Multichannel audio for interdisciplinary site-specific installations

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ABSTRACT

Multi-disciplinary arts projects featuring sound often neglect the importance of sound projection and the technical concerns that arise when working with loudspeakers. Relating directly to site-specific works, the problem is compounded by the common observation - ‘Help! It sounded good in my studio. Why doesn’t it sound the same on site...?’

This paper seeks to find a solution to common technical problems encountered by curators and artists who work with sound in an interdisciplinary way, by demonstrating the author’s collaborative interdisciplinary work and teaching of ‘sound’ to Fine Art and Digital Media at the University of Hertfordshire.

1. INTRODUCTION

1.1 Time and Space

Whilst there are always contradictory examples, physical site-specific public art works commonly have no fixed time span or fixed viewing/listening point. An audience is actively encouraged to explore the space, gaining experience from as many different positions as possible. They may encounter the same work at different times of day, month or year, experiencing different environmental conditions. Will the audience hear the same audio each time (a pre-rendered loop) or will an algorithmic system be employed, changing, evolving and interacting over time?

1.2 Spatialization

The standard system for the majority of commercial listening remains Blumlein Stereo, still exceeding commercial ‘surround sound’ systems such as 5.1. With stereo, it becomes possible to create one of the most magical aspects of sonic art – the phantom image. It is accepted that the optimum configuration for positioning of listener to loudspeakers in Blumlein stereo is an equilateral triangle, with the listener observing equidistant from both loudspeakers (the sweet-spot). Whilst this is acceptable for independent listening in a home or studio environment, the sweet-spot is rarely achievable in a public-art environment where there will be multiple listeners, and they are likely to be moving. For a listener situated away from the equidistant point, the difference in distance means the sound from the farther loudspeaker arrives later. For identical signals coming from different directions, a tiny difference in time (a few milliseconds) makes the combined sound appear to originate from the direction of the closest source. Known as the Haas effect, a psychoacoustical phenomenon described by Helmut Haas in 1949, and also described as the precedence effect, it shows that when two identical sources are presented in such a way they will be heard as a single fused sound. With more than two speakers (quad, 5.1, 8.1, 10.2, 16.4…), this becomes an almost insurmountable problem.

So, what is the artist trying to technically achieve spatially and is it achievable in a public-art space? Is the phantom image desirable or are their other possibilities?

This paper describes technical and aesthetic solutions for audio projection and reproduction in public-art site-specific spaces where listening conditions and acoustics may not be at their optimum.

1.3 Practicalities and technical

The observation ‘It sounded good in my studio’ often occurs due to a lack of understanding of acoustics and the effect of environment. It requires technical experience, but primarily, the ability to listen.

I advocate an in-situ mixing ability allowing the user to mix sound in the site-specific environment. This may be as simple as balancing individual channels, or providing equalization to each channel. When using multiple channels, being able to place small delays on each channel becomes important. This in-situ mix can then be rendered for repeating ‘performances’ creating a ‘plug and play’ system (using a DAW to mix on site and then port over to a multichannel media card).

1.4 The visual loudspeaker

The dubious visual appeal of much sound transmitting equipment should be considered when working in a site-specific environment. This paper explores some novel ways of integrating loudspeakers into artworks.

2. WORKS BY THE AUTHOR

2.1 Cosmoscope (2016-18)

Led by artist Simeon Nelson, Cosmoscope is a Wellcome Trust funded interdisciplinary project, researched and
produced in collaboration with a team of artists and scientists (Dr. Nick Rothwell, programmer; Dr. Simon Walker-Samuels, Wellcome Trust Senior Research Fellow; Dr. Richard Bower, Professor of Cosmology, Durham University; Dr. Pete Edwards, Director of Outreach, Durham University; Dr. Andrew Goodwin, Professor of Materials Chemistry, University of Oxford; Monia Brizzi, Chartered Psychologist and Daniel Bosia, Structural Engineer). It culminated in a monumental sound and light sculpture made of 52 laser-cut steel 3D Platonic elements nested and bolted together into an overall spherical geometry to form a type of ‘cosmic orrery’ of the very small, the human and the very large scales.

