Flexible interfaces: future developments for post-WIMP interfaces

Benjamin Bressolette, Michel Beaudouin-Lafon

Flexible interfaces : future developments for post-WIMP interfaces

Benjamin Bressolette and Michel Beaudouin-Lafon

LRI, Université Paris-Sud, CNRS,
Inria, Université Paris-Saclay
Orsay, France
benjamin.bressolette@lri.fr

Résumé Most current interfaces on desktop computers, tablets or smartphones are based on visual information. In particular, graphical user interfaces on computers are based on files, folders, windows, and icons, manipulated on a virtual desktop. This article presents an ongoing project on multimodal interfaces, which may lead to promising improvements for computers' interfaces. These interfaces intend to ease the interaction with computers for blind or visually impaired people. We plan to interview blind or visually impaired users, to understand how they currently use computers, and how a new kind of flexible interface can be designed to meet their needs. We intend to apply our findings to the general public, to design adapted multimodal interfaces that do not always require visual attention.

Keywords: Multisensory interface, non-visual interface, flexible interface, blind users, visual attention, auditory, tactile.

1 Introduction

In Human-Computer Interactions (HCI), the large majority of information is transmitted to users through vision. This paper presents an ongoing project on interfaces that would be used without vision, by a combination of other modalities that convey rich and meaningful information. This process may lead to a new type of multimodal interfaces that we call *flexible interfaces*. These interfaces need to be flexible to users' desires, but also to users' abilities. In particular, we believe that visually impaired or blind users should more easily interact with computers. Digital tools enriched with new sensors and devices should be capable of going beyond people' disabilities.

In the next section, we briefly present related work on sound as information feedback, assistive technologies used by visually impaired and blind users, and interfaces that can inspire the design of a prototype. Section 3 develops the design process of a potential flexible interface adapted to blind and visually impaired users, before concluding in section 4.

2 Related Work

Computer interface mainly conveys visual feedback, thanks to the development of Graphical User Interfaces (GUI). Almost all recent computers have such an interface, and visual information is sometimes completed by informative sounds.

2.1 Sound as Information Feedback

Auditory icons introduced by Gaver [1] convey rich information and are still used nowadays, e.g. on Apple computers. The earcons are another example of icons, based on abstract sounds, and are widely used in computer interfaces [2]. Other sound icons has been designed, as spearcons that are based on accelerated speech [3], morphocons [4] or beacons [5].
Information can also be conveyed by continuous sounds through the sonification process [6]. Several studies showed how interactive sonification can help to improve movements [7, 8]. This continuous feedback is not used while interacting with computers, but it may be an interesting solution for this project.
As information are interactively transmitted through sounds, a design process is essential for aesthetic and emotional reasons. The Sonic Interaction Design in an interdisciplinary field that address the related interrogations, between "interaction design and sound and music computing" [9], and and this project can benefits from their work.

Even if sound icons are used on computers, information is mainly conveyed through vision, making these interfaces not adapted for visually impaired or blind users. Several systems has been designed to ease the transmission of visual information or to convert them into sounds or haptic stimuli.

2.2 Assistive Technologies for Blind or Visually Impaired Users

So-called WIMP – for Windows, Icons, Menus and Pointing – interfaces mainly give information through vision, leading to a serious problem of accessibility for visually impaired or blind people [10]. Some visually impaired people still rely on visual information, using for instance screen magnifiers [11]. However, palliative alternatives for blind users are based on visual information transmitted through another modality, namely sounds or tactile stimuli.

Screenreaders, which convert the visual information into speech, are broadly used [12–14]. These applications are useful for texts accessibility, but they are not really efficient with other contents, such as pictures or two dimensional representation and exploration. However, several improvements have been made to screenreaders, to address these issues [15, 16].
Braille interfaces are also widely used to convey textual information through touch [13, 17]. They are composed of matrix of pins that are controlled by the computer, as shown on Fig. 1. Several prototypes have been built with both devices to create rich multimodal interfaces [17–19].

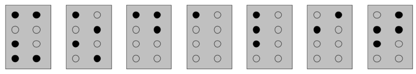

Figure 1. An example of Braille interface, from Bellik and Burger [17].

