SONIC GREENHOUSE - Considerations on a Large-Scale Audio-Architectural Installation

Otso Lähdeoja
University of the Arts Helsinki Finland,
MuTri / Music Technology Department
otso.lahdeoja@uniarts.fi

Josué Moreno
University of the Arts Helsinki Finland,
MuTri / Music Technology Department
josue.moreno.prieto@uniarts.fi

ABSTRACT

This article discusses a recent large-scale audio-architectural installation which uses the glass structures of a greenhouse to create a multichannel sound system driven by structure-borne audio transducers. The sound system is presented and its implementation is discussed in reference to the constraints of a site-specific installation. A set of sound spatialisation strategies are proposed and their effectiveness weighted in the specific context of a large-scale work where the audience acquires an active role in moving within the piece, countering traditional centered spatialisation methods. Compositional strategies are developed in response to the context, emphasizing the spatial dimension of composition over the temporal and narrative ones and pointing towards the concepts of "Sonic Weather" as well as "Sonic Acupuncture".

1. INTRODUCTION

This article constitutes a report and an analysis of a large-scale audio-architectural installation "IN SITU: Sonic Greenhouse", which took place in September-October 2016 at the historical Winter Garden Greenhouse in Helsinki[1], Finland, and was experienced by approximately six thousand visitors. The piece's rationale is to transform the glass structure of the greenhouse into a multichannel sonic architectural object - or a macroscale musical instrument - by activating the glass panels with an array of sixty structure-borne sound drivers, transforming them into visually transparent loudspeakers. The idea is to drive sound all over the greenhouse's structure, creating an immersive aural architecture at the crossroads of software-controlled multichannel sound spatialisation and a soundscape inviting for a first-person discovery.

The work brings together a combination of sound and architecture with the larger issues related to the "greenhouse"-concept, such as environmental issues and the poetics of connection/separation inherent to a glass structure. A greenhouse is a man-made biotope where favorable conditions are created in a delimited space for plants which would not survive in the local natural conditions. The greenhouse metaphor was developed in the compositional and spatialisation strategies involved in the piece, as well as in the establishment of a weather data stream into the installation's generative sound engine. Sonic Greenhouse was a collaborative work by two composers of electronic music. The process was completed in parallel and in dialogue, with no specific personal tasks assigned. The resulting piece can be considered to be a duo. The piece's website can be accessed at: http://sonicgreenhouse.eu.

In this article we discuss examine the piece from three different interrelated levels of analysis: 1) sound diffusion system design and implementation, 2) spatialisation and data input, and 3) compositional strategies.

"Sonic Greenhouse" is a work stemming from both artistic and technological research, aiming for the fertile dialogue between the two. The technical research motivations involved testing a large-scale structure-borne sound diffusion system directly on the structure of a building. We had no precedent knowledge of how such a system would sound and how it could be used to produce effective spatial aural impressions. On the artistic side, our research questions related to finding the optimal compositional strategies for a site-specific work in a large space with defined architecture, luxuriant plant life, social behaviour and interaction, abounding with multisensorial stimuli.

2. RELATED WORK

Creative combinations of audio and architecture has been explored in a number of works, connecting "Sonic Greenhouse" to a continuing line of aural installation art. Building structures have been used as sound sources, as in David Byrne's piece "Playing the building": "Playing the Building is a sound installation in which the infrastructure, the physical plant of the building, is converted into a giant musical instrument. Devices are attached to the building structure — to the metal beams and pillars, the heating pipes, the water pipes — and are used to make these things produce sound. The activations are of three types: wind, vibration, striking. The devices do not produce sound themselves, but they cause the building

[1] Talvipuutarha is the Helsinki City public greenhouse, open for visits since 1907. http://www.hel.fi/hki/hkr/fi/Viheralueet/Talvipuutarha

elements to vibrate, resonate and oscillate so that the building itself becomes a very large musical instrument." [1]. "Sonic Greenhouse" presents a parallel with Byrne's piece in its aim to induce vibration into the building's physical structure, with the notable difference of the present project using audio-rate actuators rather than sub-audio frequency mechanical devices such as motors and solenoids. Audio-rate excitation at bass frequencies has been investigated within the "Resonant Architecture" project's different instantiations, exciting the lower spectrum resonant modes of large-scale architectural and sculptural entities [2]. Structural vibration has been used as a compositional element in numerous works of Bill Fontana, for example in the "Harmonic Bridge" piece at Tate Modern, London [3]. More recently, Rodolphe Alexis has used the Greenhouse context for sound installation, using wavefield synthesis to create a soundscape for a flower exhibition at Natural History Museum in Paris [4]. The present work builds on prior research on structure-borne sound in intermedia context by Otso Lähdeoja [5].

