SONIFICATION DESIGN PATTERNS

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ABSTRACT

Most product designers have little or no experience with sonifications. Designers from a range of different domains use a common method called Design Patterns to describe "solutions to problems in context" in a way that can be readily understood and reused. Design Patterns may provide a way to communicate sonification research results with product designers and other design communities. I have written a handful of prototype Sonification Design Patterns from papers in the ICAD 2002 proceedings. The papers I selected had clear statements of hypotheses, results to support them, and repeated examples elsewhere in the proceedings. These Patterns are now on the SonificationDesignPatterns site on the WikiWeb and can be edited and added to using any internet browser. The lively development of SonificationDesignPatterns by the ICAD community may help build sonification-specific vocabulary, identify sonification hypotheses, and allow product designers to pick up and apply our research.

Keywords: Sonification, Auditory Display, Design Patterns

1. INTRODUCTION

The Bauhaus Design Movement, founded by the architect Walter Gropius in 1919, sought to 'unify intellectual, practical and aesthetic concerns through artistic endeavor and the exploitation of new technologies'. Bauhaus designers took advantage of new industrial technologies and materials such as steel, reinforced concrete and mass-produced glass, to build factories, schools and urban projects. The Bauhaus principle that 'form should follow function' was a response to the architectural focus on embellishment at that time, and is still a major influence on architecture, furniture, appliances, typography, graphics and many other areas of design today.

One area the Bauhaus has not had so much influence is Sound Design, perhaps because the manipulation of sounds has only become feasible with fairly recent developments of digital audio processing technologies. Auditory Display has been defined as 'the use of non-verbal sounds to convey information' [Kramer et al. 1999]. Consider Bertin's statement that 'useful information is the answer to a question' [Bertin 1981]. Extending the idea of usefulness further, also consider Wittgenstein's statement about language – 'ask not the meaning but the use' [Wittgenstein 1953]. In this view, sonification could be considered a 'tool' rather than a 'representation of information' and Sonification Design can be defined as 'the design of functional sounds'. As in other areas of design, Gropius' statement that 'form should follow function' [Gropius 1935] is important to ensure that sonifications are designed to function rather than just embellish.

2. BACKGROUND

Methods for sonification include Audification [Hayward 1994], Parameter Mapping [Bly 1982], Parameter Nesting and Beacons [Kramer 1994], Musical Structures [Bargar 1994], Gestalt Principles [Williams 1994], TaDa Task and Data Sensitive Mappings [Barrass 1998], Psychophysical experiments [Smith et al. 1994] [Flowers et al. 1996] [Walker et al. 2000] [Nuehoff et al. 2002], Model-based [Hermann 1999], Ecological Metaphors [Saue 2000] and others. That's a lot to learn if you are not a sonification specialist! Rather than designing a new sonification every time, a product designer may prefer to adapt and reuse an already existing example that has the required functionality. This requires the Sonification community to communicate their research results in a form that is easy for non-experts to understand and apply.

Design Patterns are a way of describing good solutions to common problems that was 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' [Alexander 1979]. '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' [Alexander 1997]. Here is an example of one of Alexander's original architectural Design Patterns:

A Place to Wait
The process of waiting has inherent conflicts in it.
On the one hand, whatever people are waiting for -- the doctor, an airplane, a business appointment -- has built in uncertainties, which make it inevitable that they must spend a long time hanging around, waiting, doing nothing. On the other hand, they cannot usually afford to enjoy this time. Because it is unpredictable, they must hang at the very door. Since they never know exactly when their turn will come, they cannot even take a stroll or sit outside...
Therefore,
In places where people end up waiting, create a situation which makes the waiting positive. Fuse the waiting with some other activity -- newspaper, coffee, pool tables, horseshoes; something which draws people in who are not simply waiting. And also the opposite: make a place which can draw a person waiting into a reverie; quiet; a positive silence.

Although Design Patterns were originally architectural, Patterns have gained prominence as a method for designing computer software [Gamma et al. 1995] [Buschmann et al. 1996]. The conference on Pattern Languages of Programming (PLoP) holds regular workshops on writing Patterns and there are now Patterns for Usability, Interaction Design, Human Computer Interfaces and many other software related disciplines [Coplien and Schmidt 1995]. Guidance for writing Patterns is available in the form of a Pattern Language for Pattern Writing [Meszaros & Doble 1996]. Patterns are evaluated at PLoP workshops according to criteria that include:

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.