These assistive technologies brings interesting alternatives for blind or visually impaired users. Nevertheless, several interfaces examples show principles that can help us reconsider actual GUI.

2.3 Beyond Actual Interfaces

An inspiring study was conducted by Newman and Wellner, with the ambition to reduce the incompatibilities between the physical and digital worlds [20]. They built an interface based on a desktop where real and digitial objects can be manipulated thanks to a videoprojector and a camera positioned above the desk. Recent prototypes have been built with the same principle [21, 22].
The previous example still involves a screen, but it is not the case of Gustafson et al.'s *Imaginary interface*, which is based on the relative position of the hands [23]. After specifying an L-shaped coordinate system with the non-dominant hand, users form shapes in the free space with the other hand. Even if visual attention is necessary for the coherence of the drawn shapes, this inspiring interface proposes fluid interactions without a screen.
In subsequent work, Gustafson et al. studied how the knowledge acquired while using a physical device as a phone can be transfered to build an *Imaginary Phone* [24]. As the users involuntarily learn the relative position of the icons of their phone, Gustafson proposed to use it remotely by pointing on the same relative position on their non-dominant hand. This study highlights how visual memory can contribute to design an interface manipulated with gestures and proprioceptive information, without requiring a screen. It adds an interesting flexibility to the classic smartphone, however vision is still needed to point to the desired icon.

These examples are still based on visual information, which are sometimes completed by sounds. We now give an example of a *flexible interface*, created for a specific situation where the user's sight is dedicated to a more important task.

2.4 MovEcho : an Interface Adapted to the Driving Context

MovEcho has been created to be used blindly, in a driving situation. Recent vehicles are equipped with touchscreens, but the major drawback of these interfaces is the visual distraction from the road they cause, which can lead to concentration problems and safety issues [25]. MovEcho has been designed to be manipulated with 3D gestures, and a rich sound feedback lets the user know if the gesture has been taken into account, which function has been manipulated,

and what is the current setting. The first version controls the ventilation system, and a second one manages the music system.
One of the major claim made is to use a virtual object as a natural link between the gestures and the sound feedback. This assertion is based on Gaver's work, describing the sound production in the environment as an interaction between two objects [26, 27]. In our opinion, creating a meaningful link between gestures and sounds had to connect the user's gestures performed in mid-air with an object, which we chose to add in virtual reality. Rath and Rochesso developed an idea about sonified virtual object that inspired this study [28]. The first theoretical results have been published [29], and the system has been compared to a touchscreen and tested in a driving simulator. The results show that even a first usage of MovEcho allows for a better visual task completion related to traffic, and is more appreciated by participants while driving.

Interfaces based on visual information should be more flexible with respect to users' abilities – e.g. is users' visual attention available – but also users' desires – e.g. do users want to use visual information. We agree with Dufresne on the need to develop "alternate modes of interaction for blinds or "sight occupied" users" [19], and that multimodal interfaces can be a promising solution.

3 Flexible Interfaces : Design Process and Future Work

In this project, we intent to rethink the construction of computer interfaces, starting by what is one of the foundations of these visual interface : the files, folders, and window management system.

3.1 Framework

The first step will consist of conveying rich information through the auditory and tactile channels, which can lead to the design of a first prototype. The different sequences of the project are detailed in Fig. 2, which is inspired by the framework described by Mackay and Fayard [30].

The literature provided examples of assistive technologies used by blind or visually impaired users, and inspiring ideas. However we believe that a first step in the design of a first prototype is to perform semi-structured interviews.

3.2 Semi-Structured Interviews

An important point is to understand how visually impaired or blind users interact with their computers, and in particular how they manage their files. How do they find a particular file on their computer ? Do they use several windows ? If so, how do they manage them ? How do they manage the actual possibilities of their computer and the potential external devices to meet their needs ? What are their strategies and workarounds to their impossibility to perceive visual information ?