The music forms a complementary musical orrery – a play on the astronomical clocks of the Renaissance; a huge cyclic sonic construction of macro and micro pulses and phases. Whilst it is easy to perceive our universe as an entirely regular oscillatory mechanism - what happens when events disturb this regularity? Small and large are unsatisfactory adjectives to describe musical events. So, can we experience a quantum sound; or a sound that is ‘cosmic’ in ‘size’?

The research demonstrated that human beings (at close to 2m in height) are equidistant in spatial scale between quantum and cosmic. The music for Cosmoscope consists of variations of three ideas – light, rapidly moving granular clouds associated with ‘quantum’; the pulsed sinusoids of ‘cosmic’ combined with sustained clustered vocal sounds (‘human’). The interlocking 3D tessellations, and further geometry of the structure, provide rhythmic material enhanced by the rhythmic lattices as described by Godfried Toussaint.

The music and lighting are algorithmic. They co-evolve over time. A viewer witnessing the work on multiple occasions, common in public art works, will experience something new on each viewing (analogous to how the perception of a visual work might change owing to light and other environmental conditions).

Audio spatialization is entwined in the premise of Cosmoscope. Operating over a 16.4 discrete sound system, designed by the author with the British audio-visual company ArtAV, it creates a truly immersive environment. The central timing of the audio controlled the algorithmic light display within the structure – forming a quasi-graphic score to the immersive audio/visual surroundings.

The 16.4 speaker array was partly contained within the structure and also surrounds it, providing an audience the opportunity to move within the soundscape. Eight near-field monitors were employed within the structure itself.

Commissioned by Artichoke Trust and initially shown at the Durham and London Lumiere’s (2017/18), Cosmoscope was a long-term exhibit at Watts Gallery 2019. The technology allowed the artists to easily customize and ‘remix’ for a gallery situation. Further versions of Cosmoscope (audio/visual film with Professor Richard Bower, Durham University) have also been shown at the Noisely Music Festival 2018/19 and WOMAD 2019.

2.2 Point Source localization
Cosmoscope uses extensive point source localization over the 16.4 speaker system. Owing to the Haas effect and resultant masking and phase issues occurring when the listener is closer to one loudspeaker, the listener will not be able to hear the output of others when listening in multi-channels. However, the listener can hear the sound of all loudspeakers, no matter their location, if they are treated as point sources in isolation. In short, when a sound is emanating from one loudspeaker, it isn’t coming out of the others. In this way, the technique allows an audience (no matter of their location and movement), the opportunity of hearing all sounds from all loudspeakers.

Movement from loudspeaker to loudspeaker in such a way will produce abrupt changes of localization. Whilst this may be considered a problem, or a ‘feature’, there are solutions to this issue. More loudspeakers, placed closer together, will create smoother transitions of movement (a variant of Wave Field Synthesis). If the rate of change from one loudspeaker to another is fast enough, then a granulated space is produced forming a convincing immersive acoustic structure.

2.3 Code
A series of modules, written in Cycling ‘74’s visual programming language Max, have been created to control sound projection in the authors public art works, most notably Cosmoscope and Anarchy in the Organism. There were a number of key aims for building the toolkit including allowing the user to mix and master audio on site, vary spatialization including speed and density of granular movement, make allowances for alternative
speaker placements (individual EQ for each speaker and delays), adjustable reverberation and the ability to ‘bounce down’ to media card for playback without a computer (for ‘plug and play’ capability).

The click-free point source localization allows for mono or stereo signals to be projected over multiple speakers, an important rule being that the signal may only be emitted from one speaker at a time. Various geometric shapes were produced, from circles that change direction and speed, to random distributions. When the sequenced duration of each point is suitably short (less than 50ms), a form of granular synthesis is achieved; or, to be more pertinent, a granular cloud (Iannis Xenakis 1960), and micromontage (Horacio Vaggione 1980). Whilst granular synthesis and clouds are commonly found in 21st Century electroacoustic music, the technique used in this capacity solves the sweet-spot problem found in conventional playback systems. Granular synthesis and micromontage may be compared to pointillistic paintings (Georges Seurat, Paul Signac et al), a cross-disciplinary analogy worthy of further exploration with particular regard to mixed-media collaborative work.