The compositional considerations of "Sonic Greenhouse" have echoes in Janet Cardiff's "Forty Part Motet", which sets the listener as the active agent in the unraveling of a spatially distributed audio work, leading into a first-person spatialisation [6]. A similar idea has been explored in "Parabolic Dishes" by Bernhard Leitner creating spatial regions sonically, in which the visitors are required to explore the acoustically structured space [7]. In a situation where the visitor is an explorative agent, questions of form and sound spatialisation strategies arise. In our work, this was reflected in a dialogue considering placing sounds in space rather than in time, and creating a generatively changing sonic situation rather than a narrative, echoing Max Neuhaus: "Traditionally composers have located the elements of a composition in time. One idea which I am interested in is locating them, instead, in space, and letting the listener place them in his own time." [8]

3. DESIGN AND IMPLEMENTATION

The Helsinki Winter Garden comprises three different spaces, as shown in Fig. 1: a) the central Palm Room (surface 280m^2), b) the eastern wing's Cactus Room (200m^2) and c) the western wing's social space (170m^2). "Sonic Greenhouse" was designed in intimate connection to the given space in order to foster integration into the physical structures, plan and human life, acoustics and poetics of the space. A prior period of sensorial research was completed by multiple visits to the site spanning over a year, observing how the staff and visitors behave in the space and how the building reacts to different weather conditions. These observations had a decisive effect on the design of the piece, which had to take into account high humidity levels, leakages and the regular activities such as watering the plants. The visits also served to familiarise ourselves with the acoustic specificities of the site.

The Palm Room (a) acoustics are very reverberant, cathedral-like and the space is filled with luxuriant vegetation. The sound work was designed to respond to this grandeur with full-spectrum and dynamic sonic constructions involving precisely rendered movements of sound within the glass structure. The Cactus Room (b) is very silent and intimate. In accordance, the sound was designed to occupy the space with precise, intricate sounds which draw the visitor's attention to details and silent contemplation. The social space (c) was left as a relaxation space, convenient for discussion and studying documentation about the work presented in printed format.

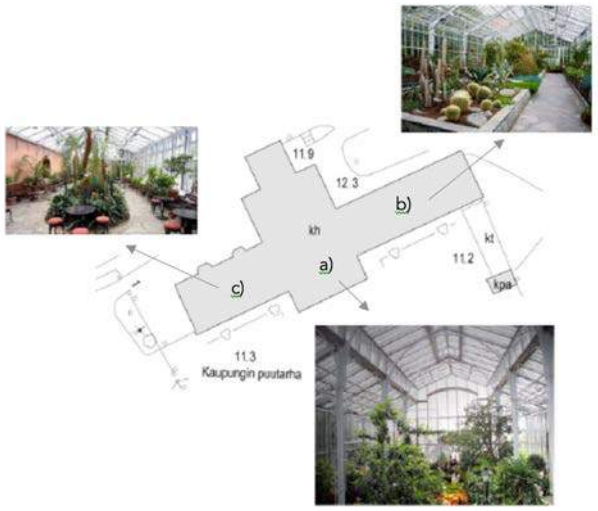

Figure 1: Helsinki Winter Garden floor plan and photos of its three rooms: a) The Palm Room, b) the Cactus Room and c) the Chatting Room

3.1 System Description

The Sonic Greenhouse implemented a sound diffusion system in two of the Winter Garden's three rooms. A 40-channel system was built in the Palm Room and another, independent system with 20 channels was built in the Cactus Room.

