Audio Navigation: Using Spatial Audio In Ubiquitous Interfaces

Robert Day
Simon Holland
David Bowers
Anton Dil

10th May 2004

Department of Computing
Faculty of Mathematics and Computing
The Open University
Walton Hall,
Milton Keynes
MK7 6AA
United Kingdom

http://computing.open.ac.uk

AUDIO NAVIGATION: USING SPATIAL AUDIO IN UBIQUITOUS INTERFACES TO SUPPORT PHYSICAL NAVIGATION TASKS

Robert Day, Simon Holland, David Bowers and Anton Dil
The Open University
Walton Hall
Milton Keynes
MK7 6AA
{r.h.day, s.holland, d.s.bowers, a.dil}@open.ac.uk

ABSTRACT

An important current movement in computing is towards mobile and ubiquitous interaction. A major research field within mobile and ubiquitous computing is minimal attention interfaces. At present however, there is little in the way of validated heuristics to inform the design and implementation of minimal attention user interfaces. A paradigmatic example of a challenging mobile interaction task is physical navigation. A potentially promising solution to the problem of providing a minimal attention interface for physical navigation tasks is spatial audio. The initial focus of this research is to investigate the use of spatial audio as an element in a minimal attention interface to provide usable and meaningful navigation cues in one or more common navigational contexts. The aims of this project are to highlight problems, identify and analyse issues and evaluate potential solutions. Finally, we intend to formulate guidelines for the use of spatial audio in the wider context of minimal attention interfaces.

Keywords

Physical navigation, spatial audio, ubiquitous interfaces, minimal attention user-interfaces.

1. CONTEXT

Many applications for mobile computing involve providing assistance or information to users engaged in a primary task, such as driving a car, which requires the critical focus of the user's attention. In addition to constraining user attention, the demands of such tasks often call for the user to be physically involved, resulting in a need for any mobile computer to require minimal prompting or physical interaction from the user. The design goals of minimal attention user interfaces [1] and ubiquitous computing [2] offer potential solutions to the requirements of such scenarios. It is clear however, that an ideal interface for many task-critical mobile applications would enable hands-free, eyes-free interaction. In addition, necessary information should be presented via a medium that requires minimal cognitive processing and avoids distraction.

Physical navigation involves the complex integration of information about one's current state (position and heading) and the state of a target destination (position, bearing and distance) in order to calculate directional information to guide one from A to B. The development of GPS (Global Positioning System) technology means that current navigational aids are more than capable of performing this integration task yet the presentation of subsequent directional cues is still largely confined to the visual or speech modalities, which both require cognitive resource away from any primary task in order to interpret [3,4,5]. In contrast, spatial audio attempts to replicate the spatial cues (essentially comprised of temporal, intensity and spectral cues) derived in human free-field hearing and enables audio cues to be presented to listeners as though they were emanating from a particular point in the virtual space around them. As human spatial hearing is innate and requires little or no conscious effort to interpret, spatial audio may provide a suitable medium for minimal attention navigation interfaces where users could simply follow an audio cue.

2. IMPLEMENTING SPATIAL AUDIO

A number of recommendations for the successful implementation of spatial audio can be derived from the literature on psychoacoustics. Such recommendations include using a head-tracker to moderate output and allow head movement cues [6] and using broadband noise cues to improve accuracy [7]. Further recommendations will be derived from explorative studies measuring not just abstract

accuracy but also individual tones and mappings of distance information for usability (acceptability) and functionality (effectiveness).

3. GOALS

Focussing on the potential tasks, users and environments for mobile navigation systems will lead to the methodical and principled development of prototype interfaces, techniques and tools for improved interaction and highlight domain and technical issues.

The main aim of this project is to develop principles and heuristics for the design, application and evaluation of spatial audio in mobile user interfaces.

4. STATUS

This research was inspired by the earlier work of Holland et al. [8] and began as a PhD project in October 2003, as such it is still in its infancy. However, rapid progress with the necessary technology has meant that the implementation of an initial prototype spatial audio navigation interface for testing is imminent. Early explorative studies are planned to assess the potential of such a system in terms of safety and usability.

Future work will look at expanding the scope of the system for alternative navigational environments and user groups. In particular there is clear potential for a fully spatial audio system to provide functional navigation support as assistive technology for visually impaired users. This application will require the development of specific interaction techniques above and beyond those required for sighted users.

5. INTERIM CONCLUSIONS

Being very recently begun and relatively novel research, at present very few conclusions can be offered. However, it is clear from our early investigations that the area of spatial audio has considerable potential for diverse research.

6. REFERENCES

[1] Pascoe, J., Ryan, N. and Morse, D. R. (2000). Using while moving: HCI issues in fieldwork environments. *ACM Transactions on Computer Human Interaction*, 7, 417-437.

[2] Weiser, M. (1991). The computer for the 21st century. *Scientific American*, 265(3), 94-104.

[3] Burnett, G. E. and Joyner, S. M. (1997). An assessment of moving map and symbol-based route guidance systems. In Y. I. Noy (Ed.), *Ergonomics and Safety of Intelligent Driver Interfaces*, 115-137, Mahwah NJ: Lawrence Erlbaum Associates.

[4] Trbovich, P. and Harbluk, J. L. (2003). *Cell Phone Communication and Driver Visual Behaviour: The Impact of Cognitive Distraction*. Proceedings of CHI 2003.

[5] Klatzky, R. L., Lippa, Y., Loomis, J. M. and Golledge, R. G. (2002). Learning directions of objects specified by vision, spatial audition, or auditory spatial language. *Learning & Memory*, 9, 364-367.

[6] Begault, D.R., Wenzel, E.M. and Anderson, M.R. (2001). Direct comparison of the impact of head tracking, reverberation and individualized head-related transfer functions on the spatial perception of a virtual speech source. *Journal of the Audio Engineering Society*, 49, 904-916.

[7] Butler, R. A. (1986). The bandwidth effect on monaural and binaural localization. *Hearing Research*, 21, 67-73.

[8] Holland, S., Morse, D. R. and Gedenryd, H. (2002). Audio GPS: Spatial audio in a minimal attention interface. *Personal and Ubiquitous Computing*, 6(4), 253 – 259.