A FRACTURED EARTH: SONIFICATION AND SPATIALISATION OF SEISMIC DATA WITH MAX/MSP AND SPEAKER.MOTION

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ABSTRACT

This paper provides an overview of a Max/MSP patch that sonifies seismic data and the use of spatialisation to explore the resulting soundscape. The background to the development of the patch and spatialisation techniques are discussed and a brief overview of the implementation of the patch is provided with contexts for its use. Spatialisation is explored with the use of a new mechatronic speaker system and its use in a live performance. Finally, the paper considers future development of the system.

1. INTRODUCTION

A Fractured Earth is a Max/MSP based implementation of the sonification of seismic data - the sound of earthquakes. An earthquake is an event that is typically felt rather than heard. We tend to hear the effect of an earthquake rather than the earthquake itself.

This paper presents the motivation behind the project, the process used to capture, store, transform seismic data into sound and spatialisation techniques based on the speaker.motion system. It describes the techniques that have been applied in an interactive based performance to more fully explore the combination of sound and space. Finally, the experiences provide ideas for further development of the Max/MSP patch and how it can be utilised in different performance and installation environments.

2. RELATED WORKS

2.1. Earthquake Sonification

There are numerous and varied examples of the sonification of seismic data (available from the Internet). Examples of such works include r x2 by Dmitry Morozov (Morozov 2015), Tim Prebble (Prebble 2015), Micah Frank (Frank 2015) and SeisSound by Debi Kilb et al (Kilb 2012). These and other examples have ranged from a general interest by people to create a small sonic piece to larger installation pieces. Examples have used a range of sonification techniques from exciting sounding objects in acoustic pieces to synthesised sonic interpretations of seismic data. Some examples have included visual representation of earthquake statistics such as date/time, location and magnitude through static maps or Google Earth. The sonification of seismic data has varied with each person using a different technique to represent their interpretation. This diversity/uniqueness was part of the inspiration for me to explore this area of sound creation.

2.2. Spatialisation Techniques

There is a strong tradition within electroacoustic music of utilising spatialisation techniques to add a further compositional element to new works. Early speaker orchestras such as the Gmebaphone (Clozier, 2001) and the Acousmonium (Desantos, 1997) used variation in the placement and the type of loudspeaker in order to colour the compositions and to more fully utilise the acoustical properties of the performance space.
The advances of Wave Field Synthesis, Ambisonics and Vector-Base-Amplitude Panning have allowed composers to create phantom source positions within the performance space so the audience can also draw meaning from precise spatial positioning and spatial relationships in the piece. There has also been some more recent development in the field of extending the loudspeaker itself. Bahn and Trueman (Trueman, 2000) created the hemispherical speakers as a way to simulate the complex radial patterns created by traditional musical instruments. These speakers also allow electronic musicians to create the same point source localisation when collaborating on stage that would be experienced through localising different sounds to specific instruments in the orchestra.

The research presented in this paper aims to combine areas from all the fields mentioned above.

3. A FRACTURED EARTH

3.1. Motivation

The motivation for this project was to explore the sounds of earthquakes by taking seismic data from an Internet source and transforming this into some form of sonic representation. A number of data types and streams were available so part of the project was deciding on the type of information that was easily accessible.

