CULTIVATING DESIGN PATTERNS FOR AUDITORY DISPLAYS

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ABSTRACT

Auditory Displays are quite well known in the research community, but very little of this experience is being transferred to product designers. The method of Design Patterns is well known to a number of design domains and is used to describe "solutions to problems in context" in such a way that they can be reused again and again.

Here we present six new prototype Design Patterns for Auditory Display: SystemMonitoring, SituationalAwareness, SonifiedLineGraph, AuditoryIcon, Attenson, and Personalisation.

We invite the Auditory Display community to collaboratively cultivate these patterns and other patterns via the communal WikiWeb repository.

Keywords: Auditory Display, Design Patterns, Sonification

1. INTRODUCTION

The spread of small, cheap, and powerful audio technologies and the need to convey new types of information with sounds is leading to a demand for sonifications in phones, PDAs, automobiles, and many other consumer products in the near future. However, most designers working on these products will not have a lot of knowledge of sonification or auditory display. The success of sonifications in these products requires that designers are aware of the functionality that sonifications and auditory displays can provide, and can design them to support required functionality. One way that designers do share knowledge between domains is through Design Patterns that describe good solutions to common problems in a way that can be easily understood and reused.

Patterns only really come to a life and evolve when they are used actively for collaboration, design and communication. An initial four patterns were described at ICAD 2003 [4] and subsequently placed in the SonificationDesignPatterns pages of the WikiWeb System [27]. The WikiWeb was originally devised for collaboratively writing Patterns, and allows anyone to edit and add new Patterns to a Pattern collection very simply using an internet browser. We are encouraging the involvement of the ICAD community in developing this design resource.

In the following sections, we present an additional set of six prototype patterns that we are adding to the WikiWeb repository. In joining the patterns that are already there, these will provide a base for the community's contributions.

As part of the ICAD 2004 Poster Session, we aim to further encourage this collaborative process by inviting conference attendees to indicate which of their own projects might be included in the WikiWeb as examples of the patterns that are already there. Also, we will use the opportunity to gather common design experiences and expedite the formation and refinement of new Auditory Display Design Patterns.

2. DESIGN PATTERNS

The concept of Design Patterns was initially developed by the architect Christopher Alexander to allow residents to participate in Urban Planning. He defined a Pattern as 'a solution to a problem in context' [1]. 'A pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice' [2].

Design Patterns have found prominence in many fields including Software Engineering [9], Graphical User Interfaces [24] and Visualisation [28]. It is generally accepted that Design Patterns should exhibit the following qualities:

TheRuleOfThree - a Pattern must be identified in at least three independent usages.

BuschmannsLaw - a Pattern should not be written solely by the person who first invented or implemented it.

Review - a Pattern should be reviewed by other people familiar with the domain, as well as those who are not.

3. GROWING THE SET OF DESIGN PATTERNS

What follows in this section is a collection of some of the new patterns we are introducing to the SonificationDesignPatterns section of the WikiWeb. This repository can be found at: http://c2.com/cgi-bin/wiki?PatternIndex.

The pattern template used here is slightly different to the one that was used for the initial patterns submitted to the WikiWeb. We have observed that different pattern templates can be more suited to some domains than others. The 'best' one to use in this domain is not yet determined.

We used the proceedings papers of ICAD 2003 as a representation of the state of the art in auditory display as the source for this latest batch of patterns. In general, we have looked to give reported research successes as design examples. The WikiWeb is also capable of including hyperlinks and additional files, and we have tried to link to as many design examples as possible. The ability to actually experience the design examples is possibly one of the most beneficial qualities of this repository.

These patterns are a further step in an iterative and collaborative effort and are not intended to be prescriptive or final. The concepts that evolve from the patterns repository have the potential to help us re-think some of the more common ideas found in ICAD publications.

3.1. SystemMonitoring

Context:
You are designing an auditory display to allow a user to monitor the activity of a potentially dynamic system.
Problem:
You need to allow the user to perform other tasks and still be continuously and sufficiently aware of the state of the system.
Forces:
- It is likely that the user's primary attention will be on other tasks.
- Whenever a change occurs, the user will need to know what part of the system has altered state, and by how much.

