Designing Spatial Sounds for Spatial Information Environments

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This paper reports on the design of spatial sounds for information environments. This research primarily relates to developing the sound component for a software prototype of a presentation environment that integrates realtime three-dimensional graphics with user interaction. For this project sound designers were engaged to examine the design of spatial sounds to examine the issues of dimensionality within presentation environments. The sound design work utilised a range of sound techniques: real world recording and modulation, static sound collections and DSP (Digital Signal Processing). The two main themes for the research were exploring sound as both thematic and navigational tools, utilising concepts that address the issues of multi-dimensionality within a time based presentation environment.

Keywords: *Spatial Visualisation, Spatial Sound, , Information Architecture, Sonification*

Introduction

Sound is integral to ones perception of space yet the design of sound has generally remained outside the pedagogy of spatial design curricula. Within the field of design representation spatial sound composition has gained significance in the context of virtual environments that integrate sound, for example game engine technologies, and the increased accessibility of spatial sound hardware systems, for example the ubiquitous Dolby 5.1™. The combination of virtually locating sound within space and its physical reproduction can mimic or heighten a perception of reality within an architectural design context. These same technologies however can be utilised to emphasise abstract concepts of space through sound rather than the realistic and scientific replication of naturalistic sound within physical spaces. The research presented here outlines the exploration of sound within digital informational environments an area that spans three disciplines; spatial information architecture, sound design, and computer science. This research explores the use of sound to articulate dimensionality within digital spaces, mapping spatial concepts of sound to navigation, information, interaction, and computation.

Drawing on theories of electroacoustic music and sound design, the research seeks to apply notions of acoustic space, and composed space. Acoustic space is described as „The perceived area encompassed by a soundscape, either an actual environment, or an imagined one such as produced with a tape recording and several loudspeakers. Every sound brings with it information about the space in which it occurs (for environmental sound) or is thought to occur (as with synthesised sound)“ (Truax 1999). Composed space is described as intentional use of spatial displacement of musical gestures or sonic textures (Smalley 1991) to the communication of a spatial information environment. Architecture and music design will be considered in space and time respectively, and that a multimodal synthesis of the two creates opportunities for deeper understanding of complex related information.

Information visualisation (Bederson and Shneiderman 2003), an aspect of human-computer interaction (HCI) is fundamentally an interdisciplinary field, relating computer science, psychology, cognitive science, human factors engineering (ergonomics), sociology, and other fields. With the integration of spatial metaphors for information arrangement this domain expands into the realm of spatial design disciplines such as architecture and interior design. The practical goal of spatial information visualization involves selecting, transforming and representing data in a form that facilitates human interaction for exploration and understanding, and using the potential of spatial design to assist in the formation of the informational understanding.

The research reported here develops from a successful Australian Research Grant (ARC) application entitled „Sharing Complex Systems Information by Challenging the Orthodoxies of Linear Presentation“. The objectives of the central research effort are the human and social issues effecting decision making processes informed by spatial visualization and sonification with integrated computational support, especially in complex systems environments such as design collaboration, weather prediction, and disaster management situations.

The fundamental concerns in this project are how to visually and sonically relate digital and physical environments in meaningful ways; not in a manner that mimics real world visual or acoustic situations, but designs that complement user interactions to experience a unique sonic and visual condition. This paper reports on the developments to date of establishing the audio components of a software prototype, entitled „Eureka“, and the approach of design spatial sound for presentation environments, but not the ‘effectiveness’ testing of such solutions.

The sound design work used a range of linear and non-linear sound techniques including field recording, montage and modulation, triggered static sound collections and digital signal processing (DSP). These were achieved in a variety of software environments; MAX/MSP (Puckette and Zicarellli et al. 1997), Logic (Emagic 2003) and Live (Ableton 1999). With the results presented through either stereo or quadraphonic speaker systems.

Background

Comparative research of presentation orthodoxies has shown that digital media can assist where previous technologies were formally limited. For example, research at University of Maryland Human-Computer Interaction Lab has produced a software product, „Counterpoint“ that integrates zoomable user interfaces (ZUIs) to navigate 2D information. As an adjunct to MS PowerPoint™ this software reveals the advantages of simple panning and zooming through a ZUI to allow nonlinear navigation of information. This is described as a 2.5 dimensional presentation system (Good and Bederson 2002). Since the early 90s, researchers at Xerox PARC - User Interface Research (UIR) Group have examined 3D approaches to digital arrangements of information. These explorations are related to single user navigation through components of information rather than presenter and audience presentation environments.