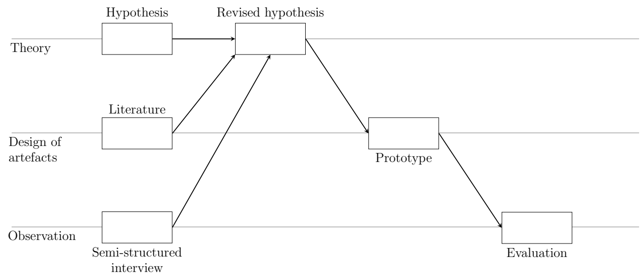

Figure 2. Sequences of the project, with respect to the framework described by Mackay and Fayard [30].

To answer these questions we propose to conduct semi-structured interviews, during which the participants will be asked to perform live demonstrations while responding. The main questions of these interviews are prepared in advance, but the experimenter adapts his queries to the answers given, which explain why these interviews are qualified of “semi-structured”. A common approach used is the critical incident technique originally proposed by Flanagan [31] and adapted to social sciences [32] : participants are asked to remember a recent incident, and give as much details as possible about it. The goal is to understand why this incident happened, why it was typical, and how it can be possible to avoid it in the future. This technique can be used on several topics, e.g. on files, folders and windows management in our case. Usually this procedure is very convenient before designing a prototype, as the answers can inspire design opportunities.

We plan to interview around 15 blind and visually impaired users, to understand the difficulties they can have while managing files, folders and windows. In particular, it would be interesting to interview participants not blind from birth, to figure out how they adapted, in particular while interacting with computers. These interviews are usually interpreted with a thematic analysis, which is formalized by Braun and Clarke [33]. The results would help to revise our initial hypothesis, see Fig. 2.

3.3 Prototype and future work

MovEcho is an example how post-WIMP interfaces can be designed, without only focusing on visual information. This flexibility would allow users to choose which modalities can be involved in the interacting process, and which have to be free for an other task, as traffic management or air traffic control [34]. For example in a face-to-face meeting, it would be better to dedicate vision to the interaction with the other person, and not to the computer.
As we mentioned, computers' interactions for blind users are only based on screenreaders and Braille interfaces. We advocate that substantial improvements

can be made with flexible interfaces, by directly designing multimodal interfaces rather than trying to convey visual information via another modality.

Multimodal objects can be the basis of the flexible interfaces we propose to build, e.g. with MovEcho. For instance, it may be interesting to extend to several modalities the notion of file, which actually can be manipulated with a mouse and give a feedback only by visual information. In our project, we may add the possibility to manipulate file objects with gestures, e.g. via tangible objects [35]. The system can give an information feedback to the user through sonification and haptic stimuli, this combination being interesting to avoid visual information [36]. The different ways to interact with the proposed multimodal objects may add this flexibility property to actual interfaces, that may be interesting for blind users or even sighted users that need vision for another task. In this spirit, MovEcho is a first step in this direction. Overall, it may be hard to manipulate all files and folders with this principle, but we think this path is worthwhile exploring. Finally, an evaluation on the field with blind and visually impaired users may follow the prototype design step, as detailed on Fig. 2.

4 Conclusion

This article addresses the limits about unimodal interfaces, which are mainly based on visual information and can even be dangerous to use while driving [25]. In our ongoing project, we propose to enrich these interfaces with stimuli from a variety of modalities to create flexible interfaces, which would allow users to interact while performing other actions.
These interfaces can also be flexible concerning the abilities of the users. In order to add rich information to existing interfaces, we propose to work with blind or visually impaired people. Interviewing these users with special needs can help us understand how they use current interfaces, their strategies and workarounds to interact without visual information. We also hope that these interviews will lead to design opportunities for the first prototype we propose to build. Afterwards, this interface can be tested in a field study, to identify the benefits and further improvements. We plan to adapt the findings of these studies to create multimodal interfaces for the general public.

Acknowledgement

This research was partially supported by European Research Council (ERC) grants n° 695464 “ONE : Unified Principles of Interaction”.

