An Exploration of the Relationship Between Touch and Sound

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A thesis submitted to the University of Huddersfield for the award of MA by Research

April 2016 (Amended September 2016)

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The University of Huddersfield

April 2016

Table of Contents

Abstract

This thesis serves as a written accompaniment for an interactive installation art project. In addition to a detailed description and evaluation of the other components of the project, it also features a number of abstract discussions on pertinent topics, and describes how the outcomes of these lines of research informed the final iteration of the installation.

The project is a sonic art installation that explores several concepts, uniting them to create an audience experience that is intended to be both novel and accessible. It deals with the experience of physical space and structure, and how it can be complemented sonically, emphasising and reimagining the structure with sound. The structure and generated sound are intrinsically linked, and this relationship is exploited to transform the perception of space for artistic effect. The installation also places heavy emphasis on collective interaction. All audience members experience the same sound (albeit from a different position and perspective), so their interactions all affect each other. The installation was designed to optimise this paradigm of interaction, and it is a point of interest to observe what happens in this regard. Complementary to the exploration of physical structure and space is experimentation with physical materials and how they can be expressed sonically. Since all of the sound in the piece has its foundation in sounds recorded by contact microphones attached to the materials that make up the structure, a relationship of some form is inherent, and further expression can be established by manipulating and transforming the sound.

Introduction

The initial form of this project was an attempt to explore the relationship between the senses of touch and sound, from an artistic perspective, through the medium of interactive installation art. Exactly what form it would take was uncertain, but preliminary ideas mostly consisted of recording tactile sound with contact microphones and using the differences between materials to generate varied sonic output. While this concept was maintained to some extent throughout the course of developing the installation, other elements emerged as equally or more important from an aesthetic perspective, and the role of materials' sonic identity was diminished in the actual final installation itself. In its final form, the installation was focused on creating a scheme of interaction between participants and a 'sound entity' through the medium of touchable surfaces, and also on the creation of compelling sonic material in real time using sound from the participants' interactions.

A more detailed system overview will be provided later in this document, but the essence of the installation is a structured space composed of ten columns with their interior faces covered with a variety of materials in a variety of arrangements. Each column has a contact microphone attached to the inside of the decorated face. Sounds recorded from user interactions with these sensors are used to populate a database of grains that form the basis of a granular synthesis engine. Parameters for this engine (which involves some other processing too) are controlled by the same user interactions. The result is a sort of dialogue between a collective audience and the system itself.

The function of this document is to detail the development process that led to the final iteration of the system, the research and experimentation that informed some of the aesthetic choices made, and how the actual run with a public audience went. There will be no quantitive data, but some localised conclusions will be formed in a reflective chapter. Overall, the exhibition of the installation is the main component of this project, and this document serves as

a contextualisation of it. In addition, there is a short video featuring some footage of interactions with the installation during its exhibition period.

The Relationship Between Touch and Sound

The concept of a relationship between tactile sensation and sound was the initial foundation of this project. The desire was not to come to any conclusions about a formalised link between the senses, but to explore them in the same artistic context and find an aesthetically interesting way to present the two as part of the same piece. Of course, similarities in human methods of perception for both senses informed the piece; presenting sound in a form understandable similar to tactile sensation formed the core of the interaction paradigm. This is related to the psychological phenomenon of synaesthesia (De Cordoba 2014), in the intent to link two stimuli (touch and sound) in such a way that they stimulate each other in the mind of the audience.

On a physical level, tactile sensation and auditory perception are not that different. They both come as a result of pressure/vibration of physical material; the difference in mechanism is that while sound generally refers to the modulation of air pressure (although transmission is possible in solids and liquids too), the notion of touch deals specifically with pressure or friction on the skin. Indeed, there is considerable overlap between the frequency ranges of the skin and ears, and vibrotactile cues can even be helpful to the auditory system for tasks such as localisation (Deas 2011). Different sensations of touch caused by different materials are perceived through the patterns of vibration in the skin the friction causes, and the quality of the sounds they produce are a result of not only the physical properties of materials such as roughness and density (Hart 2011), but also how they are interacted with. Surfaces can be understood by touching them and observing how they feel; they can be different levels of rough or smooth, with different arrangements of friction zones on the surface. In addition to the nature of the material itself, the interaction a person has with a surface is a highly variable system (Eitan 2011). The hands are the most obvious way to touch an object or surface; clearly it is possible to achieve tactile sensation with any part of the skin, but the act of touching something is generally achieved with the hands. Using the hands, the notion of ‘gesture’ becomes important when considering

interactions between people and materials. A surface can be tapped, scraped, rubbed and so on; the palm of the hand can be used, or the fingers, or just a single fingertip – even fingernails might be incorporated into this interaction.