Figure 3. Point Source Code used to control spatialization of the eight inner loudspeakers. Selection of outputs is controlled via Max’s [matrix~] object. Later versions have used the [cycle~] object as a means of choosing different window shapes for the de-clicker.

Figure 4. Cosmoscope Mixer contains EQ for each channel, delays and reverberation if required.

Figure 5. Cosmoscope Clock containing the hour-long sequence of macro-events (with the micro-scale being algorithmically controlled within the system) and rehearsal mode.

2.4 Hydrosiren (2017)

A competitively awarded commission from the Canal and River Trust, London, made in collaboration with Simeon Nelson and produced by Modus Operandi Art Consultants, Hydrosiren was built by Nelson and a large team of volunteers. The work is a performative acoustic sculptural boat responding to the sights and sounds of the locality around Regents Canal and Meanwhile Gardens, West London.

The sculptural acoustic boat references ceremonial barges and Polynesian catamarans. It was performed live with a soprano singing in the bow and a punter in the stern. The soundscape, composed by the author, encompasses vocal and environmental recordings (including hydrophone recordings of the aquatic life of the canal) combined with the sound of the ‘siren’ – the voice of soprano Elisabeth Karani, who sang live from the structure as it progressed down the canal.

Figure 6. Acoustic sound mirrors at Denge, Kent.

The structure uses two loudspeakers mounted into parabolic mirrors together with a central parabolic microphone. The system is based upon the principle of acoustic sound mirrors used in the first half of the 20th Century functioning as early warning listening devices to detect
enemy aircraft flying over the English Channel. Whilst
the mirrors at Denge, Kent and elsewhere, were soon
rendered obsolete due to the much more effective radar,
the concept still functioned and maintains an imposing
structural impression.

Underwater and micro recording techniques were ex-
plored allowing us to hear the inaudible. The considerable
challenge of creating a high-end audio system using 12v
on a floating structure has been overcome (although the
technology remains largely invisible to an audience or
viewer).

The visual appeal of the sound mirrors also aided the
sonic experience. The mirrors produced a ‘focused’
sound, allowing us to project the sound directionally. In
this way, it mixed with environmental sound and place in
a meaningful way.

The original installation version, displayed for fourteen
months in 2012/13, consisted of four 55” video screens
embedded in a geometric pattern and displayed abstracted
organisms that evolved and developed cancer to varying
degrees according to algorithmic code produced by Nick
Rothwell - a random depiction of cell growth and death.
Music, also generated from cellular mutation, was pro-
jected into the spaces using Feonic ‘Whispering Window’
technology – a method of attaching a transducer to a
physical object (such as a window) to make it ‘sound’.
An octophonic soundscape was produced through the
four windows. This projection system allowed the sound
output to be focused around the site, causing the least
amount of unwanted disturbance to those who might not
wish to engage with the work.

Central to the concept, is the idea of interruption, inter-
ference and disturbance. The music uses a rhythmic tech-
nique the author named (somewhat erroneously…) Pulse
Time Modulation (PTM) - the idea being that a repeating
sound (a pulse) is subject to a constantly changing tempo
creating a shifting accelerando/rallentando effect. Where
simultaneous multiple PTM’s take place, any definitive
pulse quickly becomes perceptually complex and/or cha-
oytic. Breathing, tension and relaxation, physical and psy-
chological time all come under the auspices of the tech-
nique. Each pulse is projected as a point-source over a
multi-speaker array.

2.5 Anarchy in the Organism (2012/13)
Anarchy in the Organism is a Wellcome Trust funded
collaborative artwork initiated by Simeon Nelson chal-
lenging our perceptions of cancer. It consisted of two
outputs – an audio-visual installation presented in four
windows of London's Macmillan Cancer Centre before
transforming to a live concert-hall version (for Eb clarinet,
strings and live electronics).
3. TEACHING

3.1 Listening
The author’s teaching of ‘sound’ at the University of Hertfordshire includes Music Composition and Music Technology; plus, students of Fine Art and Digital Media. Central to the classes is a detailed expose of listening. Students’ are invited to take part in variants of Pauline Oliveros scores. ‘Listen to a sound you have never heard before. In 50 words or less, verbally describe the sound to us.’ They examine terminology found in interdisciplinary works - rhythm, harmony, pulse, structure, pitch, space, tempo, phrasing, meter and ornamentation. How might these terms be used in Fine Art or Architecture? Students’ visit the UH anechoic chamber as a means of experiencing ‘quiet’ and the effect of physical space on sound localization perception. What happens when we add electronic sound to the natural environment? Is one person’s sound art another’s sound pollution?