Patterns are written using templates that vary depending on the design domain but share most aspects of Alexander's original. The Pattern Template I chose comes from the Patterns-Discussion FAQ [Lea 2000]:

Pattern
If you find yourself in
context
for example
examples
with
the problem
involving
a number of forces that need to be resolved
THEN
for some
reasons
apply
design form and/or rule
to construct
a solution
leading to
a new context
and
another pattern

3. SONIFICATION DESIGN PATTERNS

Design Patterns can help develop domain-specific technical vocabulary that hides detail and enables higher levels of abstraction between experts. An increase in technical vocabulary is an indicator of progress in a discipline. In order to help progress the field of sonification design I have written a handful of prototype Sonification Design Patterns from the proceedings papers of ICAD 2002. I chose to use the most recent papers to capture the state-of-the-art ideas and results that have built up over the past ICAD conferences.

The first pattern captures the recurring idea at ICAD 2002 that sonifications could be very useful in PDAs, mobile phones and other small mobile info-tech products that have limited screen-space and are used in eyes-busy situations [Cohen 2002], [Hiippakka et al. 2002], [Maeda et al. 2002], [McGookin and Brewster 2002], [Smith and Walker 2002], [Sugikubo 2002], [Tsuchida 2002].

SonificationProducts
IF you find yourself
designing sonifications for small, mobile, info-tech consumer products
for example
e1: sound schemes for menu browsing in a mobile phone [Marila 2002]
e2: sound design for a digital camera [Maeda et al. 2002]
e3: sound design for electric home appliances [Tsuchida 2002]
with the problem that
the sounds in most products are either alarms or embellishments, and most people are not familiar with sonifications that convey other types of information

entailing forces

f1: people are used to alarms and decorative sounds

f2: but are not familiar with the use of sounds to provide information for other kinds of tasks

THEN

Design a sonification that provides information that makes the product more useful, usable and enjoyable

Apply

The Bauhaus aesthetic that 'form should follow function'.

Design and evaluation criteria from papers at ICAD 2002.

- Amusing, Interesting
- Annoyance, Nuisance, Stress, Unnecessary
- Brand, Logo, Look and feel, Image, Style, Theme
- Comfort, Ergonomics, Pleasantness
- Culture, Culture neutral
- Effectiveness, Efficiency, Effort, Performance
- Emotional quality
- Environmental context, Intentional context
- Hearable, Perceivable
- Expressiveness, Information level, Urgency
- Learning curve, Instant Usability, Long-term Usability
- Understandable, Accuracy, Errors, Identifiable
- Usefulness, Functionality, Importance, Relevance

to construct

a sonification that sets the product apart by making it more useful, useable, easy to learn and understand, and pleasurable to use.

leading to

wider use of sonifications in new products

and

application of sonification from laboratory research projects to real world applications

This Pattern is more like a meme than an actual solution to a problem. The remaining Patterns are more concrete problem-solution pairs based on ICAD 2002 papers that have clear statements of a hypothesis, experimental results to support it, and two other papers that show some form of repetition. This is not to say that papers with results that did not support a hypothesis are not important – they are *very* important in research! It's just that Patterns are meant to capture *solutions* to *problems*, and results that support a hypothesis are the closest thing we have at the moment. The paper that was used to identify and write the Pattern is referenced as the first **"for example"**, since it also provides the empirical support for the 'goodness' of the solution. The second and third examples support the pattern by repetition even if they do not include empirical results.

TheEarsLeadTheEyes

IF you find yourself

Designing a display to direct the users attention to critical intermittent information while they are involved in an eyes-busy foreground task

for example

e1: classifying incoming threats while tracking another plane [Brock et al. 2002]

e2: an ambient soundscape for peripheral awareness of remote processes [Kilander and Lonnqvist 2002]

e3: dimensions of spatial audio that can be used to represent information in auditory displays [Carlisle 2002]

with the problem that

it is stressful to keep switching visual attention between different displays and intermittent events can easily be missed

entailing forces

f1: the need to keep visual attention on one task

f2: the need for immediate response to another critical but intermittent task

THEN

Use sounds to provide the critical intermittent information

Apply

The adage that 'the ears lead the eyes'

to construct

an auditory display that allows non-visual awareness of intermittent processes and directs visual attention using spatialized sounds when necessary

leading to

a display that allows the user to more effectively manage attention between the tasks to reduce response times, increase accuracy, and improve efficiency in attention

and

a dietic auditory display

PerceivingPatternsInData

IF you find yourself

Designing a display to support exploration and discovery of patterns in complex multi-attribute, multi-dimensional and/or time-varying data

for example

e1: predicting the direction of stock prices from depth of market stock data [Nesbitt and Barrass 2002]

e2: analyzing high dimensional data sets [Hermann and Ritter 2002]

e3: exploring patterns in spectral oceanography data [Sturm 2002]

with the problem that

it is difficult to perceive higher level information about relations between attributes in conventional graphs and impossible to perceive patterns in tables of data values

entailing forces

f1: the need to perceive global information about the entire data set

f2: the need to perceive intermediate level information about relations between attributes as they vary over time

f3: the need to perceive local level information about how individual attributes vary with time

