Towards a Method, Techniques and Tools to Support the Development of Auditory Displays

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ABSTRACT
Auditory displays have been around for some time, but lacking is any widespread understanding or consensus on how to develop and evaluate these interfaces. In the first part of this paper, we summarize the evidence for this lack of understanding and consensus, and go on to outline an approach to auditory display design based on Soundtrack composition. Space permits only an overview of the method, techniques and tools developed, but the presented method encapsulates the principles and ethos intended in applying ideas from soundtrack creation to auditory display design.

Author Keywords
Auditory Display, Auditory Interface, Soundtrack Composition.

ACM Classification Keywords
H.5.2. User Interfaces: Auditory Feedback, Theory and Methods

INTRODUCTION
Auditory display (AD) is the use of sound to communicate information from a computer to the user. The technique of using non-speech audio to convey information or perceptualize data is known as sonification. With a role similar to the use of visual displays in the human-computer interface, sound is employed to enable human-computer interaction, data exploration, accessibility and present aesthetics. ADs permit eyes-free usage by visually impaired users as well as by sighted users who need to use their sight for other tasks or who don't have line of sight of the display. The importance of sound in interaction design is growing as technology becomes increasingly embedded and portable (with smaller or even no screens) and the range of contexts of use continues to diversify. Some examples of auditory display included the Geiger Counter, which, as an early form of ubiquitous sonification [12], provided auditory clicks to display levels of radiation. Audio has also been used for process monitoring, which often involves real-time and continuous audio playback in order to communicate directly to the user. For example, Cohen created the ShareMon system that alerted users to file sharing systems on an Apple Macintosh network [9]. Vickers created CAITLIN, a system that used audio feedback to help with program debugging [21]. Audio has also been used to represent the completion of tasks on the desk top, for example, Brewster designed a set of user interface widgets that used a collection of non-speech audio messages, known as Earcons, to enhance the visual feedback [6].

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Some Challenges for Auditory Display Designers
- Sound is better at representing temporal information. The challenge, therefore, is representing spatial relationships with sound.
- Managing overlapping streams of information and avoid masking, whereby the perception of one sound is affected by the presence of another.
- Developing methods and tools to support the process of creating auditory displays.
- Taking an understanding of visual-HCI and seeing if it translates across to audio-HCI. Doing this by understanding what works best in the different mediums audio/visual.

MOTIVATION
The soundtrack of a film serves to support action; anchor meaning; develop thematic narrative strands; portray on and off screen action; enhance emotional reaction and generally give a sense of 'reality' to the real-world noises that objects make as they are moved, hit, and interacted with. The craft of soundtrack composition is well established and the creativity of the composer (sound designer) is supported and encouraged as a result of existing theoretical guidelines [7], techniques [20, 15], software-based tools, and, if the composer requires, optional sample and sound libraries. Soundtracks are composed and constructed with great intent and their success is apparent. It therefore makes sense to explore how this knowledge could be methodically applied to support the development of other applications that require sounds to be skilfully designed and arranged to display information.

ADs also serve to support action; anchor meaning; develop thematic content; represent both visual and non-visual unseen processes; enhance reaction and give a sense of reality to the real-world noises that virtual objects make as they are moved, hit, and interacted with. However, (unlike soundtrack composition) it is argued that many sonifications lack an aesthetic quality [22] and that the choices that went into the data/information - sound mapping lack rationale [14]. The results of the survey carried out by [14] revealed that many designers found it hard to incorporate audio due to a lack of existing structured methods, design tools and awareness of the possibilities. The authors concluded that as a result, design guidelines for auditory interfaces need to support a novice designer but also not limit the more experienced designer as well as supporting creativity and allowing designers to express and sketch out their initial ideas. It was also observed that design guidelines need to incorporate ideas and best practice concerning aesthetics.

Position

As a result of the above, we argue that the principles, tools and techniques of soundtrack composition can inform the design of a method for the creation of ADs. Specifically we propose that the application of such a method could support the iterative, creative choices that a designer will make from start to finish, as well as promote the creation of aesthetically considered ADs. As part of the process of developing the method, we aim additionally, to identify what sort of interfaces the method will be used to design. For example what will the function of the display be - monitoring? presentation of data for understanding and analysis? Feedback and acknowledgement of an interaction upon the interface, a combination?

