, PhD thesis (2002),
http://www.certec.lth.se/doc/hapticinteraction/

4.2 Physical device

4.2.1 Users should be given proper training in using a device, if they are not used with the kind of manipulation it requires

Many blind people do not commonly use a pen and using a force-feedback device with a stylus (e.g. the PHANTOM Omni) can cause difficulties.

If the use of a stylus gives problems, a thimble can be considered.

References: Jansson, G. & Ivås, A. (2001). Can the efficiency of a haptic display be increased by short-time practice in exploration? In G. Goos, J. Hartmanis & J. van Leeuwen (Series Eds.) & S. Brewster & R. Murray-Smith (Vol. Eds.), Lecture Notes in Computer Science: Vol. 2058. Haptic Human-Computer Interaction (pp. 88-97). Heidelberg, Germany: Springer.

4.2.2 A Braille display may be used on the non-dominant hand

To avoid overloading the main display and when the dominant hand is occupied with the main task, information could be presented via Braille to the non-dominant hand. This could be used with a complex auditory environment where the dominant hand is controlling a pointer.

References: Deliverable D5

Crossan, A. and Brewster, S.A. Two-Handed Navigation in a Haptic Virtual Environment. In Vol II Proceedings of CHI 2006 (Montreal, Canada), ACM Press, pp 676-681.

Group work

5 Context

5.1 Background knowledge

5.1.1 Instructions for the task should be provided to each user in a format he/she can access.

The description of the task must be accessible by all the users whatever the way they access to it. It is important that the group members can have it at any time and make their own interpretation, without having to rely on another of the group members interpretation.

If instructions are given on a paper copy, provide a Braille version for a Blind user. If it's a computer document make sure it is in an accessible format that can be read properly using Jaws together with a Braille device and/or speech output.

References: D8

K Pernice Coyne & J Nielsen 2004. How to conduct Usability Evaluations for Accessibility. Nielsen Norman Group

5.1.2 Most pieces of information available in the workspace should be provided in an accessible format. Documents that cannot be provided in an accessible format should be carefully checked in perspective to the sighted group members in order to ensure that they are able to give proper description.

All members of the group should be able to access independently. In exceptional cases it is acceptable that an element (graphical for instance) is not accessible and have to be described by the other users.

Use paper Braille if paper copies are provided. Check that formats for documents are accessible.

References: D8

5.1.3 Accessibility of websites that are given to the group has to be checked.

For the same reason as guideline 5.1.2. Make sure that websites are accessible as well. Use applicable Web accessibility standards.

References: D8

5.1.4 Provide support for both getting a quick overview of the shared workspace and to get detailed information about a subset of the workspace.

Supporting getting an overview of the workspace is important to provide each participant with indiviual means of exploring the workspace. Detalied information is necessary to locate and interact with interface objects.

References:

D9 section 3

Winberg, F. (2006). Supporting cross-modal collaboration: Adding a social dimension to accessibility. In McGookin, D. & Brewster, S., *Proceedings of HAID 2006, First International Workshop on Haptic and Audio Interaction Design*. pp. 102-110, Springer Berlin / Heidelberg, Glasgow, UK, August 2006.

5.1.5 Provide help scenario and exercises to discover the shared workspace and the various functionalities of the system.

Use haptics to guide blind users in the workspace and speech to explain what is what. This will enable the users to learn the system before collaborating, and thus be on the same level if understanding of the shared workspace.

References: D8

5.1.6 The knowledge that both visually impaired and sighted persons could interact on equal terms should be shared among group members.

Members that are not experienced with the system should have this information stated clearly.

References: D8

5.1.7 Group members should have a common terminology for discussing the manipulation of the environment.

In order to support smooth collaboration, eliminating misunderstandings and support collaborative error recovery it is important for the group members to communicate in a non-problematic fashion about the shared workspace and the objects.

References:

D9 section 3 & 6

Winberg, F. (2006). Supporting cross-modal collaboration: Adding a social dimension to accessibility. In McGookin, D. & Brewster, S., *Proceedings of HAID 2006, First*

International Workshop on Haptic and Audio Interaction Design. pp. 102-110, Springer Berlin / Heidelberg, Glasgow, UK, August 2006.

5.2 Shared workspace.

5.2.1 The focus should be on creating shared workspaces in order to avoid parallel work processes.

Parallel processes means that even though the group members work with the problem at the same time, the work is really happening in parallel instead of collaboratively, effectively meaning that the amount of work is doubled and that the group members doesn't help each other in solving the problem.