Solution:
Sonify various processes within the system. Systems that are working perfectly/desirably should exhibit familiar, non-annoying sounds. To indicate undesirable status of processes, one might use lower tones, dissonance, out-of-time rhythm, minor scales, etc.
Rationale:
People can listen to a sonification while performing other tasks. It is usually possible to detect minor changes in frequency, dissonance, rhythm, musical key, etc.
For Example:
- Interactive Visualization and Sonification for monitoring Complex Processes by Herman et. al. [15]
- Design Considerations for a Background Auditory Display to Aid Pilot Situation Awareness by Kazem et. al. [16]
- NeMoS: Network Monitoring with Sound by Malandrino et. al. [18]

3.2. SituationalAwareness

Context:
You are designing an auditory display which needs to keep a user aware of activities and events in the local or remote environment.
Problem:
Without appropriate support, the user is not likely to perceive and understand all the relevant environmental activity.
Forces:
- It can be hard to keep track of simultaneous activities.
- Whenever something new happens in the environment, the user will need to know what has happened, and will probably need to know the extent of the event.

Solution:
Sonify the local or remote environment. The relevant aspects of the environment should each be mapped to sonic information channels.
Rationale:
Sonifications can be perceived during varying levels of attention. Multiple events and phenomena can be perceived via a user's ability to maintain awareness of parallel sound streams.
For Example:
- The Use of Walking Sounds in Supporting Awareness by Mäkelä et. al. [17]
- "Listenin" To Domestic Environments From Remote Locations by Schmandt and Vallejo [20]
- Design Considerations for a Background Auditory Display to Aid Pilot Situation Awareness by Kazem et. al. [16]

3.3. SonifiedLineGraph

Context:
You are designing an audio-only display to present one or more two-dimensional (function-based) data sets.
Problem:
You need to convey the quantitative information as accurately as possible.
Forces:
- The dimensional value of the data needs to be perceived, relative to measurement scale.
- Multiple data sets must be properly perceived relative to one another.

Solution:
Use the metaphor of a two-dimensional line graph. Map the X-axis of the graph to time, and map the y-axis of graph to the pitch, timbre and/or volume of musical notes.
Additionally: Use musical sounds rather than pure sine waves; Only use notes within a useful perceptible range (e.g. MIDI #35-100); Present graphs at a speed that does not impair comprehensibility (e.g. 50-70ms between values); Use stereo-panning to separate data series; Present data series in Parallel Mode rather than Serial Mode.
Rationale:
There have been a number of experiments showing that sonified line graphs are an efficient way of displaying two-dimensional data (A recent instance is from Bonebright [6]). Brown et. al. provides some comprehensive justification for most of the above dot points [8].
For Example:
- Drawing By Ear: Interpreting Sonified Line Graphs by Brown and Brewster [7].
- Sonification Sandbox: A Graphical Toolkit For Auditory Graphs by Walker and Cothran [25].
- Design Guidelines for Audio Presentation of Graphs and Tables by Brown et.al. [8].

3.4. AuditoryIcon

Context:
You are designing an auditory display which includes the representation of dimensional data as well as conceptual objects in a computer system.
Problem:
You need to provide dimensional data as well as conceptual objects to the user in a coherent and effective way.
Forces:
- A large number of new sounds can be hard to learn.
- Related dimensional data values need to be perceived as coming from the same information source.

Solution:
Use caricatures of naturally occurring sounds (Auditory Icons). Synthesise these sounds in such a way that manipulating the algorithmic parameters can result in the perception of specific dimensional data.
Rationale:
Gaver's Auditory Icons are based on the way people listen to the world in their everyday lives. It is claimed that this means the user will percieve more the actual event or information the sound results from, rather than the sound itself [10].
Through the parameterisation of Auditory Icons, auditory displays can categorise data into distinct families. Each family of data can therefore be recognised through the use a single sound, reducing the need to include complex sound language.

