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Auditory display design—An investigation of a design pattern approach

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Abstract

We present the evaluation of a methodological design framework that supports expert and novice designers in creating auditory artefacts in human–technology interaction. We first motivate the development of our framework by analysing available guidance and the current practice in the field. Subsequently, we recapitulate on the design of the framework—*paco*, *pa*ttern design in the *co*ntext space—and present its key concepts and methods. The evaluation of *paco* aimed to investigate how useful this framework is in a real-world environment. It was conducted in two phases: experts in auditory display design first captured successful designs through *paco* and created a body of design patterns. These patterns were subsequently used in a controlled experiment with novice designers who were given a design task that forced them to use audio. The results demonstrate that *paco* has facilitated the transfer of design knowledge and good practice from experts to novices through design patterns. The context space, a key concept in *paco*, improves the contextual awareness of designers and provides an organising principle for problems, patterns and artefacts. We close by reflecting on the results and discussing future lines of research.

Keywords: Auditory display; Design patterns; Design methodology

1. Introduction

The auditory channel in human–technology interaction has received increasing attention as shifting contexts of use and interaction paradigms expose the limits of traditional, vision-dominated computing. Despite our growing knowledge about sonic interaction and promising results in related research, the impact on design practice has been limited. Much of the sound produced by today's technology fails to exploit the sophisticated abilities of human hearing. We aim to address this gap by presenting a methodological framework constructed around design patterns to improve the transfer of design knowledge.

Auditory display—audio as a means to convey information—provides interaction designers with a distinct set of features that effectively extend the available design space. For example, through its flexibility in managing user attention or exploiting the sensitivity to temporal structures. This allows designers to address key challenges in modern interaction design such as the "visual overkill" resulting from the ever growing demand for conveying still more information to users. Auditory displays can help to overcome some limitations by reducing the cognitive load and increasing performance in complex tasks when used in complement to visual displays (Oviatt et al., 2004). Interaction designers also face a whole new era of computing with contexts of use being freed from the traditional desktop environment. Ubiquitous and mobile computing are emerging fields with users requiring eyes-free interfaces, with devices too small to carry a visual display and with environments that make conventional interaction design inappropriate. The exploitation of auditory interaction in these contexts shows great potential (e.g. Brewster, 2002).

Auditory display also plays a key role in making information technology accessible to the visually impaired. The growing impact of technology on our everyday lives makes access to these resources a key factor in being fully

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integrated and self-dependent. However, despite the rapid development of technology, the means of access has changed very little for visually impaired users over the years, remaining predominantly based on Text-To-Speech (TTS) systems. This inadequacy reflects the more general argument about the limited impact of auditory display on technology we use every day. Mobile phones, portable music players and kitchen appliances incorporate sufficient technology to produce pleasant, functional and informative sounds, but the designs of their interfaces are often limited to simple alarms or speech. We argue that the field of auditory display design could benefit greatly from an efficient means to capture and transfer design knowledge for designers to build on the expertise in the field and apply it in different contexts. By the introduction of a methodological framework for designing auditory display we aim to facilitate this transfer and contribute to the wider use of sound as an efficient means for conveying information.

This article is organised as follows: the subsequent section provides the background to this research including a review of related work and two studies that investigate current practice in auditory display design. The results of these studies informed the design of the *paco* framework (*pa*ttern design in the *co*ntext space) introduced in Section 3. This is followed by a report on an evaluation study investigating the usefulness of *paco* in real-world design tasks with novice and expert designers of auditory displays. Section 5 summarises the work and examines the future of this line of research.

2. Background

2.1. Guidance and methods in auditory display design

At the International Conference on Auditory Display 2008 in Paris, a workshop on re-usability of design knowledge[1] produced a valuable taxonomy of fundamental approaches to auditory display design. This taxonomy provides a useful classification of design processes within the field[2] and we shall adopt it here to structure the review of available guidance and methods.

Perceptual design: The majority of guidance is focused on the perceptual and cognitive aspects of human hearing. The principles by Kramer (1994a), for example, link perceptual issues with implementation techniques, mainly in relation to mapping strategies. Other guidance draws on auditory scene analysis (Bregman, 1990) and links perceptual issues such as stream segregation with design issues of auditory display (e.g. Mitsopoulos, 2000). Gestalt principles have also driven the work of Blattner et al. (1989) on earcons and led to the guidelines presented by Brewster et al. (1993).

Ecological design: This approach is informed by studies in ecological hearing and everyday listening (e.g. Ballas, 1993). For example, Mynatt (1994) provides guidance for choosing sounds in a user interface or more recently Brazil and Fernström (2007) have proposed using the Repertory Grid Technique to classify auditory cues to be used in ambient information systems. Gaver (1993) was one of the first advocates of ecological acoustics informing sound design with his work on auditory icons. A similar argument is made by Coleman et al. (2008) who proposed the use of *earwittness*[3] accounts to prompt designers to think of future sound design possibilities.

Contextual design: It could be argued that this overlaps with the previous category, but contextual design not only considers acoustical ecology, but also other aspects of the context of use such as technological or social constraints. Barrass (1998) has used a case-based approach (''EarBender'') to link sound designs to narratives. Similarly, Pirhonen et al. (2006) use rich use-case scenarios to inform sound design.

Task driven design: Task analysis is a very significant approach to interaction design (Redish and Wixon, 2003). The TaDa! analysis (Task and Data Analysis) introduced by Barrass (1998) aims to capture similar requirements for auditory display design, but extends it to the data to be conveyed. It also adds a short story to the semi-formal process bringing it closer to contextual design. Brewster (1994) has used the event and status analysis (Dix, 1991) to identify inaccessible information in user's tasks which he subsequently makes available by auditory means.

Semiotics: The meaning making of sounds, as in the interpretation of a sign, is a perspective on auditory display design that has gained increasing attention recently (e.g. Mustonen, 2008; Jakosch, 2005). The design methodology by Pirhonen et al. (2006) argues for rich use-case scenarios as syntagmas in analogy to approaches to musical semiotics. Their stance aims to ensure the correct interpretation of sounds by designing it in a rich context of use.

Compositional design: Composers are experts in creating music, i.e. expressing themselves through sound. Often, composers are asked to participate in auditory display design tasks to increase the æsthetics of the result (e.g. Stallmann et al., 2008). Vickers and Hogg (2006) argued for an ''æsthetic perspective'' for classifying auditory display and discussed the relationship between sonifications and electronic music. The creative nature of composition, however, makes capturing of expertise or provision of guidance difficult.

[1] Recycling auditory displays, organised by C. Frauenberger & S. Barrass, http://icad.org/node/499.

[2] A related, but more sonification specific taxonomy has also been discussed in Barrass (1998, pp. 7–28)

[3] A narrative-based approach to describe the acoustical environment (Coleman et al., 2008).