Background

The idea of using music and soundtrack composition as well as other creative approaches from artistic practice to address issues concerning accessibility and aesthetics in the computer interface is not new. It was proposed by [10] that the use of sound within the arts could inform the use of sound for software development. The author argued that the role and function of sound in film as proposed by Film Critic and theorist Michel Chion [7] can take on a similar role and function within human-computer interaction: Namely the ability that sound has to alter perceptions of time and space as well as alter the perception of the speed and pace of movement. The author argued, by way of example, that the fact that sound can be designed to mimic texture, could enable an interface user to "feel" as though they have made contact with an interface object, even if it, in fact, remains unseen or virtual.

The perception of physicality that sound can give to an object or interaction was also described by [8]. The author argued that the overall feel and perception of an interaction can draw on the function of film sound to induce and communicate emotion. The author put forward the view that because music can create 'arousal' in the user, it can help the designer in focussing the user's attention, and as a result filter out noise-related distractions in the workspace. Additionally, the author pointed out that the use of repeating musical motifs can aid as an important cue to memory, which in turn could support the work flow by reducing dependence on visual communication.

The benefits of using sound to support work flow was highlighted by [3]. The authors argued that a conceptual and theoretical offering concerning how to use sounds for computerised instructional environments was needed. They argued that there are four ways in which the best practices of film sound can inform the sound design within computerised learning environments. These are as follows:

1. Consider sound from the start of the design process as opposed to after the visuals are put in place.
2. Have the means to 'listen' out for objects, actions, environments, emotions and physical or dramatic transitions within the narrative in order that they help shape the sound design.
3. Take into account the way that people hear and listen to the different types of sounds, albeit passively, actively or a combination [7, 22, 11].
4. Employ tools used on soundtrack composition [20] to support a methodical approach to incorporating sounds within the context of use.

OUR APPROACH

There have been several contributions toward establishing methods, techniques and tool kits for developing ADs [2, 18, 13]. With the aim to support novice AD designers, many of these are bought together and reviewed in [4, 5]. Interestingly, the authors conclude by recommending that a novice designer would benefit from "consulting someone with expertise in these methods". It was also argued by [14] that many of the methods are not accessible to an inexperienced designer and that, perhaps for this reason, there still is a general failure on the part of AD designers to take up methodologies and guidelines for the development of ADs.

The approaches reviewed above in the background section outline those contributions that have explored what arts practice can bring to the design of auditory interfaces. The research is rich in offering theoretical insights into the benefits of film sound and how an interface designer might be encouraged to explore its potential. However, despite previous research in this area, we argue that a designer contemplating how to apply principles of film sound to the creation of an auditory display, having researched any proposed approaches, would come away with inspiration, techniques and methods to support only part of their design, rather than the knowledge or confidence in how to create an entire display.

As a result we support the argument that creating a method for producing auditory display based on soundtrack composition can help an AD designer by offering a structured, accessible and supportive set of guidelines and techniques to assist them through the creative process. A distinguishing feature of our proposed method is that it is designed to encourage creativity, having its foundations in creative practice. In turn we speculate that the interfaces produced using the method may be somewhat characteristic, because they may manifest artistic

and creative qualities, making them more interesting and engaging to use [22].

The Method

To date we have developed the principles of the method and conceptualised the techniques that the method will support through a series of method steps and supporting tool kit. The steps are supported by use of a *Cue Sheet /Sound Map*[1], a *Database* and a *Time-line*. We have also carried out early stage evaluation of the work. We present these developments below.

Principles

We propose the following principles based on a synthesis of our investigations into soundtrack composition and the approaches that composers take [17], along side our investigations into designing auditory displays. We feel they encapsulate what the method should support and what they should enable the designer to achieve as a result of applying it.