Two different types of audio transducers were used: 1) TEAX32C30-4/B structure-borne sound drivers attached on the building's glass walls and on custom-made suspended plexiglass panels, and 2) small cone loudspeakers enclosed in glass jars placed on the ground amidst the vegetation. Sound diffusion via structure-borne sound drivers was an aesthetic starting point for the entire piece. These drivers - or vibration speakers - enable to transform a rigid surface into a full-range speaker[2] with minimum visual impact. The driver and glass panel combination is acoustically ideal for creating a large-scale soundscape - oriented aural impressions. The panels act as flat panel dipole speakers, providing a larger and more dif-

[2] The measured frequency range of the TEAX32C30-4/B transducer is 70Hz - 14kHz.

fuse acoustic image than a more directive cone speaker. In this sense, diffuse sound emanating from glass panels creates an aesthetic unity: the sound source is not easily located, and perceptually it blends into the glass, its transparency and the surrounding landscape. The cone loudspeakers were designed to provide a spatial counterpoint to the wall and ceiling transducers, as well as to create a symbolic visual element - a speaker enclosed in glass replicates the greenhouse idea in miniature scale. In a sense the speaker jars work as a metaphor of the whole installation. The building is sounding through its glass and the speaker cones sounds are contained by the glass making the setting for an inner-outer sonic and visual interplay.

Figure 2: photos of transducer on glass panel and miniature speaker placed in a glass jar.

The audio transducer distribution in the space resulted from a compromise between the aim to produce a highly immersive sound field and the technical constraints of the building. Immersive diffusion of sounds from the ground, walls and ceiling was a priority in our design. However, the building's top layers of glass were not accessible from the inside with a scissor lift. Also, attaching panels amidst the vegetation was not feasible due to plant protection regulations. With these constraints, we designed a hybrid system of glass-panel mounted transducers, plexiglass panel speakers and loudspeaker jars, all characterised by visual transparency and a unified aesthetic design criteria.

3.2 Audience Feedback

The installation was open to the public for two weeks in September-October 2016 and it was well visited - the estimation of reached audience is 6000 persons. The Helsinki Winter Garden is a popular recreation place for locals as well as tourists, and many visitors did not come specifically for the installation, rather for the site itself. The site also has a strong clientele of people who visit regularly, even almost every day (such as elderly people living nearby). Audience reactions were overall positive, but varied strongly between the motives of the visitors. Some Winter Garden regulars felt that their beloved garden should not be altered in any way, some others were enthusiastic about the novelty and the added auditive dimension. The authors did not collect feedback in a systematic manner, but a guest book was available at the installation. A theme that arose from the guest book comments was the felt need for more explanatory material concerning the audio techniques involved which seemed too abstract for some visitors to appreciate. An intellectual counterpart to the piece's sensorial character could have been beneficial, such as written documentation, schemas and links to web media. We also conducted a final interview with the Winter Garden staff in order to have their impressions recorded. The staff's reactions were of particular importance for us, as they acted as project collaborators and they harbor a very intimate relationship both with the building and the plants that they take care of every day. The staff members were very enthusiastic about having a sound art premiere in the greenhouse, and they noted a revived interest in the site in some specific categories of audience such as elderly people, impaired persons and children. For the staff members, the sonic dimension created a novel dimension in a space they know very well, and they appreciated spending two full weeks discovering relationships between architecture, plants and sounds. By the end of the installation, it was agreed that two weeks was a correct duration – for a longer installation the sonic matter should be changed periodically in order not to become too redundant.

4. SOUND SPATIALISATION AND WEATHER DATA FEED

Two separate sound diffusion systems were implemented, one in the larger Palm Room and a second in the Cactus Room, due to the will to design two very different sonic atmospheres and spatialisation control systems. A common starting point for both systems was the determination to avoid any concept or technique of a sound field centered around a sweet spot. The Winter Garden's central areas are occupied by plants and there is no single central space available for audience. In addition, a typical visit to the Winter Garden involves walking from one room to the other, between plants, and a perceptual movement between large ensembles and tiny details. The sound spatialisation was designed from the following premises: moving audience, immersive soundscape allowing for perceptual zooming into details and out towards general impression, as well as a detailed, moving and lively general character.

Sonic Greenhouse stems from a collaboration between two composers of electronic music, each following a specific aesthetic agenda. In this setting, we chose to experiment with a set different and complementary approaches to sound spatialisation, ranging from the distribution of numerous multichannel sources up to the point of multichannel redistribution of a stereo source creating the multichannel perceptual sensation due to the extended

size of the space. Working in collaboration created a dialogue for testing a range of ideas on sound diffusion. While Moreno had a very strong preference for avoiding panning trajectories, Lähdeoja was intrigued by the perceptual effects of large-scale sonic trajectories in such complex multi-channel acoustic space. The following sections provides a detailed account of the different spatialisation techniques involved in the piece.

4.1 The Palm Room (Main Hall)

For the Winter Garden's main hall - or Palm Room, each composer created three compositional modules, combined within a generative Max MSP mixer diffusing the modules in random order.