Références

1. Gaver, W. W. :Auditory icons : Using sound in computer interfaces. Human-computer interaction **2**(2), 167–177 (1986)
2. Blattner, M. M., Sumikawa, D. A., Greenberg, R. M. : Earcons and icons : Their structure and common design principles. Human–Computer Interaction, **1**(1), 11–44 (1989)
3. Walker, B. N., Nance, A., Lindsay, J. : Spearcons : Speech-based earcons improve navigation performance in auditory menus. In : Proceedings of the International Conference on Auditory Display, pp. 63–68. London, UK (2006)
4. Parseihian, G., Katz, B. F. : Morphocons : A new sonification concept based on morphological earcons. Journal of the Audio Engineering Society, **60**(6), 409–418 (2012)
5. Kramer, G. : Sonification system using auditory beacons as references for comparison and orientation in data. U.S. Patent No 5,371,854 (1994)
6. Kramer, G., Walker, B., Bonebright, T., Cook, P., Flowers, J. H., Miner, N., Neuhoff, J. : Sonification report : Status of the field and research agenda. In : Proceedings of the International Conference on Auditory Display, Santa Fe, USA (1999)
7. Schaffert, N., Mattes, K. : Acoustic feedback training in adaptive rowing. In : Proceedings of the International Conference on Auditory Display, pp. 83–88. Georgia Institute of Technology, Atlanta, USA (2012)
8. Danna, J., Velay, J.-L., Paz-Villagran, V., Capel, A., Petroz, C., Gondre, C., Thoret, E., Aramaki, M., Ystad, S., Kronland-Martinet, R. : Handwriting movement sonification for the rehabilitation of dysgraphia. In : Proceedings of the 10th International Symposium on Computer Music Multidisciplinary Research (CMMR), pp. 200–208. Marseille, France (2013)
9. Serafin, S., Franinović, K., Hermann, T., Lemaitre, G., Rinott, M., Rocchesso, D. : Sonic interaction design, The Sonification Handbook, chapter 5, pp. 87–110. Logos Publishing House, Berlin, Germany (2011)
10. McGookin, D., Brewster, S., Jiang, W. : Investigating Touchscreen Accessibility for People with Visual Impairments. In : Proceedings of the 5th Nordic Conference on Human-Computer Interaction : Building Bridges, pp. 298–307. ACM Press, Lund, Sweden (2008)
11. Chiang, M. F., Cole, R. G., Gupta, S., Kaiser, G. E., Starren, J. B. : Computer and World Wide Web Accessibility by Visually Disabled Patients : Problems and Solutions. Survey of Ophthalmology, **50**(4), 394–405 (2005)
12. Watanabe, K., Shimojo, S. : When Sound Affects Vision : Effects of Auditory Grouping on Visual Motion Perception. Psychological Science **12**(2), 109–116 (2001)
13. Dufresne, A., Philippe Mabilleau, P. : Touching and Hearing GUI's : Design Issues for the PC-Access System. In : Proceedings of the Second Annual ACM Conference on Assistive Technologies, pp. 2–9. ACM Press, Vancouver, British Columbia, Canada (1996)
14. Kane, S. K., Bigham, J. P., Wobbrock, J. O. : Slide Rule : Making Mobile Touch Screens Accessible to Blind People Using Multi-Touch Interaction Techniques. In : Proceedings of the 10th International ACM SIGACCESS Conference on Computers and Accessibility, pp. 73–80. ACM Press, Halifax, Nova Scotia, Canada (2008)