This notion of a tactile gesture is something that informed the development of the installation to a considerable extent, dictating several elements of it throughout the course of development. It was not initially clear how gestural content should be incorporated into the system, and numerous attempts were made to assimilate this idea before one really felt successful. The first way it was used was an attempt at what might be considered a crude form of gesture recognition: tracking user interactions in space, across the surface of the structure (initially it was intended to be one large, continuous dome or wall). This was accomplished by tracking and comparing activation levels of contact microphones across the surface, using them to create a sort of heat map corresponding with roughly where users were, and introducing a temporal dimension to this data allowed for motion to be understood. It worked to a certain extent, and was not particularly complicated to implement. However, the issue was simply with a lack of useful data produced by this system. Initially, it might seem that understanding the motion of participants might be useful, but in the context of the installation, it didn't turn out to be particularly meaningful. The reasons for this are twofold: firstly, precision of spatialisation was not a priority for this piece: even with 3rd order ambisonics (the maximum allowed on eight speakers), there is a problem with a sweet spot (Hollerweger 2008), outside of which the ability for participants to localise sources deteriorates. Since the audience is encouraged to move around the circumference of the circle, they spend most of their time outside the sweet spot, and extremely precise tracking is rendered mostly useless since anything it can be mapped to cannot be perceived most of the time. Secondly, there was simply nothing interesting enough to map the parameters of interaction to. To go into a little more depth on the latter point: the obvious thing to map input motion to is spatialisation of output sound, moving sounds to the locations of participants. However, this turned out to be far too direct to be aesthetically interesting; bringing sounds towards points of interaction made the experience feel too much like "playing an instrument", which was

not the intended outcome at all. This early idea of input gesture tracking was largely discarded, but conceptual elements of it did return in the final version: audio sources (‘orbs’ in the code) maintain some characteristics over periods of time between user interactions, and they do follow participants in space, albeit less directly (i.e. a single source does not follow a particular participant over a period of time, which would be impossible with the final structure of columns anyway).

As a side note, it is important to distinguish between the interaction between a person and this interaction as recorded by a contact microphone. The person hears the vibrations caused by the touch through air, emanating from the point of impact. The microphone, on the other hand, experiences the vibrations through a solid material. In addition, the microphone as a system does itself impact the sound to some extent, and the development of this project was initially plagued by the distinctive shaping it performs on any sound; there were issues with all materials sounding too similar when recorded by contact microphone. Specifically, untreated contact microphone recordings largely have a characteristic sound – the sounds that can be heard are very raw and ‘close’; the nature of the interaction has a greater effect on the sounding result than the physical material. However, the information differentiating materials certainly is there, and it is really the lack of room tone or reverberation in the recordings that give them their distinctive sound. This idea actually led to an interesting system of convolution that not only circumvents the issue of similar sounding sources, but also uses the dryness of the signal to create hyperreal sound spaces. This system will be covered in more detail in the system description chapter. The point of this paragraph is simply that contact microphones as sensors are not identical to biological receptors, and this perhaps contributes to the unsuitability of a scheme for tactile interaction similar to playing an instrument, as the sound recorded might not even closely match what the participant feels anyway.

As such, the installation was designed around the tenet of ensuring each column was not to be treated as an instrument. This had to be approached from a psychological perspective. People have a natural tendency to perform

‘source bonding’ on sounds – automatically associating them with objects and events, and with other sounds (Smalley 1997). The system was designed with this in mind, and the intent to guide the source bonding somewhat, so that the output sounds were bonded with the materials on the columns, but not so strongly that participants see each column as an individual, distinct object, rather than a component in a larger interface.

Apart from spatial gesture recognition, attempts were also made to understand the nature of the tactile gesture itself; i.e. scraping versus tapping, for example. Descriptor analysis was the chosen method for this, and a fairly long time was spent trying to find features that would allow different tactile gestures to be easily discerned between. There was reasonable success here – features such as spectral flatness and logarithmic centroid did help in categorising sounds based on their perceived roughness and resonant qualities; success was also found using the standard deviation of the RMS level of recorded grains. This makes sense when considering the physical nature of a series of transient touches against longer, sustained touches such as scraping – the level of the sustained touches will be more consistent and therefore has a lower standard deviation. The question then is what to do with these categorised grains. CataRT was an inspiration here – a concatenative synthesis engine that uses real time navigation of a descriptor space of grains (Schwarz 2008). In installation form, Diemo Schwarz’s *dirti installation at nime* (2014) exemplifies some of the creative possibilities of this technology, creating an instrument interface out of tapioca grains, using them to create gestures that control an audiovisual system. Similarly, the Mogees project centres around the idea of gesture recognition with contact microphones, and using the recognised gestures to match an appropriate sound source from a corpus (Zamborlin 2012). This idea was adapted to the context of an interactive installation with audio as input by analysing input grains, and selecting output grains most related to them. Unfortunately, this turned out to be less aesthetically pleasing than envisioned, and more or less sounded like simple playback, so it was abandoned. The idea of discerning between different tactile gestures did stay in a more simple form, however – the lengths

of input segments are used to decide how long output ‘gestures’ are (this is a different concept that will be described in more detail later).