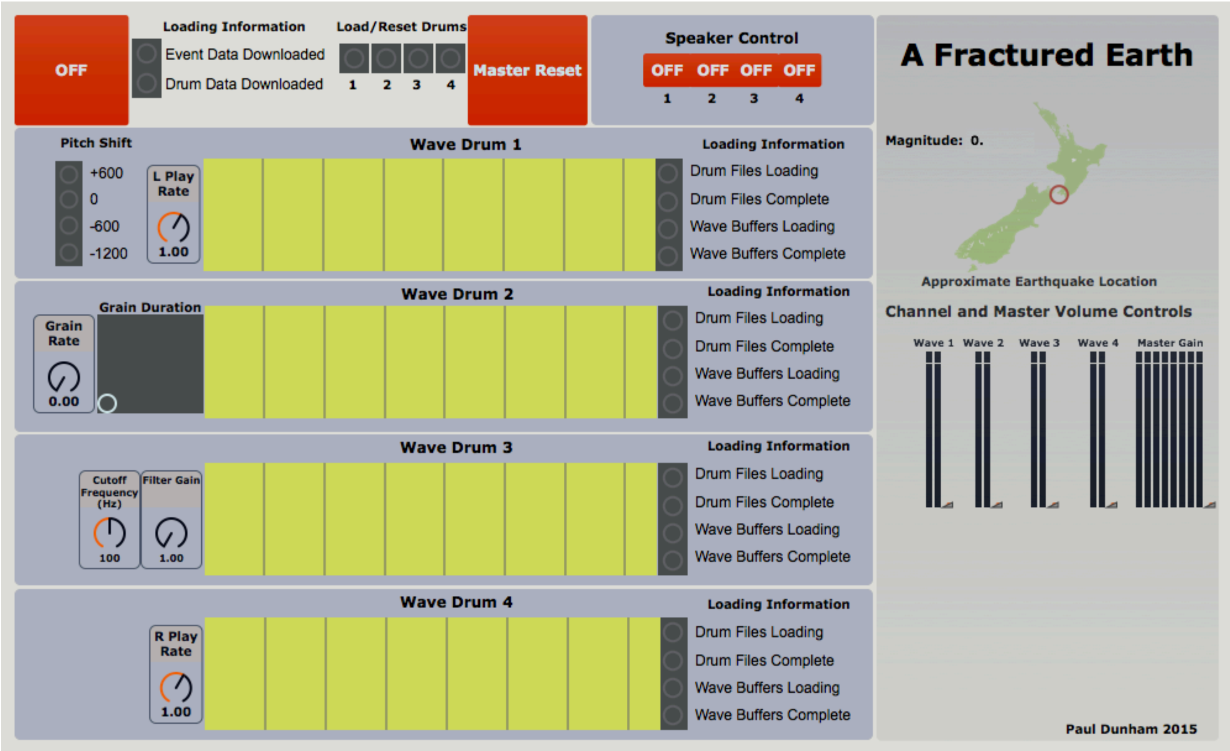

Figure 1. A Fractured Earth User Interface

Living in Middle Earth on top of fractured earth, it seemed appropriate to use a local data source. Data comes from Geonet, a partnership between New Zealand government and research agencies that monitor and research geological hazards and present public information on events.

3.2. Implementation

The original project proposal was to be able to sonify and spatialise seismic data and give another dimension to the reception of this sound. A Fractured Earth, built in Max/MSP, has been built with three design objectives in mind, to be modular, adaptable and extendable. The patch is primarily based on five modules. These are the data gathering, data transformation and storage, sound processing and synthesis modules and audio control.

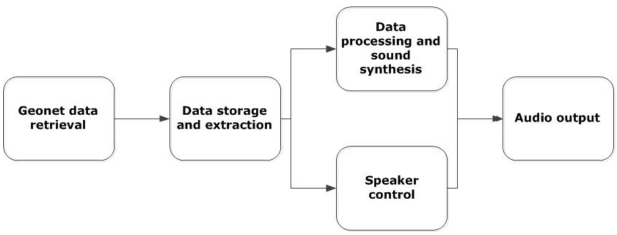

Figure 2. A Fractured Earth Module Overview

3.2.1. Data Retrieval

Data retrieval is a two step process. An http query obtains information on the latest seismic event and downloads the event information in json format. The data is then parsed to extract information from a number of fields. The Public ID is used to compare the current event with the previous one so unnecessary files aren't downloaded, Max/MSP spawns a command line shell[1] to run a script that downloads the data files and stores them on the local device.

