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CROSS-DISCIPLINARY AND PROCESS-CENTERED: AN APPROACH TO DEVELOPING SOUND SPATIALIZATION TOOLS FOR SPHERICAL IMMERSIVE ENVIRONMENTS

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ABSTRACT

This paper presents a cross-disciplinary research approach to designing new tools for sound spatialization in immersive music environments. It addresses issues of interaction design and interface design by pooling knowledge from music theory, music interfaces and design research. Spatialization is a rapidly evolving practice in need of specialized and democratic tools. Using a methodology inspired by grounded theory, the concept of a universal vocabulary to describe spatial structures emerged from a series of interviews with electronic music composers. The notion of universal language was further confirmed by Denis Smalley's concept of spectromorphology. This realization required a deeper look into music theory and spatial music practices. Seeking a better understanding of practices and composition strategies provided a frame in which to search for design cues. This paper suggests that a cross-disciplinary process-centered approach rather than a techno-centric one is best suited to designing new creative tools to unlock expressive potential.

This paper introduces a pattern-based method for the attribution of spatial behavior to sound in immersive dome environments. "Additive sound spatialization" constructs sound trajectories from the combination of various archetypal spatial behaviours inspired by spectromorphology. The use of spectromorphological archetypes allows for easier and faster creation of complex spatial sound structures in electroacoustic music. Additive spatialization takes into consideration the narrative nature of immersive sound. It allows composers to imagine a spatial narrative for their music and to use this same narrative language within the software.

Keywords: spatialization, interface design, interface for musical expression

1 INTRODUCTION

Music and video as forms of artistic expression have followed similar conceptual paths through history and technological advances. Most notably that periodically, a new technology arrives and we have no idea what to make of it. 3D audio (or ambisonics) is one of those radically new forms of technology that electroacoustic musicians and artists have been experimenting with for over 60 years. Yet composer Natasha Barrett said: « The spatialization equipment and technology have become readily available, but the users haven't caught up ». [1]

From a design standpoint, this is unacceptable. Not out of designer hubris, but simply because it makes the unlikely argument that a majority of digital artists and electroacoustic composers are unfit to learn how to use such technology. It seems far more likely that the problem lies in the design process that yielded these spatialization tools.

Sound spatialization is the process of managing the distribution and movement of sounds over a multiple loudspeaker system. In many cases, these are speaker domes, often at least 180°(also called full-domes). This means that when inside of these systems, the listener can hear precisely the provenance of sounds, be it from in front, to the sides or even above him.

The field has attracted a great deal of attention in the past years with research ranging from methods for signal processing to the development of performance systems. New music interfaces often result from music or digital media and technology research, however few are like this one, strongly anchored in design research while using a cross-disciplinary approach. Our work combines the study of interface and interaction design with music theory in order to generate an innovative sound spatialization method for hemispherical speaker systems. By pooling knowledge from an array of disciplines, we propose an approach to spatialization that is meaningful from both an interaction design and musical standpoint. This paper suggests that such cross-pollination has brought a new perspective to the rapidly evolving practice of immersive music and can benefit future research.

In this paper, we present a design approach focused on identifying electroacoustic composers' mental models in the process of spatial music composition in order to design a new sound spatialization method. Specifically, we have addressed the topic of interfaces for spatial composition in hemispherical sound installations. In this work we strived to distil spatial composition strategies to it's most fundamental elements in order to translate them into characteristics for software design. The process presented here aims to maximize creative freedom within a computer tool while giving composers access to basic elements of spatial sound composition that we have extracted from a study of their process and perception of spatial sound.

2 COMPLEX PLAYING FIELDS

In 2011 the Society for Arts and Technology (SAT) in Montreal inaugurated the Satosphere: a hemispherical audio-visual immersive installation, 18m in diameter, equipped with 8 video projectors and a 157-speaker sound system. The Satosphere is one of a few full-dome performance installations to be found around the world and fulfils exceptionally well the needs of spatial music. Even though the Satosphere is built specifically for ambisonic sound performances, composing works for this performance device is complex and immensely time consuming. According to some artists, 5 minutes of music for a show can require up to 8 hours of spatialization work. This does not include the composition of the music itself, only the dynamic distribution of sound throughout the performance.

Taking on this research raised questions about human-computer interaction, interface design and applications of music theory. In addition, these questions had to be framed within the context of the immersive interactive space of the Satosphere.

3 SPATIALIZATION INTERFACES

Before continuing we must distinguish sound diffusion from sound spatialization. On the one hand we are describing the task of building a monolithic distribution of sound (diffusion) while the other consists in the creation of a dynamic and evolving sound environment (spatialization).