In the final version of the installation, grains are selected randomly, periodically, from a set of the 100 most recent audience touch recordings. Perhaps surprisingly, this presented a significant aesthetic improvement over more deliberate choices of grains. This can be understood by considering that selecting grains at random allows the installation to be treated as one large composite interface for interacting with the sound, rather than each column being an instrument. There is perhaps what could be seen as a disadvantage in a less easily understood response to each interaction, as the sound that comes out is less directly related to the sound that goes in, but the overall experience is more compelling as a result, if the audience is able to come to an effective way of interacting with the installation. This is not to say that the materials and the sound generated are not related; the relationship is simply more complex. A strong link between the physical materials and the output sound was intentionally kept in the system to the end, as it was a founding notion of the project that touch and sound could be used to enhance each other. Research from a psychological perspective has found direct links that the use of sound can enhance and alter the perception of touch (Ro 2009), typically suggesting that although sound does not cause touch events to have their perceived duration or number of events increased, it can change the perceived nature of the touch, perhaps understandable as its ‘timbre’ (Tsai 2013). In particular, Suzuki (2008) found that auditory stimuli could alter the perceived roughness of a surface for a person. Suzuki found that ‘complex sounds selectively affected tactile roughness perception, even when they were seemingly irrelevant to the exploration of the surfaces’ (2008). This is immediately applicable in an artistic context such as this one, and informed the selection of parameters that define the vast temporal dimension: the long-term changes between different levels of ‘rough’ and ‘smooth’.. This certainly did seem to have an effect on user interaction cohesive to Suzuki’s conclusions: drastic changes in the ways participants touched the columns were observed between different segments of output sound. They generally seemed to be gentler with the surfaces during ‘smoother’ sections of sound,

and had more vigorous, scraping ‘conversations’ with them during the ‘rough’ segments.

The final development of this concept of tactile gesture became the foundation for much of the ideas constituting the paradigm of interaction implemented in this installation, and this was the idea that mirroring properties of tactile gestures in sound might be sonically interesting. To elaborate, what this means is simply that many of the sounds were designed to sound “touch-like”, and moreover that they were presented in a way reminiscent of how people investigate the touchable properties of surfaces. That is to say that the output sounds mimic the gestural nature of the input in general, but come from a process of third-order surrogacy (Smalley 1997) – the output sounds have unfamiliar qualities despite there being an inferred cause. The extrapolated version of this is that output sound in this installation was presented in such a way that it seemed somewhat like tactile interaction, and that these ‘gestures’ were used to create an environment in which participants and installation ‘communicate’ with each other, almost in a sort of dialogue; tactile-esque sonic gestures are the way in which the system expresses itself, and it is possible for audience and system to have a sort of abstract conversation. This intended ‘conversational’ scheme of interaction is in contrast with a notion of musical play. Of course, it is possible to consider the installation as a musical instrument in a distant and abstract sense – users ‘perform’ with a system to create sounds. However, the distinguishing factors are twofold: firstly, the responses are fairly unpredictable from the audience’s perspective; secondly, the audience and the installation are supposed to interact as equals, in contrast to the hierarchy that having a performer and an instrument implies (the performer in control of the instrument).

Sound and Space/Structure

The idea of harnessing and exploiting a relationship between sound and space was the second integral element of the installation; it seemed like an interesting compliment to the touch/sound link. It became obvious fairly early on in the conception of this project that it would take the form of a structure of some description that participants are supposed to interact with from the inside. This allows the sound to take a physical shape, which is naturally complimentary to idea of tactile gestures; these are much more powerful when coupled with a panning movement of some sort. In addition to the simple emphasis of gestures, using space as an integral part of the installation allows the sound to 'focus' on individual participants or groups of participants, heightening the sense of an interaction between audience and system. Using space in this way is what allowed for the rigid association between input sound and output sound to be broken, allowing for a more fluid and less 'instrumental' paradigm of interaction.

Even the simple act of playing a sound in a space transforms it (Born 2013, p. 74), and it can become infinitely more complex an interaction than this. Different sounds can obviously have different effects on different spaces, and the extension of this is that sound can be designed for a specific space, to transform it in a specific way. This act of transposition (i.e. transforming one space into another) can be used as part of another process, parameterised for control and harnessed as part of an installation, allowing continuous transformation. Of course, this can also be considered a mutual transformation: the physical space obviously shapes any sound played back in it too, and combining this with the perceptual transformation the sound affects on the space can bring forth a reflexive process which could be considered a dialogue between sound and space. Since in this installation, audience tactile sensation and sonic output material have a similar conversational relationship, the influence of space can be integrated into this interaction for a highly fluid and responsive sound world.