References:

D8 section 4,

D9 section 1.2 & 9

5.2.2 Provide the users with representations that are similar enough to support the collaborative tasks.

Sometimes providing exact representational equivalence is not needed to a certain task, striving for equivalence might in those cases be counter productive to collaboration since they overload the user with information that is not necessary. Always try to establish what is sufficient for the task at hand.

References:

D9 section 2, 3 & 6

Winberg, F. (2006). Supporting cross-modal collaboration: Adding a social dimension to accessibility. In McGookin, D. & Brewster, S., *Proceedings of HAID 2006, First International Workshop on Haptic and Audio Interaction Design*. pp. 102-110, Springer Berlin / Heidelberg, Glasgow, UK, August 2006.

5.2.3 Give the possibility to group members to guide the other across modalities.

It should be possible for a group member to guide any other member's pointer. A phantom user can guide another phantom as well as the mouse pointer of another member. A mouse user should be able to guide the phantom (dragging the stylus).

References:

D9 section 4

6 Awareness

6.1.1 Provide feedback on other people's activities in a collaborative environment.

Feedback about changes in an environment that other persons make is needed in order to get a general sense of awareness, which is essential for coordination. This applies both when a person is moving an object or writing some text or drawing a shape as well as if a person changes the mode of interaction in the environment from. Feedback can be given auditively whenever a person grasp an object in order to move it and whenever a person is putting an object down at a new place in the environment.

References:

D9 section 2

Sallnäs, E-L., Moll, J., & Severinson-Eklundh, K. (accepted, 2007). Group work about geometrical concepts among blind and sighted pupils using haptic interfaces. In *Proceedings of the Second Joint Eurohaptics Conference and Symposium on Haptic Interfaces for Virtual Environments and Teleoperator Systems (World Haptics 2007)*, Tsukuba, Japan, March 2007.

6.1.2 Provide support for collaborative error recovery. This involves mutual understanding of how to solve a specific problem, and support for detecting deviations from the solution.

An auditory interface can make it possible for a blind person to take part in the problem solving, both by *active inquiries* in the interface (exploration of the auditory space) as well as *repairing breakdowns* (realizing when an error has been made and taking the necessary steps to correct this).

Monitoring the other person's actions can indirectly be supported by the assembly of resources provided by the manipulation in the interface and the social interaction. The interface supports the blind subject participation in a *working division of labour*, where each participant at every instance has a job to do, as well as resources for monitoring the activities of the other participant.

References:

D9 section 3

Winberg, F. (2006). Supporting cross-modal collaboration: Adding a social dimension to accessibility. In McGookin, D. & Brewster, S., *Proceedings of HAID 2006, First International Workshop on Haptic and Audio Interaction Design*. pp. 102-110, Springer Berlin / Heidelberg, Glasgow, UK, August 2006.

Winberg, F., Bowers, J. (2004). Assembling the Senses: Towards the Design of Cooperative Interfaces for Visually Impaired Users. In *Proceedings of CSCW '04*. ACM Press

6.1.3 Provide support for both getting a quick overview of the shared workspace and to get detailed information about a subset of the workspace

In order to have awareness of the status of the groups work and to be able to coordinate your own activities it is important to be able to zoom in and out between a view of the whole work space and parts of the workspace. For example being able to work in one part by yourself and at the same time have access to the parts of the workspace that others work in.

References:

D9 section 3

Winberg, F. (2006). Supporting cross-modal collaboration: Adding a social dimension to accessibility. In McGookin, D. & Brewster, S., *Proceedings of HAID 2006, First International Workshop on Haptic and Audio Interaction Design*. pp. 102-110, Springer Berlin / Heidelberg, Glasgow, UK, August 2006.

6.1.4 The visual and haptic feedback about the location of the Phantom stylus should be very noticeable when several visually impaired and sighted persons are working in the same interface.

If it is not, then it is difficult for the user to know where the other one is and what other persons are referring to in the virtual space.

The representation of the collaborating persons are useful for many purposes and makes verbal interaction easier. If the representation of a person is felt and seen it functions as a reference point that all persons can relate to in relation to details in the environment. A person can ask another to move closer to a target area and to fine adjust coordination of joint action. A person can show direction and intention by pushing the other person in a certain direction, by holding on to the other proxy or by holding on to the same object.

Thus, it is recommended that all proxies should be visible and haptically felt.

References:

D9 section 6

6.1.5 Joint manipulation of objects is possible and haptic feedback may be used in order to coordinate joint handling of objects.

Multiple users can use force feedback to communicate in a shared object manipulation task. They can coordinate their actions through the force feedback in tasks involving jointly lifting and moving objects. Further, this feedback can be used for guidance to an area of the environment during the joint object manipulation task.