The arrival of multi-channel audio systems in the mid 1950s began the search for new instruments that could play music specifically for multi-loudspeaker systems, breaking from the traditional fixed, single source paradigm of traditional instruments.

In the early explorations of sound spatialization tools, it seemed clear (and natural) that it was necessary to design new instruments specifically for spatial music practices. The *potentiometre d'espace* designed by Pierre Scheffer is widely considered as the first spatialization interface dating back to 1951 [2]. However, over time, the prevailing interface for spatialization became the mixing desk due to its close relation to the well-established signal-routing interaction paradigm of faders and sliders. The works of Moore and Mooney [3-5] make use of potentiometers and sliders for sound spatialization, ultimately underlining the interface's shortcomings. Though the transference of the fader interface is easy to grasp, it has become evident through recent works that the mixing console is not adapted to the specificities of spatial music [4]. Moreover, the available tools for spatialization have moved far beyond traditional signal routing (one fader to one loudspeaker) and toward the fluid management of speaker grids using 3D modelling systems and game engines [6] offering a more intuitive use of hemispherical speaker grids. Some solutions are proposed by Wozniewski et al. [6] who have developed 3D modelling software for spatial interaction (SPIN) in immersive environments. Spin offers ways to interact with sound in an immersive setting with the same interaction paradigms of the real world employing physical models. Together, software such as SPIN and SPAT-OSC [7] can visually render the objects' in space and also accurately render ambisonic sounds in an audio-visual dome.

In a similar way, Rui Penha developed *Spatium [8]*, a set of spatialization plug-ins based on different physical interactions. It makes use of physics engines similar to those used for video games. These physical behaviours are made available in a suite of various graphical interfaces. Unfortunately it is a series of distinct plug-ins providing only one type of spatialization in each plug-in instance: Dynamic, kinetic, gestural. Though this is not a flaw *per se*, from a usability standpoint, it requires for musicians to interrupt the flow of their composition work in order to launch another plug-in and motion type.

Though these are still emerging musical practices, they provide a perspective into new forms of interaction for the creation of spatial sound. Examples such as *tactile.space* [9] have explore new possibilities for tangible interfaces, though still adopting a techo-centric approach. This raises many questions as to what an interface to create spatial music might be, what interaction paradigm might better inform it's design and what technologies could be used to this end most effectively?

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4 **METHODOLOGY**

The present research began with the hypothesis that the spatial composition process exhibits commonalities from one composer to the next. Uncovering these commonalities could then provide basis for the design of a spatialization tool that is tailor-made to the specific requirements of spatial composition.

Using a methodology inspired by grounded theory, we conducted interviews with composers seeking shared mental models in spatialization practices. The interviews took the form of discussions about different stages of their creative process.

The pivotal moment within this methodology was shifting our line of inquiry from "How do you do it?" to "What do you want to express? What do you want people to experience?". The first line of questioning lead to discussions about the composers' creative process but inevitably shifted toward software efficiency, sometimes taking the form of demonstrations of how they use their software and certain functions with various praises and highlighted shortcomings. This might have been sufficient if our objective was improving a software, however, we were searching for a novel way to spatialize music through a deeper understanding of the spatial music composition process that broke free of currently used paradigms. In order to achieve this, it was necessary to keep the discussion around the artistic intention of these composers. This is how we began extracting mental models that defined the spatial composition process of each composer.

This is what we've called a process-centered design approach. Though it is not radically different from the well know « user-centred design», this approach takes into consideration that there are aspects of creativity and artistic endeavour that can neither be expressed explicitly by the artist nor observed directly by the researcher – somehow both must meet halfway by focusing their attention on the underlying creative process.

After observing different software and discussing with composers, it seemed that the available methods for spatialization offered in music software did not correspond to how musicians conceptualise space in their creative process. The most common method used in spatialization software is parametric spatialization that requires the composer to determine a sounds trajectory by using keyframes and 3 axis coordinates. A composer must establish where one sound sample is located on the speaker grid (where it will sound to the listener's ear), then where it will be a few seconds later and so on. This is no doubt inspired by animation film and 3D modelling software. However our research has shown that composers writing for immersive speaker domes do not envision spatial sound this way.

Therein lies the problem with currently available spatialization software: there appears to be a fracture between the process required by the software and the process implied by the language of spatial music composers. Composers do not naturally imagine sound as existing within a three axis virtual space; they do however base most of their spatial understanding on the narrative nature of real-world sound references. They more commonly develop a form of narrative in their work and try to represent it sonically and spatially. Here are just a few extracts from some interview transcripts:

" […] a marching band is an excellent example of potential for moving music, meaning that the sources are moving and the listeners are also moving. When a marching band passes by, you can step inside and follow the procession, in which case the music continues normally. You can also walk in the opposite direction and double the speed of the music. Then suddenly you think: Hey! There's potential here!"