For the purposes of this installation, the notion of physical ‘structure’ was considered to be defined as some way of organising space. The obvious way of doing this is to incorporate physical objects into an area, using their arrangement to create structure. This form of structure is implemented in this installation as the baseline upon which the rest of the structure is built. A circle of ten columns with their interior faces decorated creates a container for the sound and a limiting circumference for audience interactions, along with giving the interface a tangible presence. This arrangement was inspired by other art works such as Jaume Plensa’s *Jerusalem* (2011) – essentially a circle of large gongs, which participants interact with from the interior. The important part of Plensa’s installation is not only to do with the objects themselves, however, but also with how the space is transformed by sounds which have their root in tactile interactions between the audience and installation. This aesthetic of an immersive environment founded in physical objects and transformed by sonic textures is the basis of the intended spatial representation and transformation scheme implemented in this installation.

Other artists have worked with the idea of transforming space using different media. Ryoji Ikeda, with his large scale *spectra* installation works, transforms space using white light as a sculptural material. In particular, his *spectra [for Terminal 5, JFK]* (2004) is of interest. It involves using very bright light to make the dimensions of the space (a tunnel) fairly indiscernible. Sound is also employed here – constant sub bass allows the participant to understand the space only through moving through it, as the oscillations in their ears caused by their movement provide sound cues. Of course, this is just a straight tunnel, but it is perceived with completely different dimensions to its true nature through the intervention of sound and light. It is interesting in the context of this work in the way it transposes space, and depends on the space to create the desired effect. An example of a similar sort of transformation is Carsten Nicolai’s *alpha pulse* (2014), in which entire buildings on the Hong Kong skyline were illuminated as part of an installation piece. However, this transformation was interactive – audience interactions with a mobile app controlled the nature of the illumination, and thus allowing user-driven transformation of the environment. Tristan Perich’s *Microtonal Wall* (2011) is a

more linear transformation of space, creating structure with sound. He covered a wall in 1,500 speakers playing a simple sound at different frequencies. What was a wall with no evolution, moving over its physical dimensions, is transformed into something that changes as a listener walks by it. This partially inspired the implementation of a dynamic soundstage in this work – more than simply walking through a space for it to change, but changing over time too. The intent was to take this linear transformation of space with sound and extend it over time.

It was clear from the beginning that this installation should transform space in some way with sound, but it took several months of development before an appropriate paradigm was found. Initial solutions involved very direct processes such as simply increasing the perceived size and shape of the space using sound, and mapping these parameters to an element of the input; specifically, the earliest version simply attempted to make sounds appear further away depending on how many sensors were activated at once, making the perceived structure of the space smaller when more people were interacting with it. This was an interesting effect, but it evolved into something less direct and better integrated with the nature of the interaction between audience and structure.

The direction this went in was an attempt to integrate the morphing sonic structure with the ‘personality’ of the sound. In fact, in the final installation, the shape of the space is dictated by the dialogue-esque interaction between system and audience, and the spatial shape could be considered the edge of the sound entity. As this has much to do with audience participation, this will be elucidated in more detail in the chapter about interaction that follows this one, as although the principle is quite simple; the variety of ways in which it can be executed depends on the interaction more than anything else. However, the essence of it is that the space is somewhat defined by the ‘shape’ of the sound in the circle, i.e. how it is distributed across the speakers. This shape is determined by the distribution of participants as they touch the columns, but in addition, the participants moving to ‘converse’ with the sound results in a reflexive spatial transformation process.

Paradigms of Interaction in Installation Art

Central to the design of this installation was the decision of exactly how participants should interact with it, not only in the sense of what the interface should be like, but also more general concerns. For example: how strongly guided should the participants be? And how will they interact as groups? The interaction is the core of this work; although the focal points are the relationship between touch and sound, and the way sound can be used to transform space, these two elements are dictated largely by the nature of the interaction. The way audiences interact with art depends on a lot of things, but largely, the desired interaction paradigm can be achieved through design (Farkhatdinov 2014). However, when allowing participants significant freedom in how they choose to approach the installation, the way in which the interaction is design changes. In concrete terms, because users were not told to perform specific actions in specific orders, several things became less fixed: the way they interact together and the way they respond to feedback, for example. To elaborate: when a participant interacts with a column and hears a sound, they might stay at the column and try to continue that line of interaction, but they also might feel compelled to move to another point, or another user's interaction might affect them and cause them to do something else. A constructivist view (Fosnot 1996) was taken on this: the dialogue between participants and installation was allowed to develop over time by the audience assimilating the experiences and using them to shape their future interactions. This interaction is two-way, since the sound produced by the system also largely consists of sounds provided by the users, and develops over time as a result of them. The paradigm of interaction was designed such that individuals could have their interaction guided by the installation as they assimilated experiences, and that the output installation is constructed from the interactions of the participants as a whole, but also on individual levels. The end result should be gestalt, drawing all of the interactions together, but still having semblances of being constructed from them.