Much of the pedagogy of architecture is based on the interpretation and understanding of space and, in turn, on spatial information. In the last decade architects have begun to explore the bridge between digital information spaces and constructed physical space, especially in museology. The Virtual New York Stock Exchange project by Asymptote (Couture and Rashid, 2002) is one example that provides a digital simulation of a physical stock exchange with an overlay of continually updating information represented digitally. If this example succeeds on one level, utilising new media to deliver content to the requirements of the NYSE, it nevertheless offers little in the realm of digital spatial reconfiguration. Rather, it reinforces spatial concepts that mimic the physical world through a static model.

Parallels can be found in the area of music and sound design, where the spatial concepts of composed and acoustic space mentioned earlier are situated within a larger body of thought related to sonification, or the rendering of data into sound, and spatialisation. This is „perhaps the most all-embracing and general term used to describe the means by which loudspeakers are used to articulate or create a spatial musical experience for listeners in playback or performance. … It includes formats (e.g. Stereophonic, Ambisonic, Dolby), the placement and movement of sounds in space in any number of listening situations … and performance practices.“ (EARS 2003). Within and around these general concepts lies the „phenomenologically inspired researches into the experience, perception and classification of sound, music technology, and composition of musique concrete“ (EARS 2003) of Pierre Schaeffer and subsequent composers and researchers.

Multidimensional Presentation Environment (MPE)

The MPE prototype is defined here as a digital environment containing spatially located data that can be navigated by a presenter via an OpenGL graphics engine. Given an array of data types and the potential infinity of the associated datascapes, there is an opportunity to integrate sound systems that assist the presenter in the navigation and analysis of complex information scenarios.

The Eureka prototype to date allows a user to navigate their image collection by ‘clicking on’ and moving to the items. Figure 1 illustrates in a transformation from a two dimensional thumbnail sheet presentation into to a three dimensional arrangement or images, and how the viewer in placed in a spatial condition via the perspective of the camera view. Ultimately this allows the user to sight the context of their collection, and move freely in a nonlinear manner around the content. The recent graphical and interface developments in the software are in two main areas, which informed the brief for the sound design researchers. Firstly, a multi-modal approach for the environment, and the secondly, considering the environment as a space for editing and defining lecture content.

The multi-modal nature of the system allows the user to switch between different configurations of the information space. For example the „history“ mode reconfigures every slide that has been shown

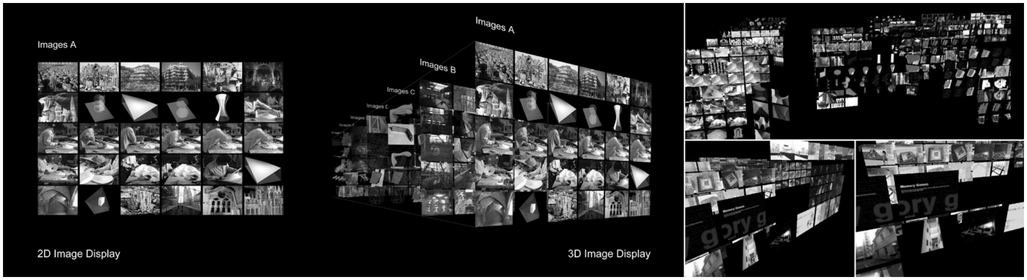

Fig1
MPE Environment.

in the lecture into a linear sequence, pulling them out of relationship with the images not shown. Each mode can have a unique configuration, environmental conditions, and the configurations can be designed to dynamically reflect the quantity and type of information being presented.

As an editing environment Eureka is in the development stages. In this mode, content from image libraries can be selected into a list, reordered, discarded, and recorded for future use. For this approach the lecture is split into two types of elements that have been termed ‘compositions’ and ‘items’. A composition is a containing component, which can include lists of items (images), and in turn also contain additional compositions. This is a nested or tree hierarchy approach to information organization, which intuitively allows the use linear and nonlinear transversal of its material.

Prior to the integration of this capability the ideas were conveyed in the brief for the sound design of the project, allowing the potential to map sound to nested elements, and the dimensional layouts of such informational structures. The multiple modes of information representation, and the concepts of editing and nesting material within space, provide rich sources for designing sound elements that could aid the user while path or ‘thread making’ in the space.