For Example:

- Auditory Icon Support For Navigation In Speech-Only Interfaces For Room-Based Design Metaphors by Skantze and Dahlbäck [21]
- The Use Of Walking Sounds In Supporting Awareness by Mäkelä et. al. [17]
- Broadcasting Auditory Weather Reports - A Pilot Project by Hermann et. al. [15]
- Audio games: fun for all? All for fun? by Targett and Fernström [23]
- "Listenin" To Domestic Environments From Remote Locations by Schmandt and Vallejo [20]

3.5. Attenson

Context:

You are designing a system which must be able to direct the user's attention to intermittent or rarely experienced information while they are involved in some other activity. The information usually would pertain to some type of event or warning that is important and/or urgent.

Problem:

The system must be able to attract the listener's attention and must be sufficiently clear and unambiguous in their representation of the importance/urgency.

Forces:

- The user's attention might be hard to detract.
- There may be little or no chance to learn the sounds.
- There must be some 'reference' or 'zero' condition for conveying urgency or importance.

Solution:

Use an attention-getting sound (Attenson).

Ensure that the sound is sufficiently distinct from the user's acoustic environment. It should be louder than other sounds, have a broad frequency range and have unique temporal characteristics such that it does not blend in. It should have a shaped onset envelope in order to avoid startle.

Ensure that the sound properly conveys the necessary degree of importance and/or urgency. Manipulate the sounds by applying the appropriate increasing or decreasing amounts of: modulation, sustained length, vibrato, high/low freq filtering, and/or reverberation.

Rationale:

Sound does not require your continual focus in order to gain your attention. A few levels of urgency and importance can usually be perceived by manipulating the various parameters of the sound. In some instances, this can be achieved with little or no prior learning. Also, sounds that are too quiet, or to similar to environmental sounds will blend in and be less effective.

In Patterson's set of Attenson design guidelines [19], he presents a detailed rationale. Hellier and Edworthy [13] describe some further experimental evidence.

For Example:

- Acqua Alta A Venezia: Design Of A Urban Scale Auditory Warning System by Avanzini et. al. [3].
- Spatially-Modulated Auditory Alerts by Begault et. al. [5]
- Perceptive Study And Recommendation For Sonification Categories by Susini et. al. [22]
- Dynamic Auditory Cues for Event Importance Level by Häkkilä and Ronkainen [12]

3.6. Personalisation

Context:

You are designing an auditory display in which one or more sounds may be used to convey categorical information.

Problem:

Users can find new or foreign sounds hard to learn and/or interpret.

Forces:

- In some cases, user chosen sounds can be inappropriate, or not particularly functional.
- Users may find it hard to produce/find their own sounds.

Solution:

Provide a mechanism whereby users can personalise the sounds used by the auditory display. A few different choices should be provided (in some contexts, the choice may need to be constricted to the provided options)

Rationale:

The user will have 'ownership' of the sounds. They will be more familiar, and the sounds will be more easily associated with their intended meanings. Providing the user with a prepared set of sound schemes can make it easier if sounds are hard to find or create. Providing a specific set of sound choices can help to maintain some consistency between multiple users and can ensure that the sounds are maximally functional.

For Example:

- NeMoS: Network Monitoring with Sound by Malandrino et.al. [18].
- Perceptive Study and Recommendation for Sonification Categories by Susini et.al. [22].
- This is also a popular concept in current products. It can commonly be found in mobile phone ringtones, computer operating systems, and instant messaging software.

4. FUTURE WORK AND CONCLUSIONS

The patterns we have begun to develop here are only the beginning. More patterns will emerge form the further consideration of sonification data mappings, auditory interface components (audio widgets), audification techniques, multi-modal interaction, and auditory display devices.

As the set of patterns grows, we will begin to see grouping schemes emerge. These groups of patterns may help to define and guide new research problems. Additionally, each pattern in the set can include a list of related patterns. This will result in the realisation of another key benefit of the design patterns technique, a network or web of useful design solutions.

We hop that the ICAD community, through the poster session at ICAD 2004, and the SonificationDesignPAtterns site on the WikiWeb, will contribute design experiences to this growing collection. The collaborative development of a comprehensive Auditory Display Design Patterns resource will further build the vocabulary, guide new research directions, and allow product designers to understand and apply our research.

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