This system drew inspiration from other installation art pieces, such as two visual-oriented works exhibited as part of *Right Here Right Now* at The Lowry, late 2015: Daniel Rozin's *Darwinian Straw Mirror* and *Snow Fall* by Fuse* collective. Both of these were quite similar in appearance: the former essentially tracked the outlines of audience members and redrew them on a projector screen with sticks, and the latter tracked the outlines of participants and used them to obstruct digital snowflakes on a projector screen. Despite their visual similarities, they actually exhibited quite different forms of interaction. *Darwinian Straw Mirror* was interesting in that it displayed roughly what was stood in front of it, simply in a different 'style', which contrasts with *Snow Fall*, which was more about other elements on the screen and provided a method for them to be controlled. What they did have in common was that the interactive element was not particularly explicit; audiences were presented with visual components, and audiences' interactions developed with it as they assimilated the new experiences into their understanding of the installations. When the snow falling was blocked by their body, they moved into different positions to try to find interesting ways to alter the visuals; when they realised that the straws made up their silhouettes, they moved in order to make the visuals move. This sort of interaction was what was intended for this installation: the audience should find ways to interact with the sound, with little in the way of instructions. The design was made so participants would find their own ways to interact with the sound, through experimentation and informed by the feedback the system gave them. There is perhaps a dichotomy to be found between paradigms of interaction that encourage a user to operate a 'controller', and paradigms that consist of a fluid state of interaction, where the participant controls the feedback through their interaction, but it is indirect (Miranda 2008). The latter was deemed desirable for this piece.

Extending from this, there is the matter of how directly comprehensible the feedback of the system is in terms of the input. In other words: how obvious is it that a specific user interaction creates a response? Is it possible to reproduce particular responses from the system by recreating the input that caused them to happen? How are the input and output related and to what

extent can the audience tell? This is a complicated set of parameters to consider when designing an interactive installation art piece, and the process happened over several months of experimentation. What became clear fairly rapidly was that a certain amount of opaqueness in the mapping of input to output was interesting, but an excess of vagueness rendered the entire piece meaningless. In concrete terms, having the system respond immediately and consistently with sound related to what was just touched was less interesting than when the system was set up with a higher level of randomness, producing a definite response when user interaction was detected, but not one that was consistent or reproducible. In the case of this installation, this meant choosing grain sources at random rather than selecting ones similar to the input that was detected. It meant that several touches in the same place in a row did not always attract the same sound source (described later). Overall, this decision informed a trajectory of design that led towards a system that was optimised for ‘conversation’. Clearly this is not real conversation, as the system does not have the sort of intelligence to allow it to decode language, nor do its responses have elemental consistency. However, it does certainly feature a capability for abstract interaction that *sounds* like a conversation.

In terms of mapping, the vagueness occurs in the way input gestures are mapped to output gestures. Specifically, some parameters from the input gesture are used to inform the output, such as the length of time the interaction takes, which controls the envelope of the output gesture. However, other parts of the output gesture are independent of the input, such as which grain sources are actually selected. This was not only important in making the installation less instrumental, but also in accommodating multiple participants at once in the right paradigm of interaction: simply put, setting the system up like this allowed an interaction where n participants interact with 1 system, rather than n participants interacting with n systems.

Simply thinking about how a single participant might interact with an installation art piece is not enough, however, when the work is designed to accommodate several people at once. This is fairly understandable when considering that, for an interactive piece, what is observed is shaped by the

audience, and each audience member experiences the same thing (with the caveat of perspective). Therefore each audience member obviously affects the nature of the interaction between every other audience member and the installation. Audience members are also affected by each other in more obvious practical ways, e.g. it is difficult for two people to be in the same place and therefore interacting with the same column. The result of this is that all participants are interacting with each other as well as the installation, and also that their collective interaction should be considered as well as each individual's participation. It is important to consider how audience members might affect each other in the context of the installation when designing both the interface and the feedback.

There are multiple ways that audiences can interact collectively with installation art. They might attempt to play it like an instrument, improvising with each other. This process is made convoluted by the nature of the installation: instead of allowing individuals to use the system as a tool with which they express themselves, the system is supposed to mediate participants' interactions with each other in this use case. Audiences might emerge where a single person or small number of people interact with the installation while the rest observe (Kwasek 2013, p. 95). Because the installation is designed to handle several (up to 5) different inputs discretely at once, situations could emerge where each person is communicating with the system in a largely autonomous way. However, it is also designed in a way such that global parameters are always affected by any audience interaction, so there it is never possible for a participant to completely isolate themselves from the others.