"For example, the movement of flowing back and forth, waves on the beach, bouncing, all these movements are archetypes that exist and that we share as humans […]. Electroacoustic music is built from these archetypes."

Our greatest reference for spatialised sound is undoubtedly nature. Walking in the forest, sitting by the beach or waiting on a busy street corner are all settings with a wealth of examples of moving sound. Composers share these experiences and draw from those same references to create the virtual space in their music. We can observe this in the very material, almost tangible vocabulary they employ when explaining their artistic intentions. These were referred to as spatial archetypes or spatialization patterns. The notion of universal spatial music language was further confirmed by Denis Smalley's concept of spectromorphology [10], which lists typical spatial behaviours found in electroacoustic music. Though it was meant as a descriptive vocabulary for the analysis of music, spectromorphology has successfully been used as a compositional language in the past [11]. Blackburn's work suggests that composers can successfully use Smalley's vocabulary, not only to analyse past works but also in the creation of future works.

The concept of spectromorphology that emerged from the interview process later lead to a literary review surrounding Denis Smalley's work. This allowed us to develop a design brief for a new spatialization interface and propose a new approach to spatial music composition that we call additive spatialization.

5 ADDITIVE SPATIALIZATION

As mentioned earlier, what our research suggests is that spatial music is not composed as a succession of small movements from one specific location to another, but rather composed as a narrative – a feeling – as events that occur through time, most likely with an identifiable pattern of movement. What some composers referred to as spatial archetypes: the ebb and flow of the ocean, a marching band marching by, planes flying overhead.

This brought us to integrate spatial archetypes - identifiable spatialization patterns taken from our shared, universal understanding of sound in space – into software form. Computers are particularly well adapted for executing patterns; therefore, making the software responsible of reproducing spectromorphological archetypes would undoubtedly make it an accelerator of the composition process.

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Also, beyond simple patterns, composers spoke of emergent sound behaviour; spatialization events that would happen with little or no intervention - like sound objects with the ability to evolve autonomously.

« […] what makes me keep something rather than discard it is that I'll reach a point where I put things together and these things will have emergent properties beyond what I had planned. »

Using Denis Smalley's spatial archetype categorisation, we developed a spatialization approach where composers create spatial profiles or recipes through an overlaying process. This layering approach facilitates the creation of complex spatial behaviours by allowing composers to imagine a sound narrative and use that same narrative within the software.

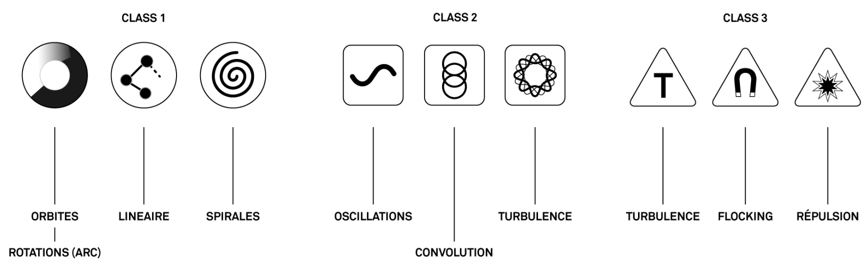

Figure 1 - Three classes of spatial behaviours

The spatial behaviours are split into three classes: 1) General motion 2) Internal movement 3) Environmental effectors. Each archetype has a small number of variable parameters (figure 2). Figure 1 shows an example of three behaviours per class. When the spatial behaviour is composed, we then have a spatial profile as shown in figure 3.

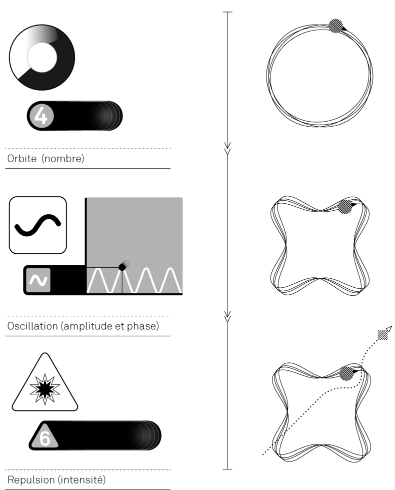

Figure 2 - Building process of a spatialization profile

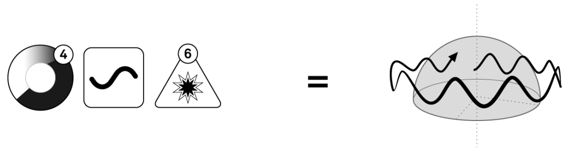

Figure 3 - Resulting spatial profile

Additive spatialization reincorporates the narrative nature of sound into a music interface destined for use in immersive environments. It has the potential to accelerate music spatialization while augmenting the artistic abilities of composers. We believe that such a spatialization method is more in tune with the mental models of spatial music artists. Its various uses are currently being tested at the Society for Arts and Technology in Montreal.