The spatialisation strategies were:

- Single sound source trajectories generated with distance-based amplitude panning (DBAP)[9], combined with larger masses of more stationary sonic material as spatial counterpoint.

- Polyphonic envelope-based texture in which every sound comes from only one channel. The panning sensation is produced by having similar sonic content on different channels.

- Sonic "breathing" in and out of the space: a sonic gesture would be initiated from a single diffusion point and then gradually spread to all channels, or the inverse gradual "retreat" process.

- Random "hard-panning" distribution: a sound is randomly switched between all channels in a temporal sequence.

- Stereo source spread across multiple channels: Channel location and surfaces alter the perception of pitch and timbre.

- One sonic element in the center while the other element travels from channel to channel exciting different areas of the site one at a time.

4.2 The Cactus Room: Weather Data-Driven Granular Engine

For the Cactus Room, our aesthetical decision was to associate sound particle clouds diffused at hearing threshold levels with the dry acoustics and desert-like atmosphere of the space. A 19-channel instance of the [munger1~] MSP external [10] was used as the basic grain engine, completed with Moreno's design of a generative wavy process based on pre-synthesized grain streams that add a complimentary mid-range frequencies to the overall spectrum.

Both granular engines and their source audio material were controlled by real-time weather data retrieved from the openweather internet service[3]. Wind velocity, temperature, pressure, and humidity data were mapped both to macro-scale events such as sound selection and mixing and to microsound-level operations like grain density and spectrum.

The motivation for connecting the Cactus Room's internal "sound life" to the external weather conditions stemmed from the poetics of transparency and frontier of a greenhouse. Within the glass frame one can visually observe outside events, but has a very limited perceptual access to the elements. By connecting the outside conditions to the sound engine, we envisioned to find a way around the greenhouse's "boundary condition". As a result, we obtained a perpetually variating generative sound structure tightly related to the atmosphere inside as well as outside the room.

4.3 Audience Agency: First-Person Spatialisation

While a considerable attention was invested into the prior design of sound spatialisation, once the installation was open to the public it became clear that the foremost spatialisation strategy was not computational, but rather the individual human trajectories within the piece. Writing on his piece "We Have Never Been Disembodied" at the Mirrored Gardens, Guangzhou, China, Olafur Eliasson echoes precisely our findings on how Sonic Greenhouse came alive by the individual agencies of the visitors: "For 'We have never been disembodied', I was inspired by the idea of using this humble context, intended for plants and agriculture, as a platform where full responsibility is handed over to the visitor, enabling him or her to become an agent in the space that is Mirrored Gardens. It is a platform of potentials, taking the intimacy of the village to its extreme, allowing for micro-sequences when visitors move through the building, and making explicit the temporal dimension of life." [11]

Eliasson's work has been analysed by Adam Basanta and extended to the conceptualisation of form in audio-visual installations, where "the three Euclidian dimensions (length, width and height) are not only modulated by the fourth, topological dimension (time), but also by the fifth 'dimension' of perceiver subjectivity. [...][12] Following Eliasson, we can contemplate form as the particular temporal experience of the first-person subject as they navigate in, through and out of the work's frame. That is, form as the particular first-person narrativisation of experience in a given installation." [13]

Basanta's analysis corresponds to the experiential outcome of Sonic Greenhouse. In the design phase, we did not predict the importance that the audience agency would take in the final work. It turned out that not only spatialisation, but also the form and narrative of the piece were largely defined by the first-person trajectory within the space and between the rooms. In large spaces with numerous non-symmetrically placed sound sources, the audience becomes the primary spatialisation agent. This finding has important consequences for our future designs of large-scale audio works, as it challenges estab-

[3] https://openweathermap.org/api

lished ways of designing sonic spatialisation as well as form in audio art.

5. COMPOSITIONAL STRATEGIES

5.1 Considerations on Time and Spatiality - Composing Sonic Weather

"I was to move from structure to process, from music as an object having parts, to music without beginning, middle, or end, music as weather" - John Cage [14]

Music is often considered as a time-based art. Max Neuhaus proposed that musical creation is not about placing sounds in time but rather in space, the visitor being the agent who would enact the time dimension. [8]. Audio artists who are notorious for creating an alternative use of time in their sound works (La Monte Young, Phil Niblock, a. o.), usually rely heavily in using either long sustained sounds or loops. In this work we propose the creation of a more complex sonic environment that surpases the perception of sonic discourse as a narrative in time, getting closer to a "sonic weather" echoing the words of John Cage. When listening to this sonic weather time becomes a secondary dimension.