1. Support the creativity of the designer
2. Draw upon the existing body of work and know-how surrounding soundtrack composition and approaches to designing ADs.
3. Support the design process from start to finish
4. Permit a designer to sketch out ideas and work in an iterative way
5. Utilise and make accessible the functions of a soundtrack and the proposed benefits of these to ADs and sonic interaction design
6. Support the production of a functional and aesthetically pleasing display

Method Steps

The following steps are designed to support the process from start to finish and combine techniques from human-computer interaction and soundtrack composition

- Method Step 1- Scenario Analysis: the designer is presented with the scenario and specific use-case for an initial read through. The use case outlines the user and the story of their interaction with the interface
- Method Step 2 - Interface and Interaction design: the designer analyses the scenario in terms of the users, the mode of listening they employ [11], the context of use and the initial interaction triggers.
- Method Step 3 - Information Design: the designer analyses the scenario in order to gather, categorise and map out information and data requirements within the interface. The results of this step are used to fill out the details of a Cue Sheet.
- Method Step 4 - Mapping information and interaction to sound: the outputs from the Cue Sheet/ Sound Map map directly to a database of sound design ideas and the designer can prototype various information to sound mappings.
- Method Step 5 - Iteratively auditioning and reorganising: the designer places the sounds on a time line in a first cut prototype of the sequence of interaction. The step then proceeds with the designer iterating through a process of auditioning and reorganising the sounds, taking into account the fact that certain interaction sequences may cause sounds to be rendered in parallel and/or in different sequences. The objective of this step is to examine the aesthetics of the sounds as they may be heard both individually in different interaction contexts and in relation to one another.

Techniques & Toolkit

Our method supports the designer in carrying out the method steps accounted above through a set of techniques that can be supported by the following: a *Cue Sheet /Sound Map*, a *Database* and a *Time-line*. To date we have begun an implementation of these in the graphical-programming language Max/MSP, as a set of tools that can be applied to support the designer.

The Cue Sheet/ Sound Map supports a narrative approach to both the gathering and the mapping of the requirements for the sound design for the auditory display (method steps 1-3). By utilising the cue sheet the designer is supported in the following ways:

1. Considering the story of the user interaction with the interface[19]; the context of use for the interface alongside the mode of listening that the user will employ in order to perceive and comprehend the sound.
2. Identifying characters, objects, locations, actions, themes, emotions and transition points in the story [20] in order that these can mapped to sound design ideas that support how these can be communicated most effectively through sound.
3. Identifying the physical properties of the information that needs to be sonified as well as the nature of how this might change as a result of changes in the interaction or data
4. Considering the story of the actual sound itself in terms of how it evolves in relation to the story it is telling [1]. The means to apply a linear, narrative-based who, what, where why, when structure to inform when the sounds occur, how long they occur for, how they change over time and what causes them to change.
5. Taking into account the non-linear nature of human-computer interaction by considering the transition points in the story. Designing sounds to smooth these points in order that the sound remains consistent [1]. In turn being able to design sound for several possible use-cases for one given scenario.

The Database acts as a knowledge base of sound design guidelines to support a specific function within a soundtrack.

[1]According to [20] A Cue Sheet (or sound map) acts as a guide for the sound team follow the different tracks of dialogue, music and sound effects. The tracks are represented along a time-frame of seconds and minutes and laid out horizontally. A "time-frame of dramatic sequences and with notations of sonic elements that may enhance the storytelling aspects of the film"

The resulting output of the Cue Sheet/ Sound Map directly maps to the different categories within the Database (method step 4). The categories are largely based on musical styles; structures; components and parameters.

The Time-line serves as an interactive tool to support the placement, audition and arrangement of the sounds within the display. The Time-line parallels and further supports the cue sheet in that it also caters for the non-linear nature of human-computer interaction, with the specific ability to focus on the affect this has on the sounds. The designer is encouraged to arrange and audition sounds according to the particular use-case under consideration (method step 5). The time line also encourages a potential investigation into the aesthetics of different sound sequences.

Initial Evaluation

We have carried out a preliminary evaluation of an early stage version of the Cue Sheet /Sound Map, which indicated its value as an organising mechanism in the AD design process, but which also highlighted the need for tight integration with a knowledge base of sound design principles, which guided our further development of the method and associated techniques and tools [16].

CONCLUSION

The creation of auditory displays for the interface is an ongoing challenge. Among the many future challenges for researchers are the design and evaluation of sound for mobile devices; the use of spatial audio and the consideration of increased and wide-spread usability and personalisation of interactions. In this paper we have presented our ideas towards a method, techniques and a tool kit to support an interface designer in applying audio. The method presents an integration of techniques employed in human-computer interaction design, such as user scenarios, with approaches and tools utilised in soundtrack composition. We hope that this poses an interesting design position and raises awareness of both the importance and the challenges involved in designing audio for the interface.

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