In the search for new interfaces and new modes of interaction for sound spatialization, this elemental approach takes steps towards an organic way of spatialising. These spatial building blocks are so fundamental to the creative process that they allow modularity within the practice and create opportunity for extreme customization by each user according to his or her habits, thus offering opportunities to explore new forms of expression in electroacoustic music. To the best of the authors' knowledge, no spatialization tool functions according to this model.

6 **CROSS-DISCIPLINARY AND PROCESS-CENTERED**

The initial intention of this research was to explore what results a typical design approach to research could yield if its efforts were focused on sound spatialization interfaces. But as knowledge was gathered, any single methodology seemed to lead to another, thus transforming into a research form akin to Kincheloe's *bricolage* [12]: an aggregate of research methodologies. We began with a literary review of spatial music interfaces and approaches to embodied interaction, then conducted with user (composers, sound artists and engineers) and studied spatial music history and theory.

It seems that a majority of current sound spatialization tools focus on making effective use of a selected technology rather than question how any technology could best serve the specific needs of spatialization practices. We believe that understanding the technology, the music theory, the artistic intentions, the socio-cultural setting are only some of the essential components that can be combined in order to truly understand the potential of a technology and make meaningful use of it. It is through such a multi-layered process that both artists (end-users) and design researchers can find common ground to create meaning. Design as a practice of knowledge synthesis has the ability to do this on the condition that it does not limit its reach to any single pool of knowledge. Borrowing from methodologies such as Kincheloe's bricolage could be vital to yielding a deeper understanding of the underlying connexions between complex contexts, diverse user-bases and the fundamental knowledge that defines creative practices. The value of this research has been to understand the deeply routed shared perceptions of sound in space that can be observed in practitioners' vocabulary. Through this, we suggest a method for sound spatialization that is elemental and fundamentally universal, and makes optimal use of computing power while giving complete freedom for composers to find their own, unobstructed way of expressing their artistic vision through the composition tool.

7 ACKNOWLEDGEMENTS

This research is ongoing at the University of Montreal in collaboration with the Society for Arts and Technology. We intend to further implement additive spatialization in a music-software plug-in for digital audio workstations. I would like to extend my thanks to my colleagues at the SAT for their support and I enthusiastically look forward to further research on spatialization interfaces.

8 REFERENCES

1. Otondo, F., *Creating Sonic Spaces: An Interview with Natasha Barrett.* Computer Music Journal, 2007. **31**(2): p. 10-19.
2. Harley, M.A., *Space and spatialization in contemporary music: History and analysis, ideas and implementations*. 1994, McGill University.
3. Mooney, J. and D. Moore. *Resound: open-source live sound spatialisation,"*. in *Proceedings of the International Computer Music Conference, Belfast, UK*. 2008.
4. Mooney, J.R., *Sound diffusion systems for the live performance of electroacoustic music*. 2006, University of Sheffield, Department of Music.
5. Moore, A., D. Moore, and J. Mooney. *M2 Diffusion–The live diffusion of sound in space*. in *Proc. ICMC*. 2004.
6. Wozniewski, M., Z. Settel, and J. Cooperstock. *A spatial interface for audio and music production*. in *Proceedings of the International Conference on Digital Audio Effects (DAFx)*. 2006.
7. Quessy, A., et al. *SpatOSC: C++ library that controls various 3D audio spatializers*. 2012 Septembre 12, 2012; Available from: http://code.sat.qc.ca/redmine/projects/spatosc.
8. Penha, R. and J.P. Oliveira, *SPATIUM, TOOLS FOR SOUND SPATIALIZATION.* 2013.
9. Johnson, B.D., *Diffusion Evolved: New Musical Interfaces Applied to Diffusion Performance.* 2013.
10. Smalley, D., *Spectromorphology: explaining sound-shapes.* Organised sound, 1997. **2**(2): p. 107-126.
11. Blackburn, M., *Composing from spectromorphological vocabulary: proposed application, pedagogy and metadata.* Electroacoustic Music Studies, 2009.
12. Kincheloe, J.L., *Describing the bricolage: Conceptualizing a new rigor in qualitative research.* Qualitative Inquiry, 2001. **7**(6): p. 679-692.