3.2.2. Data Transformation and Storage

A shell script queries the list of filenames and this filename information is stored in a coll object for each sonic wave representation (four in this case). A randomly selected file is extracted from the list of filenames and parsed to the data storage and transformation module where it is manipulated to drop unwanted information and to include indexing information then stored.

The extraction process is triggered between two patches that load the seismic data into a wave buffer and represent it as an audio-like waveform. Stored seismic data is parsed to a buffer object for use by the various sound processing and synthesis engines.

1 Bernstein, Jeremy. 'Shell Max/MSP external', in Cycling '74. https://cycling74.com/toolbox/bernstein-shell/#.VhOPaROqqko (6 October,2015)

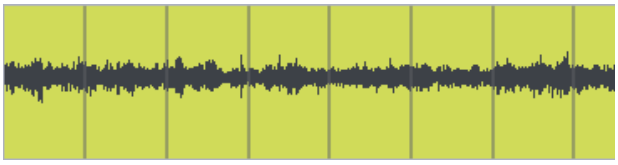

Figure 3. Representation of seismic data as a waveform in Max/MSP

3.2.3. Sound Processing and Synthesis

With the flexibility of Max/MSP, a myriad of different processing effects can be created. One of the hardest things is deciding what to do as a generic processing technique as each set of seismic data could be best suited to different processing techniques and outcomes. To date, the following sound processing and synthesis techniques have been used in this project.

- Time stretching, looping and pitch shifting with interactive playback control.
- Granular synthesis[1] with interactive duration and rate controls.
- Low pass filtering to emphasise the subsonic qualities of the waveform with interactive frequency cut off and filter gain controls.
- Time stretching with interactive playback control

As the system is modular it can easily be adapted to create new processing modules and to select the ones to use based on the performer's criteria.

3.2.4. Audio Control and Spatialisation

There are two components to audio control. The first is simply presenting the audio output. Depending on the output, it is simply a case of selecting the appropriate device and using the individual and master gain controls. The second component is a MIDI control module and is used to control the movement of the speaker.motion system (ref. section 4). This system's flexibility and ease of use means that movement can be fully automated or left to the performer to control. Individual MIDI sequences are sent to each speaker to control its movement. A library of MIDI control parameters can be defined for different types of installation spaces, performance criteria and speaker positions if necessary. These can be easily stored and recalled using Max/MSPs Preset object.

3.3. Use Cases

A Fractured Earth was originally developed as an installation piece where most parameters and controls were automated and the soundscape was explored over a large timeframe. Since using the speaker.motion system, the patch has been adapted to a more performance oriented work.

3.3.1. Performance Use

Performance use of A Fractured Earth allows the performer to explore an environment for a short period of time with a limited data selection. To make the most of this experience, a number of automated controls are removed and the performer can change these as the interaction of sound and space is explored. The performer can change parameters within each sound or change each data file to explore a new waveform. Speaker movement can be independently controlled in real-time as the performer explore the diffused sound field.

3.3.2. Installation Use

The idea of establishing this work as an installation piece was to allow the sonic output to be explored over a large time period as different seismic events occurred. While earthquakes are a relatively regular feature of our landscape, allowing a work to play over an extended period of time would allow a far wider range of soundscapes to be experienced or explored. Placing this into different environments would also allow the interaction of the sound within the space to be explored.

4. SPEAKER.MOTION

The initial idea for spatialisation was to move the sound around a multi-speaker configuration to create a phantom source position corresponding to the earthquake's geographical location. While this may have provided some spatial context, it seemed like static sounds moving around a circle. Enter speaker.motion.