System Description

What follows is a brief overview of the system, including its physical components and software, and the overarching design decisions that led to its implementation, as well as describing some of the earlier iterations of different elements of the system. Deep technical detail will mostly be avoided, but the max patch is included as part of the submission anyway.

The exhibition happened in a public space (University of Huddersfield Student Central) for the entire day on Thursday 14th and Friday 15th April 2016. Basic instructions were provided (touch the columns!), but participants were largely left to figure out interaction by themselves, though several people with a reasonable understanding of the system (early testers) were generally present, so fresh participants could imitate them.

Physical Components

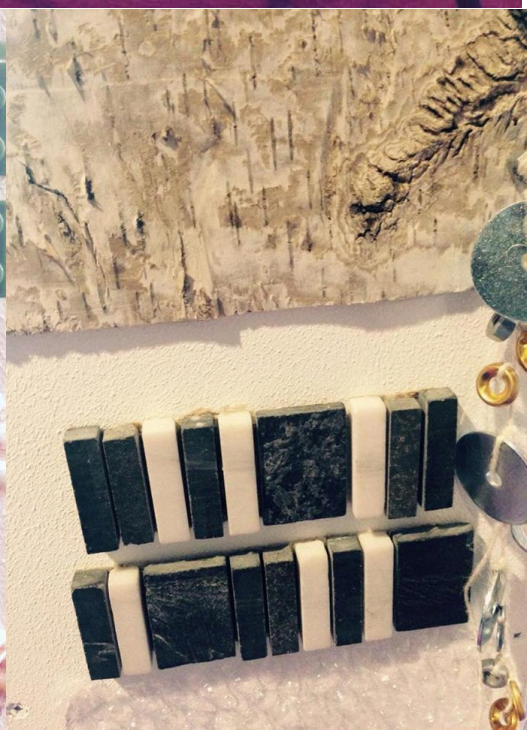
The structure of the installation consisted of a set of ten wooden columns of dimensions 120x20x20cm, constructed from MDF wood and painted with rough white masonry paint (incidentally quite an interesting texture on its own!). The columns were arranged in a rough circle, approximately five metres in diameter; they were not uniformly spaced around the circumference of the circle, instead they were arranged in two groups of five, with an opening down the middle on either side. The inwards-facing side of each column was decorated with various materials, such as bark, corrugated PVC, tiles, bamboo, artificial grass, lego and shells. In addition to the static decoration, several columns featured moving parts, in order to create a more varied tactile palette, consisting of different types of wooden and metal beads (actually nuts and washers in the metal case), and ‘chainmail’ made from metal chains.

A visual artist friend, Lucy Clayton, was heavily involved in the choice of materials and design of the decorated faces of the columns. Choices of materials was dictated largely by the desire for a large tactile palette, but

naturally had to be visually appealing and thematically coherent. To this end, a theme of natural/artificial was chosen; there is some intentional crossover, but five columns consisted of largely natural themed materials and the other five utilised mainly manmade objects. The central column on the natural side was covered in bark alone, and the central one on the artificial side was covered only in corrugated plastic. The columns between them gradually blended between the themes.

Inside each column was a contact microphone, attached to the back of the decorated surface, roughly in the centre. The exact microphones themselves varied – some of them were home made from piezoelectric plates and jack leads, and others were commercially available ones. Of the home made microphones, different size piezo plates were also used. The intent of this was to improve the diversity of the sound recorded, since one of the most significant issues during development was the defined sound of the contact microphone overpowering other elements. The diversity in physical microphones was only a small component of the main solution, which is software based.

The circle of columns was surrounded by an outer circle of eight speakers. These were uniformly spaced, and were approximately 50cm away from the columns. Eight speakers were used instead of ten primarily because my testing environment had speakers in rings of eight. Although changing this for the live exhibition might not have been a significant leap, as the HOA system in use allows for easy scaling, I actually felt that this would have been conceptually unfitting. One speaker per column might have made the installation feel more like a set of ten instruments, and I wanted to avoid that.