15. Morris, M., R., Johnson, J., Bennett, C., L., Cutrell, E. : Rich Representations of Visual Content for Screen Reader Users. In : Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, p. 59. ACM Press, Montreal, QC, Canada (2018)
16. Meijer, P.B.L. :An experimental system for auditory image representations. IEEE Transactions on Biomedical Engineering **39**(2), 112–121 (1992)
17. Bellik, Y., Burger, D. : The Potential of Multimodal Interfaces for the Blind : An Exploratory Study. In : 18th Annual RESNA Conference (1995)
18. Brewster, S., Lumsden, J., Bell, M., Hall, M., Tasker, S. : Multimodal 'Eyes-Free' Interaction Techniques for Wearable Devices. In : Proceedings of the SIGCHI conference on Human factors in computing systems pp. 473–480. ACM, Ft. Lauderdale, Florida, (2003).
19. Dufresne, A., Martial, O., Ramstein, C. : Multimodal User Interface System for Blind and "Visually Occupied" Users : Ergonomic Evaluation of the Haptic and Auditive Dimensions. In : Human—Computer Interaction, pp. 163–68. Springer US, Boston, USA (1995)
20. Newman, W., Wellner, P. : A Desk Supporting Computer-Based Interaction with Paper Documents. In : Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 587–592. ACM Press, Monterey, California, United States (1992)
21. Laviole, J., Hachet, M. :PapARt :interactive 3D graphics and multi-touch augmented paper for artistic creation. In : 2012 IEEE Symposium on 3D User Interfaces, pp. 3–6. Costa Mesa, CA, USA (2012)
22. Albouys-Perrois, J., Laviole, J., Briant, C., Brock, A. :Towards a multisensory augmented reality map for blind and low vision people : A participatory design approach. In : Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, p. 629. ACM Press, Montreal, QC, Canada (2018)
23. Gustafson, S., Bierwirth, D., Baudisch, P. : Imaginary Interfaces : Spatial Interaction with Empty Hands and without Visual Feedback. In : Proceedings of the 23nd Annual ACM Symposium on User Interface Software and Technology, pp. 3–12. ACM Press, New York, USA (2010)
24. Gustafson, S., Holz, C., Baudisch, P. : Imaginary Phone : Learning Imaginary Interfaces by Transferring Spatial Memory from a Familiar Device. In : Proceedings of the 24th Annual ACM Symposium on User Interface Software and Technology, pp. 283-292. ACM Press, Santa Barbara, California, USA (2011)
25. Dingus, T. A., Klauer, S. G., Neale, V. L., Suzanne A. P., Lee, E. , Sudweeks, J. D. , Perez, M. A., Hankey, J., Ramsey, D. J., Gupta, S. : The 100-car naturalistic driving study, Phase II-results of the 100-car field experiment. Technical report (2006)
26. Gaver, W. W. : How Do We Hear in the World ? Explorations in Ecological Acoustics. Ecological Psychology **5**(4), 285–313 (1993)
27. Gaver, W. W. : What in the world do we hear ? : An ecological approach to auditory event perception. Ecological psychology **5**(1), 1–29 (1993)
28. Rath, M., Rocchesso, D. : Continuous sonic feedback from a rolling ball. IEEE MultiMedia, **12**(2), 60–69 (2005)
29. Bressolette, B., Denjean, S., Roussarie, V., Ystad, S., Kronland-Martinet, R. : Harnessing Audio in Auto Control : The Challenge of Sonifying Virtual Objects for Gesture Control of Cars. IEEE Consumer Electronics Magazine **7**(2), 91–100 (2018)

30. Mackay, W. E., Fayard, A.-L. : HCI, natural science and design : a framework for triangulation across disciplines. In : Symposium on Designing Interactive Systems : Proceedings of the 2nd conference on Designing interactive systems : processes, practices, methods, and techniques, vol. 18, pp. 223–234, (1997).

31. Flanagan, J. C. The critical incident technique. Psychological bulletin, **51**(4), 327–358 (1954)

32. Mackay, W. E. : Using video to support interaction design. DVD Tutorial, CHI **2**(5) (2002)

33. Braun, V., Clarke, V. : Using thematic analysis in psychology. Qualitative research in psychology **3**(2), 77–101 (2006)

34. Audry, E., Garcia, J. : Towards congruent cross-modal audio-visual alarms for supervision tasks. International Workshop on Haptic and Audio Interaction Design, Lille, France, (2019)

35. Baldwin, M. S., Hayes, G. R., Haimson, O. L., Mankoff, J., Hudson, S. E. : The tangible desktop : a multimodal approach to nonvisual computing. ACM Transactions on Accessible Computing (TACCESS), **10**(3), 9 (2017)

36. Hoggan, E. E. : Crossmodal audio and tactile interaction with mobile touchscreens. International Journal of Mobile Human Computer Interaction, **2**(4), 29–44 (2010)