Sound Approach

The sound component of the prototype attempted to integrate concepts of sonification and electroacoustic composition with the presentation of multidimensional complex information. The research was interested in the development of sonic environments that aid navigation of the information in virtual space, and comprehension of thematic content contained in that information. This research was developed from several key themes presented in the International Community for Auditory Display „Sonification Report: Status of the Field and Research Agenda“ (Kramer et al. 1997), with additional reference to extant research on the role of non-speech audio for the representation of data dimensions (Walker 2000).

The research identified two primary modes of use for the MPE as ‘editing’; where a user assembles a presentation, and ‘performing’; where a user presents that information to an audience. It also identified that user interaction expectations differed greatly between the two scenarios. When editing a presentation, a (usually) singular user would be more able to engage with complex sound designs,

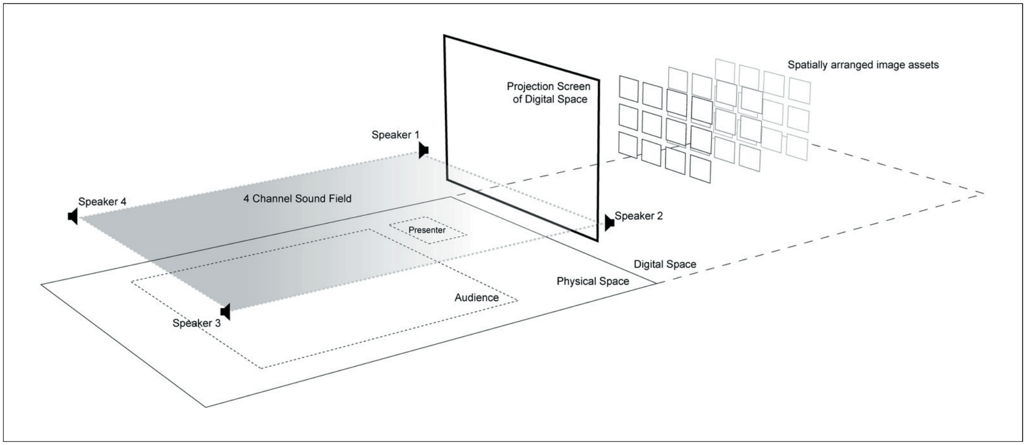

Fig 2
Diagram of presentation space.

whereas performance mode required the delivery of visual information with intelligible speech, creating an already complex soundscape, where additional sounds would often become distracting. In addressing these two modes specifically, the following research approaches were developed.

Editing and Dimensionality

This research focussed on the editing environment, and mapping the x-y-z coordinates to real-time synthesis parameters. A complex nesting of data was encoded in the audio environment that could potentially aid in the users navigation and understanding of the MPE. The audio data did not correlate to the content of the visual data but rather the nature of the sound was directly related to the position of the user in the information field, creating potential for the audio information to convey, the users position within the information space.

A Max/MSP patch was designed such that spatial co-ordinates from the MPE could control parameters of the Max DSP chain. The patch looped a sound file, sending it through a Bandpass filter and then out to 4 speakers with control over reverberation level. Communication between the MPE and the patch was initially achieved via MIDI (development is currently underway to utilise Open Sound Control) mapping incoming data onto the reverb level, bandwidth, frequency and gain of the filter, as well as the relative level of the resultant sound in each of the 4 speakers.

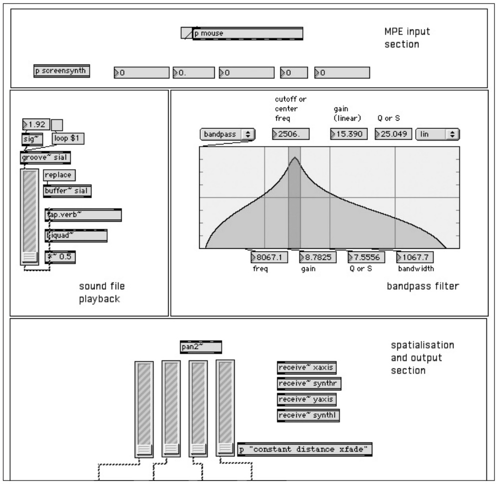

Fig 3
Max/MSP environment.

The Eureka data presentation and organization environment conveys a complex yet coherent information area that can be navigated easily in visual terms. A similar balance between complex and apparent needs to be established in any audio design for the editing environment. In this scenario, sounds used in the system need a high level of complexity in order for the relatively simple application of the Bandpass filter to define various sonic regions within the entire spectrum. In many ways this approach is a more non-linear version of the nesting and layered 'sound object' strategies mentioned below.