Software

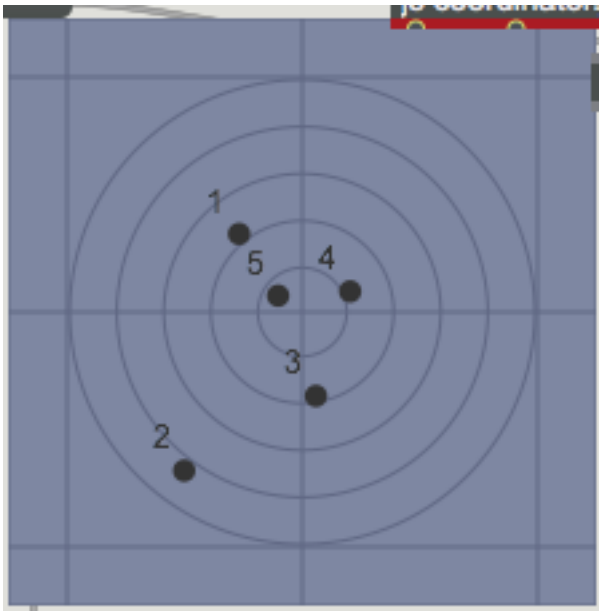
The software system that controls this installation was built in Max 7, using a few external objects:

- Alex Harker's externals for voice management (also descriptors~ when it was being used)
- High Order Ambisonics library (HoaLib) for spatialisation, and also c.convolve~
    - My choice of HOA instead of point source multichannel was primarily because I'd used HoaLib before, it integrated well with my patch and did everything I wanted; it was mostly a workflow decision rather than a technical one.
- Olivier Pasquet's op.buffercopy

In addition, some audio units are in use:

- Michael Norris' Soundmagic Spectral processing plugins (freely available)
- Fabfilter Saturn (commercial saturator plugin)

The core of the system is a set of five sources (referred to as 'orbs' in some of the code). Sources 1-3 are granular synthesisers, and 4-5 are two different spectral processing buses. Each of these can be moved separately in 2D space, using hoa.map.



A javascript object, coordinator.js, controls the trajectories of the five sources. The default behaviour for each of these sources is to wander in the central region of the 2D space, in order to create a sense that the environment is not static, without undermining the larger movements that occur when an actual event happens.

All ten input microphones are being monitored simultaneously, recording to temporary buffers until something happens. Each input has an independent set of thresholds, and when the upper threshold of an input is reached, an event is considered as ‘happening’ until the average level drops back below the lower threshold. At this point, two things happen: the sound event that just happened is stored in a global database for later use, and the system is told to make some sounds happen.

The global database stores up to 100 events; when this number is reached, the marker returns to the beginning and starts overwriting the earlier events. Each of the three granular synthesiser sources use one buffer at a time, selected at random from the database. Earlier iterations of the system used descriptor analysis to select past events that were similar to the current event, but the result of this was too ‘instrument-like’; a random selection allows the system to have a longer-term relevance with its responses. There is an

advantage to more careful grain selection in that more a coherent conversation could be constructed; that is to say that the system can reply more precisely to inputs if it understands the grains in the database better. In practice though, this didn't really happen, largely due to input touch events being too similar.

Each granular synthesis source also has two convolution paths in it. A set of impulse responses for convolution is loaded at initialisation, and a new one is selected for randomly for a random source periodically. The two separate convolution objects allow for smooth interpolation when a new response is selected. The use of convolution was the important step that brought the sound world into an acceptable level of quality; previously, there was not enough variety of sounds, and the granular synthesis sources largely sounded the same, but convolution brings out the differences between tactile events. During the development of this project, it became clear that as primary sound sources, contact microphones are somewhat lacking, but when used for 'gestural' information and combined with other sounds and parameterised well, they can be compelling. The balance between convolved and raw sound for each grain source varies over time, and is a significant force behind the long temporal evolution of the soundscape. The impulse responses used for convolution are a mixture of recordings from a variety of sources – percussive sounds such as drums, harmonic textures and instruments, and 'foley' sounds. No particular methodology was used here, a lot of IRs were simply tested and some aesthetically pleasing ones were chosen. The IRs themselves do not correspond to anything in the physical installation or anything conceptual – they simply had to be varied to allow a mixture of responses to be possible.

When an event happens, one of the five sources is selected at random and paired with the column that originated the event. The source is locked to the column, so that neither of them can be paired with any other for a few seconds, and moved towards it. While this movement is happening, an amplitude envelope is followed for the source, the length of which is related to the length of the triggering event. The other major action that happens at this

point is the modulation of a *global* grain length parameter. This results in a ‘talking’ effect for the system as a whole. There was an attempt to modulate grain size for each source individually, but the global method turned out to be more aesthetically pleasing.