References:

Sallnäs, E-L., Bjerstedt-Blom, K., Winberg, F., and Severinson Eklundh, K. (2006). Navigation and Control in Haptic Applications Shared by Blind and Sighted Users. *Proc. of the First International Workshop on Haptic and Audio Interaction Design, pp 68-80.*

7 Guidance

7.1.1 In a collaborative working environment, designers should aim to provide a means of recording and playback of trajectories in the haptic space to facilitate transmission of shape information and awareness of other users.

Haptic trajectory playback provides a means physically communicating with another user in a computer environment. It is a common technique in a traditional group work environments involving visually impaired users, where a sighted user may grab and move the hand of the visually impaired user directly to a point of interest. Haptic trajectory playback provides an analogous situation for a computer environment. This technique has been shown to be useful for both describing shapes and awareness of the location of another user in the environment.

References: D9 Section 4

7.1.2 Designers should make the playback as customizable as possible, with possibilities to set speed in order to explore areas of different levels of details efficiently.

The complexity of the trajectory will affect how difficult it is for the visually impaired user to perceive the shape of the trajectory. By allowing the guiding user to adjust the speed of playback, simple shapes or lines can be traversed quickly while complex high detailed areas of the shape can be explored more slowly and carefully.

References: D9 Section 4

7.1.3 Trajectory playback is an effective complement to a verbal description of a complex shape.

Verbal communication is an important communication channel in a collaborative working environment. It can be sufficient in itself for describing simple shapes or scenes, however when more complex or abstract shapes or diagrams are present it can be difficult to use words alone. Trajectory playback can be used in a teacher learner environment as a further communication channel when the teacher cannot find the words to describe a shape or diagram, or when learner does not understand the teachers description.

References: D9 Section 4

7.1.4 Designers should be aware that large or sharp transitions in a trajectory playback force can cause the user to lose control of the device.

Any sharp increase in force can surprise a user. If the user holding the haptic device is not expecting a large change in force, he or she could lose control of the device. By increasing the playback forces in a more gradual manner, a sharp pull effect can still be achieved while allowing the user to stay in control of the device.

References:

D9 Section 4

Crossan, A. Williamson, J. Brewster, S. A General Purpose Control-Based Playback for Force Feedback Systems, in proceedings of Eurohaptics 2006, Paris.

Plimmer, B., Crossan, A. and Brewster, S.A., Computer Supported Non-Visual Signature Training, In Vol II Proceedings of the First International Workshop in Haptic and Audio Interaction Design (HAID2006). University of Glasgow, UK, 31st August - 1st September 2006.

7.1.5 When incorporating trajectory playback into a collaborative environment, it is important to include real time playback to facilitate verbal communication in describing shapes or trajectories.

Designers should take advantage of the advantages of multimodal interaction when using trajectory playback. In a teacher learner environment, a learner can feel a trajectory drawn through playback while listening to the teacher describe the technique verbally without these feedback channels interfering. Allowing the learner to feel the trajectory in real time as the teacher draws it facilitates the communication by allowing the teacher to describe his or her actions as he or she is performing them.

References:

D9 Section 4

Plimmer, B., Crossan, A. and Brewster, S.A., Computer Supported Non-Visual Signature Training, In Vol II Proceedings of the First International Workshop in Haptic and Audio Interaction Design (HAID2006). University of Glasgow, UK, 31st August - 1st September 2006.

8 Role/initiative/empowerment

8.1.1 Users with different needs should be provided with well presented multimodal and modality specific representations of contents to activate and maximize initiative and role taking (to support collaborative work for the task in question)

Collaboration of the users is supported by taking into account the many ways (modalities) to present information to the user and using that knowledge to activate the role-taking and initiative. For the sighted user the well presented visual information can lead to active role of this user. Similarly the well presented haptic information can lead to the active role of the visually impaired user.

When two users share the application its use tends to be dominated by the user that has access to well-formed, good quality, content-rich modality as opposed to the weaker modalities. For example the user with the haptic device is prone to dominate if the other modalities are weaker, of poor quality or their content is not equivalent.

Modality's usefulness for the particular application depends of its strength in that particular application. That is, how good quality and content-rich data can be embedded to the modality.

References: Deliverable D10

8.1.2 The specific interface can be dominant in role taking which should be taken into account when designing application to be accessible by haptic sense.

User of the haptic device can dominate the collaboration situation. This can be prevented by providing a wide range of multimodal feedback that will complement each other or by designing the application so that the users will take turns in using the haptic device.

References: Deliverable D10

8.1.3 Support may be provided for linguistic description of things for the sighted user.

The sighted user can have problems in describing and explaining things on the visual display to the visually impaired user. Therefore it is important that the visual information is consistent and well presented. Furthermore it is recommended to provide e.g. textual information to support the description.

References: Deliverable D10