3.2 Sound in Space
A practical investigation into the physics of sound is provided. How does sound behave in space? How do we localize sound and why do we do it? The importance of reverberation and delay is studied, including how architects, artists and composers have exploited acoustics found in specific buildings throughout history (Vitruvius, Roman Theatres; Gabrieli’s, San Marco; Varèse/Xenakis, Philips Pavilion etc.).

3.3 Technical
Technical details of sound projection are explored – playing back through loudspeakers (headphones, stereo pairs and multispeaker rigs) and the effect of the surrounding and environment. Why do speakers sound like they do and what can we do to improve their response? Recorded sound using a variety of microphones, including contact and hydrophones, is examined and studied.

3.4 The acousmatic
What does sound mean? What, if anything, does music mean? Does a sounds source affect our understanding of it? Why is diegetic and non-diegetic sound so important in film?

3.5 Coding
Literacy in student population must evolve, in a similar way to how linguistic language changes over time. Coding is an essential form of literacy for all artists of all disciplines. The implications of creating custom code (or collaborating with a programmer) for algorithmic systems where a time-based work may evolve and change are explored. Interactive works (using sensor technology, Arduino, Raspberry Pi etc.) are also investigated. The modules used in Cosmoscope provide hackable examples of workable patches.

3.6 Sonic visualizations
Students’ explore the science and mathematics behind sound. Visualizations of sound are demonstrated including early Chladni plates and Faraday interference patterns. More advanced arts/science visualizations by Hans Jenny (Cymatics) lead to investigations of VJ technology and how this is used in the experimental and commercial sectors.

‘I’m a visual artist… can I ‘do’ sound and can I make it sound good?’… Yes! This may be in collaboration with a sound artist or technician. The aim of the teaching is to equip students with enough knowledge to inspire and create meaningful dialogue between collaborators.

4. STUDENT WORKS

4.1 Gwen Senhuichen (2019)
University of Hertfordshire Fine Art graduate Gwen Senhuichen, produced an innovative mixed-media work based around many of the principles demonstrated in this paper. Using eight speakers as point sources, it captured sound and movement via contact microphones attached to bags filled with stones and a yellow liquid.
4.2 Mat Eric Hart (2019)
University of Hertfordshire Sound Design and Technology graduate Mathew Eric Hart produced a multichannel soundscape using found archived audio from the British Library.

"From sacred texts written on tree bark, palm leaves and gold plates to exquisite silk scrolls of major sutras, follow the life of the Buddha and his previous incarnations. Find out how Buddhism was pivotal in developing writing and printing techniques, transmitting ideas and stories across Asia."

https://www.materichart.com/blbuddhism

Using original field recordings from the British Library Sound Archive's World and Traditional Music collection, Hart created a natural, evocative sound world for visitors to the British Library exhibition Buddhism, engaging with the mind, body and spirit.

5. CONCLUSIONS
Point source localization is an effective spatialization technique in a site-specific public-art environment. The ability to readily customize and mix sound on-site is crucial for an integrated work. Audiences maintain interest in evolving algorithmic sonic structures.

Whilst it is unhelpful to expect all visual artists to have the same technical knowledge as someone studying a sound-based course, experience of key technique aids the collaborative process between visual and sound artists. Coding is an essential form of literacy, as fundamental as reading and writing. A knowledge of the science of sound can lead to improved technical work but also develop new aesthetic ideas in the arts/sci field.

The audience and reach of electroacoustic music presented as a site-specific work can be many thousands, somewhat proving small audience figures for ‘concert-hall’ electroacoustic music is not to do with musical content, rather how it is presented.

Interdisciplinary works exploring sound require the skills and ability to listen, in the widest sense of the word.

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6. REFERENCES