On top of the interaction driven events, long-term temporal events occur occasionally. This was an important design decision made quite early on: the installation should change sonically over a very long period of time – minutes and hours. Such a time scale was conceptually desirable for this work firstly because it allows for more variety in the ‘dialogue’ between audience and system, in a way that didn’t seem random (because sudden variation in output in the middle of a ‘conversation’ might interrupt the interaction). Additionally, because the interaction worked in two directions (i.e. the users were influenced by what sounds are output), varying the output over such a long period of time allowed for different input experiences to happen without it feeling like different scenarios were simply being presented one after another. This was achieved by changing the convolution impulse responses for a random grain group periodically, in addition to the long-term shift created by the limited size of the database. The levels of the grain sources that are sent to the spectral processing sources also vary over time, depending on the overall level of recent activity. They decay over time, so a lot of interaction in a short period of time will cause the soundscape to become more textural for a while, until a period of quietness occurs.

Conclusion

The primary outcome of this project was an installation art piece; there was never any intent to come to any formalised conclusions about sound and touch, sound and space or audience interactions. Rather, the project was an exploration of these areas and how they can be harnessed and manipulated to create compelling artwork. So in this regard, the project was largely successful. Participants seemed to interact with the system roughly as intended, and I received plenty of positive feedback; people seemed genuinely interested and entertained. This isn't to say that the entire event was perfect, or even that the interaction went exactly as planned. There were some participants who clearly viewed the installation as an instrument, and tried to interact with it by repeating gestures in an attempt to replicate results (of course, this did not happen, by design). Largely, they fell into a pattern of trying something, waiting for a response from the installation and then 'replying' to that by touch, which is exactly what I desired. Sometimes it took a while to reach this stage, and admittedly, I found myself guiding participants somewhat, especially in the beginning. Perhaps it might have been sensible to include some written instructions somewhere; not doing this was a conscious decision, because I was interested in how the audience would approach it by default, but in hindsight I think a small amount of fixed guidance would have helped.

In terms of the interaction, I had a number of positive responses from participants who felt that it certainly did feel like conversation, and had some interesting descriptions such as "talking to a sound monster". Personally though, I do feel that the interactions could certainly benefit from a little more consistency. It was intentional that the sonic responses from the system were somewhat unpredictable, and I do tend to favour allowing chance to dictate much of my work in general. Having said that, there were some times that people touched a surface and seemingly nothing happened. This is likely a result of a combination of things, but an improvement on the event detection system might have been enough to balance this out; examining the buffers in

the grain database during the event revealed fairly long stretches of silence or extremely quiet sound in some recordings.

Aside from this, there were a significant number of technical issues. The major one was caused by using a different interface for the exhibition than what I used for testing. The latter had preamps, but the one I had access to for the exhibition did not, so all of the settings for event detection (thresholds) needed to be reconfigured. The result of this was that the responsiveness of certain columns was somewhat worse than intended, and it took refinement throughout the first day to find settings that worked. I certainly won't be running an exhibition again without testing all of the gear, but fear of something like this happening was part of the reason I booked the space for two days anyway. Testing was also an issue in general, given the lack of portability of the installation and equipment. For future works, I would prefer to have a dedicated studio space to set up and test – perhaps such technical issues could be avoided with a better testing scheme.

In terms of how this piece fits in with my artistic trajectory, originally I had planned this to be the culmination a few years of experimentation with granular synthesis and tactile interaction, an ending to what had previously been disjointed experiments. However, I found that there are actually several directions I would be interested in continuing, and I have ideas for how the piece itself could be developed.

Firstly, I would be interested in producing variants of this installation, perhaps with the same setup in a different venue, but maybe instead with a different structure. Originally, I had planned the structure to be a large dome, with a touchable ceiling, or a continuous wall surrounding the space. I did actually abandon these designs for practical reasons (ease of construction and transportation), and eventually came to prefer the columns anyway. However, a more enclosed structure would still be of interest, and perhaps in a gallery setting it would be more possible to manipulate the space in such a way. Perhaps an enclosed structure like this would offer a significantly different approach to interaction for participants; the issue with the columns is that they

can be viewed as distinct objects more easily than a wall, for example, can. Ikeda's tunnel in *spectra [Terminal 5, JFK]* (2004), for example, is quite an interesting enclosed space. I wasn't there, but it certainly appears to be quite distinct in structure from something like my circle of columns.

In terms of broader themes, there are two major elements of this installation that I plan to continue in some capacity at some point. The first is the concept of 'conversational' interaction between exhibition participant and a sound synthesis system. Throughout the duration of the exhibition, I spent a good amount of time observing these interactions and thinking about ways to harness it and create further art, particularly thinking about abstract ways of performing mapping. So I am planning some further work along these lines. I haven't really mentioned it much because it alone isn't exactly the main focus of the work, but the raw sonic content itself was quite satisfactory and I felt like it lent itself well to this paradigm of interaction, and I intend to use some of it in my fixed media work (the columns *can* be instruments!). Secondly, I found myself wondering about tactile feedback: what if the system touched back as well as creating sound? I haven't done any research on this yet, but it would certainly be interesting to extend the generated link between auditory stimuli and tactile sensation.

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