The total sound mass is presented with Eureka is in an 'initial view' position (ie you hear the entire spectrum of the sound from where you can see the entire data-set). Subsequent navigation to different coordinates affected the bandwidth of the filter (narrowing the bandwidth as one moves further away on the z-axis), the position in space from left to right and front to back in a four speaker or multi-channel array, and the overall volume of the sound.

These relatively simple mappings create an aural means of indicating to the user where they are within an information environment. The band-pass mappings are continuous in that user navigation continuously alters the soundscape, providing a constant sense of location.

Performance

Research into the use of sound in the 'performance' mode addressed the emotional and temporal experience of the audience, derived from pedagogical models and performance practice of theatrical sound design. This approach identified that the primary roles of sound design in theatre were to define the dynamic flow and focus of a performance, link ideas and scenes, describe an environment and communicate the emotional intention of the text

(Brown 2003) and that placement of sound in space and time could be employed to facilitate this process (Brown 2003). At the same time, standard teaching methods include auditory, visual and kinesthetic approaches, or a combination of the three in order to accommodate individual needs (A.N.T.A.).

The research explored how sound may be useful in creating an atmosphere prior to, during or after a lecture to enhance the experience of participants and promote absorption of information presented. This was expanded using scenario-based design techniques, where sound designs were described for important points and interstitial sections of a presentation. For example:

- When the audience enters the room – an enveloping soundscape.
- When they perceive entry to the virtual space – a sound synthesizing movement from one space to another.
- When the lecture begins – movement of a sound from the rear speakers to focus at the front.
- When a major point is made – short sets of abstract sounds that can be easily related to each other, and that don't distract form the spoken text.
- When an important concept is reiterated or put into context, or the lecture is over – enveloping soundscape to support reflection and synthesis.

Nesting and Encapsulation

Within these two modes of use, concepts of layering and nesting form a conceptual framework and system of organization and navigation. One approach to communicating this nesting of information was derived from the electroacoustic strategy of „reduced listening", or „listening to the sound for its own sake, as a sound object by removing its real or supposed source and the meaning it may convey" (Chion 1995)

A branching structure for distributing sounds through the environment was created to correspond with nested nodes of information. The top-level nodes, associated with general topics encountered on first entering the environment, are represented by relatively complex soundscapes.

Nested within each of these topics are contained more specific topics related to the first, each with their own sound objects. The sounds on this second level are simpler derivatives of the top-level complex sound object. This process could be extended further along more specialised data paths.

In this way, reduced listening, after having studied a sound object as a totality, a whole, can also consider it as a composition of small sound objects, which can be studied individually (Chion 1995)

Parallels can be drawn between this strategy and the way a broad topic of information can be broken down into smaller units of related information. Then Amplitude of each sound object increases when moving towards the visual object associated with the sound, as if the visual objects were the source of the sound.

When entering an individual visual object, only that associated sound object will be heard. Of course, that individual sound object may be subject to further division into sub-objects, ad infinitum. All sound objects on each level of information overlap one another - the radius and rate of attenuation for each sound object would be source for further research, as would be whether sound objects from different levels of information could be heard at the same time.

Three different sound designs were trailed in this system, aimed at exploring the importance of achieving direct relationships and translations between a sound and the visual information it is representing.

- The first approach utilised a variety of complex electronic and electronically processed sounds, all differing considerably from one another, and none being recognisable in any „natural" sense.
- The second approach involved the use of natural, recognisable sounds. All the sound objects (eight, as in the first approach) being field recordings of

various natural environmental sounds.
- The third approach mixed continuous sounds that were very similar by layering differently pitched tonal sounds together in order to create harmonic chords.

Conclusion

The MPE prototype is an exploration into understanding the consequences of multi-dimensional information delivery. It has revealed some intriguing issues pertaining to the role of sound relating to cognitive understanding of information and navigation through information landscapes. Sound can be used to improve cognition and enhance dimensionality within these abstract informational spaces. With this research each sound designer developed unique mapping strategies to relate the data domain to the sonic domain in ways that assist in the understanding of the dataset or its arrangement. These experiments within the abstract scenarios of information environments highlight the role of sound design within creative disciplines engaged in spatial design and representation. Which in turn give potential insights to the articulation of sonic concepts for the representation of designs for physical environments. Further to this, the application of theatrical sound design concepts has led to strategies for the use of sound to support temporal structures within a presentation environment.

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