THEN

Use a sonification to provide time varying information about multiple attributes

Apply

The primitive level heuristics from Bregmans theory of auditory scene analysis [Bregman 1991] to map data attributes onto the attributes of auditory streams [Rivenez et al. 2002]

to construct

auditory streams that perceptually group and segregate to reflect higher level relations between attributes

leading to

the capability to explore and find patterns in complex data by listening to it

and

a perceptually structured information soundscape

Stethoscope

IF you find yourself

Designing a display that allows interactive queries for local details on a global overview

for example

e1: querying for populations of cats and dogs overlaid on a GIS map [Jeong and Gluck 2002]

e2: querying the ratio of local maxima in at points above and below a point in a 2d slice from a 3d seismic volume [Joseph and Lodha 2002]

e3: scanning a theme park map for the most exciting rides [McGookin and Brewster 2002]

with the problem that

you need to show different scales or resolution or types of data in the same spatial region

entailing forces

f1: the need to keep a global context

f2: the need to allow local queries

THEN

Use sounds to represent the local information within the global visual context

Apply

Bertin's theory of information display [Bertin 1981]

'useful information is the answer to a question'

answers can be at local, intermediate and global levels

to construct

a stethoscope-like tool that allows the user to point to local regions of interest to hear details

leading to

the ability to listen to local detail while looking at the global overview

and

an interactive sonification of local information

4. DISCUSSION

I am just learning to write Patterns. Hopefully my learning exercises will inspire others to improve on them. In the first round of writing I started with my previous sonifications and identified and followed the development of various design hypotheses over a series of ongoing experiments. Then I came across the PLoP criteria and *BuschmannsLaw* that a Pattern should not be written by the originator, so had to go back to the drawing board. The next round of Patterns I wrote tried to capture the main principles I used as hypotheses in my sonification experiments -

Form should follow function [Gropius 1935]
Ask not the meaning but the use [Wittgenstein 1953]
Information is the answer to a question [Bertin 1981]
A good display answers questions at global, intermediate, and local levels [Bertin 1981]
Schema and Primitive heuristics [Bregman 1991]
Semiotic metaphor, metonym, connotation [Chandler 2002]
The Magic Number Seven Plus or Minus Two: Limits of Human Information Processing [Miller 1971]
Veridical Perceptual Representations [Ware 1993]
The Five Dimensions of Information Organisation [Wurman 1989]

But I soon realized that Principles are general guidance while Patterns are meant to be concrete problem-solution pairs. Principles fit rather well in the "**Apply** for the following reasons" part of the Pattern Template.

Finally, it dawned on me that hypotheses-results from sonification experiments might be considered as problem-solutions pairs, and that the ICAD proceedings could be a source of Patterns. There were only a handful of papers that fitted the criteria of a clear hypothesis supported by results and repetitions. Many experiments did not support the hypothesis that was being tested, as you would expect in a research field. The Sonification Design Patterns I have written are a reflection of current research hypotheses rather than 'proven good solutions' in practice. Nevertheless they provide a starting point for development of a shared language that can be extended with 'proven good examples' when the **SonificationProducts** Pattern proliferates ;)

The **and** field in the Pattern Template almost automatically generates more Patterns and will eventually connect the collection of Design Patterns into a Pattern Language.

5. WIKIWEB

Patterns only really come to a life and evolve when they are used actively for collaboration, design and communication. A tool specifically for collaboratively

writing Patterns, called the WikiWeb, allows anyone to edit and add new Patterns to a Pattern collection very simply using an Internet Browser. Some Patterns under development on the WikiWeb include UserInterfacePatterns, DebuggingPatternLanguage, OrganizationalPatterns, PatternsForEffectiveMeetings, and GraphicsPatterns. I have now added a SonificationDesignPatterns page to the PatternIndex at http://c2.com/cgi-bin/wiki?PatternIndex, and seeded it with the prototype Sonification Design Patterns above. The site is now open for collaborative development of SonificationDesignPatterns by ICAD and the wider design communities.

6. SUMMARY

Sonification Design can be viewed as the design of functional sounds where the Bauhaus principle that 'form should follow function' is particularly apt. The spread of small, cheap, and powerful audio technologies and the need to convey new types of information with non-speech sounds will lead 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 can provide, and can design sonifications 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. I have written a handful of prototype Sonification Design Patterns from papers in the ICAD 2002 proceedings. The papers I selected had clear statements of hypotheses, results to support them, and examples of repetition elsewhere in the proceedings. These Patterns are now on the SonificationDesignPatterns site on the WikiWeb and can be edited and added to using any internet browser. The lively development of SonificationDesignPatterns by the ICAD community may help build sonification-specific vocabulary, identify sonification hypotheses, and allow product designers to pick up and apply our research. The development of a Sonification Pattern Language could one day provide the integration of hypotheses needed as a foundation for a comprehensive theory of sonification.

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