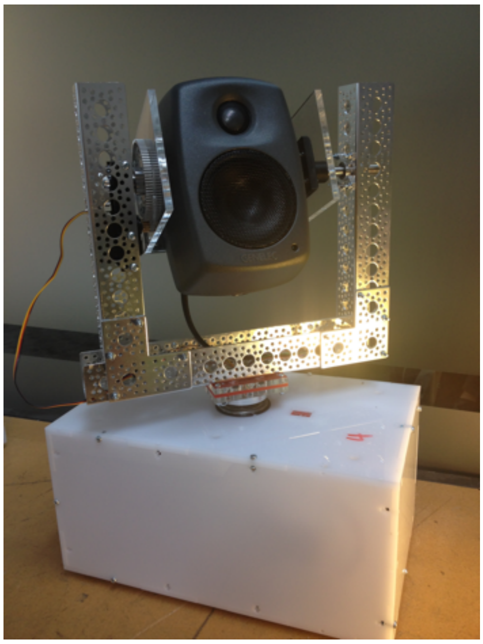

Figure 4. Mechatronic speaker

[1] Hosale, Mark-David. 'grainbuffer~' in Mark-David Hosale http://www.mdhosale.com/grainbuffer/ (6 October 2015)

speaker.motion is a mechatronic speaker system that can be used to manipulate the spatial qualities of electronic music in real-time. Each speaker has the ability to continuously rotate 360º or be accurately positioned within that sphere. In addition, the speaker can be tilted approximately 180º on its vertical axis. Again, this positioning is capable of continuous movement or can be accurately positioned. Control of the speaker system is by MIDI commands. A set of commands have been established to provide various movement commands. These can either be pre-programmed or changed in real-time. These control sequences can be controlled from any MIDI out capable device.

speaker.motion is integral to the sonification because it contributes a new dimension to the sound. speaker.motion allows the sound to be diffused in a space in a number of unique ways. The speaker placement can be determined by the sound being generated and the characteristics of the space the sound is in. The independent movement of the speakers and the control of them allows for a sound or soundscape to be explored in different ways during a performance or installation. Two key benefits of using the speaker system are that the presentation of the sound can be adapted to the type of space it is played in and the use of multichannel audio can further enhance the independent sounds of each speaker.

5. PERFORMANCE WRITE UP

A piece was performed to explore the soundscape created by A Fractured Earth and speaker.motion. The speaker layout is shown in Figure 5.

Figure 5. Speaker Layout for Live Performance Example

Speakers 1 and 4 were configured to rotate 360º and tilt though approximately 90º of their axes. Speakers 2 and 3 were configured to move through 180º facing out into the space and to tilt to pre-programmed positions within a 90º axis at timed intervals. Each sound was loaded individually and each speaker set to move when the sound was fully loaded. While the overall sound density increased, it constantly changed due to the movement of each speaker and the diffusion of the sound. Two aspects during the performance changed the sound that was being explored. First was the ability to change parameters of each sound or to change the sound itself by loading a new data file. Second was the movement of the speakers. The speaker movement had two effects on the sound. First, the collective speaker movement changed over time therefore changing the angles of sound diffusion and reflection. Second, the speaker movement changed the sound's reception by changing the location and strength of the sound. This allowed the listener to hear different aspects of each sound and to hear the change in the overall soundscape.

6. CONCLUSIONS AND FUTURE WORK

The exploration of sound and reception of A Fractured Earth is enhanced with the speaker.motion system. The combination of the diffusion of sound in a space and performance of A Fractured Earth allows the soundscape to be explored in a unique way that can be adapted for different spaces and for the characteristics provided by different seismic information. While the performance aspect of A Fractured Earth is a new idea, the initial performance experience has shown that this is an aspect of the piece that can be developed further.

There are a number of areas that can be considered for future development. One can focus on the installation and performance aspects of the system and where these may overlap and differ in use. Additional sound modules can be developed to offer a range of selectable modules based on the type of installation, performance and/or space. Another area that can be explored is to extend the spatialisation by researching the use of multichannel audio to locate additional sound pieces based on seismic parameters such as location, depth and magnitude. Finally, the performance aspect can be explored further by the addition of a control surface to make controlling speaker movement and sound parameters easier during performance.

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