When articulating sonically a complex public space, one of the possible strategies to follow is to create different areas of sonic colour in which the sonic material is grouped and spread creating a unique experience for every visitor, seeking to foster a bodily dialogue between the visitor and the space. This approach requires a non-linear narrative. in "Sonic Greenhouse", an algorithm controlled the continuous crossfading between predefined sonic situations achieving greater level of sonic complexity while keeping a natural blend of elements. This continuously evolving sonic complexity was not overwhelming to the visitors perception but rather contributing to the feeling of being immersed in a sonic weather, an intense experience of the space surpassing the perception of temporal discourse.

For "Sonic Greenhouse" we built an array of active and passive sonic objects to use in order to work as aural architects [15] creating a sonic weather focusing more in placing sounds in space rather than in time. In that sense, our aim as composers was to approach aural architectural composition in an atmospheric manner, favoring peripheral perception and light gestalt [16]. The piece illuminated sonically the architecture with a combination of active and passive sonic objects. The active sonic objects were the sound emitting glasses of the windows, the plexiglass panels, and the speaker cones inside the glass pots; while the passive objects were the glass pots which filtered the sounds coming from the speaker cones, the plexiglass panels that created a more complex network of acoustic reflections and spatio-morphologies [17], and the reverberation of the room.

In order to blend our sonic layer with the preexisting sonic structures and regular daily activities of the space we took a combined approach using a combination of recorded instruments —metallophones, organ, piano, and banjo, field recordings, and synthetic sounds, carefully tuned for the space and tested through regular visits. By tuning the sounds and imitating behaviour of preexisting sonic elements —like the wind in the surroundings or the water inside which were used as ghost electronics [18]— and by echoing the local weather conditions we created an organic soundscape that would create a continuity sensation avoiding to create any kind a sonic shock when entering or leaving the space.

5.2 A Note on Sonic Acupuncture

A possible definition of acupuncture can be: a local action by means of a pressure point on a key spot that has the power to change the situation globally, beyond the local area in which the pressure point is applied. Therefore, sonic acupuncture relies in applying sonic pressure points on key spots affecting the global sonic situation. These sonic pressure points can consist either on active acoustic objects, passive acoustic objects, or a combination of both. Urban Sonic Acupuncture parallels the practice of Urban and Public Space Acupuncture [19] in the Aural architecture field. Aural architecture deals with spatial and cultural acoustics, it also assigns four basic functions of sound in space: social, navigational, aesthetic and musical spatiality [15]. Artistic sonic interventions are placed along this axis by starting a negotiation between artistic intentions and the local knowledge and practices. "Sonic Greenhouse" proposed an early attempt of sonic acupuncture by means of glass speaker-pots placed in the central area of the Palm room. In some sections, these devices were emitting slowly sweeping frequencies sine waves[4] generated algorithmically altering the perception of the sonic weather at that given moment, also driving attention to the lower layers of the space and to specific plants in the area.

6. CONCLUSIONS

In this article we have discussed a recent large-scale audio-architectural installation from three points of view, namely system design, sound spatialisation and external data feed, as well as compositional strategies. The work was thought as a research process for a multichannel structure-borne sound system mounted directly on a building's structure, combined with specific aesthetic aims related to the Helsinki Winter Garden greenhouse. The results confirm a proof of concept: structure-borne sound drivers are an effective a meaningful way to sonify a large architectural space, presenting perceptual advantages in comparison to traditional cone speakers, such as radiation patterns and non-invasive appearance. Moreover, the results point towards a reformulation of concepts in sound spatialisation and form composition for

[4] Alvin Lucier - *"music for piano with slow sweep pure wave oscillators"* (1992). *"PIANOSCULPTURE for Mario Prisuelos"* (2016) is a piano and tape piece by Moreno based on the same principle.

large-scale works where the audience becomes an active agent in the space. Temporal and spatial elements unfold according to an individual exploration, which counter narrative designs thought for stationary audiences. Alternative compositional strategies were implemented, such as composing a Sonic Weather evolving in space rather than in narrative time, as well as Sonic Acupuncture meaning small-scale punctual sonic interventions in precise locations.

Figure 3: General view of the Palm Room, where 40 channels of sound diffusion were implemented.

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