Abstract

This article discusses the responsive sound installation *Reeds*. The *Reeds* project was commissioned by the Melbourne International Festival of the Arts in 2000, and first exhibited in November and December of that year on the Ornamental Lake at the Royal Botanic Gardens, Melbourne. It consists of twenty-one large floating sculptures[1], modelled to represent clusters of river reeds in immaculate man-made plantings. Each reed pod[2] contained a collection of electronics for either the gathering of weather information or the reception and dispersion of sound. The sound installation gathered data from two realtime weather stations, and produced eight channels of musical output by interpreting the machine unit pulses of the weather data as pulse inputs to Inverse Fast Fourier Transform (IFFT) algorithms. The *Reeds* project focused on a consideration of multiple streams of chaotic and constantly varying sound. I was interested in exploring whether the sonic environment would remain homogenous even though, unlike a musical ensemble, the control inputs varied randomly and independently of each other. The sound installation was site specific, reflecting directly upon the environment it inhabited, both in terms of its visual quality, and aesthetic of the sound.

Figure 1 One of three groups of seven reed pods that made up the *Reeds* exhibition at the Royal Botanic Gardens Melbourne, Ornamental Lake, during the Melbourne International Festival of the Arts in November and December 2000

1. Introduction

For some years now, my practice has been rather schizophrenically divided between composition and installation work. Even within the composition work I have often applied interactive techniques when working with dancers or even seeking material at early stages of composition. Whilst the computer has

[1] The sculptural elements were fabricated by Christopher Langton from concept drawings by the artist, see Figure 3 Plan view.
[2] The term "reed pod" is used to define the sculptural elements of the *Reeds* project.

had a profound effect on the practice of electroacoustic music, I personally feel the greatest paradigm shift has come through the application of the computer as a facilitator in responsive and interactive engagement. The computer has afforded unprecedented flexibility through the abstraction of the source of sonic excitation from the sounding body, which makes possible the mapping of real world phenomena to sonic outcomes. This extraordinary change has led to a new way of contemplating sound installation so that both the content and the temporal form of the work remain in flux, at the mercy, and under the control of the interactive, responsive process.

In 1998, the virtual reality and interactive installation artists Christa Sommerer and Laurent Mignonneau expressed similar thoughts when discussing the development of the interactive digital arts:

. . .the art work . . . is no longer a static object or a pre-defined multiple choice interaction but has become a process-like living system. (Sommerer and Mignonneau, 1998)

Reeds is a responsive sound installation that explores the potential of multiple, random, continuous control inputs that have an internal chaotic structure. By this I mean that the relationships between the various controllers is in a constant state of flux. In a previous responsive sound installation, MAP2[3], I had used video sensing[4] to create a responsive, interactive sound environment that was driven by the movement and behaviour patterns of those within it. In MAP2, I created four independent sensing and sound synthesis zones by dividing the horizontal video sensing field into quarters. The four zone outputs were not interlinked or under the control of a common influence, in this sense, the output of the installation was chaotic. Different individuals could be generating separate audio streams in each quadrant of the space without affecting each other in any way other than the general aesthetic of the combined outcome. The combined sound was not unpleasant to listen to, even though there were up to twelve distinct sound elements occurring together (each zone had three realtime synthesis algorithms, that were dynamically engaged according to the dynamic and position of activity as well as the direction and speed of movement in the space). These sounds were drawing from a common algorithmic pool, and therefore a common aesthetic base, but there were differences in the filter set up for each of the zones, which caused anything from subtle to marked timbrel differences, representing substantially different spectra, which seemed to work together very well.

The sonic outcomes from MAP2 encouraged me to further explore the potential of chaotic multi-modal responsive sound systems. The logical extension was to find a multi-dimensional control source that embodied truly chaotic inter-relationships, and would change rapidly, slowly and unexpectedly but within a defined overall range.

The weather seemed the most suitable candidate, as:

- The conditions can change rapidly, especially in the spring, the season during which *Reeds* was first exhibited[5].
- The weather conditions have a natural range (it is unlikely the temperature will ever get to 50 degrees celsius in Melbourne, nor is the wind speed likely to exceed 150 mph), so the characteristics of each synthesis algorithm could be developed to respond to a known range of conditions.
- The macro and micro level structures of variation would provide diverse possibilities for sonification.
- The selected weather parameters revealed inherently diverse temporal structures and distinct overall ranges of activity.

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[3] Information about MAP2 can be found at http://www.activatedspace.com.au/Installations

[4] I have mostly used the Very Nervous System (VNS) see http://www3.sympatico.ca/drokeby/vnsII.html

[5] *Reeds* was adapted for gallery showing, resulting in PlantA and PlantB, both exhibited many times in Australia and the UK

- The independence of each parameter would provide dynamic orchestration options.

These were important considerations when contemplating the generation of musical/sound outcomes.

Choosing suitable weather characteristics was in itself a difficult task, conditioned by the availability of sensors, their individual cost, and a consideration of the structure of each sensor's data output as discussed above. Sensors for the measurement of rainfall and leaf wetness were of interest but would have proved unstable when installed so close to a large body of water. With the exception of rainfall, I chose to focus on weather phenomena that directly relate to the growth patterns of plants.

Two weather stations were installed in reed pods, sensing: wind speed and direction, temperature and solar radiation.

The sound synthesis was driven by both the direct input from each of these sensors, and the difference between the two weather stations, which although not far apart (10 metres) often reported markedly different conditions.

Whilst the exploration of simultaneous chaotic control inputs, and their mapping to sonic outcomes was the principal pragmatic force for the creation of *Reeds*, I think it is important to contextualise my artwork within a broader consideration of the human condition. The *Reeds* project was no exception, exploring the relationship between the weather conditions as the provider of the foundations for biological growth, and the paradox between the apparently static façade of most plants, and their immense power, symbolically expressed by the weed that pushes its way up through a foot path, which to us is impenetrable. These considerations are best expressed through the programme notes I wrote for the original exhibition:

> *A weed, so easily crushed underfoot, can push its way up through a tarmac path, creating a sizeable fracture in what appears to us to be an impervious surface.*
>
> *One might postulate that if it could see the bigger picture, it might have decided to grow two feet to the left in the flowerbed or the grass.*
>
> *It is exactly this chaotic behaviour of the natural world that informs the Reeds project. Whilst civilisation tries to harness or tame the chaotic in nature, or to explain it in terms of quantum theory and fractals, humanity cannot perceive a truly chaotic state. The forces of nature that dictate the growth of plant life fall into this category. It is not possible for us to predict with certainty the meteorological conditions from day to day, let alone year to year, and certainly not on the micro scale of the weed in the footpath. It is precisely these chaotic variations that are used in Reeds to conduct the sound score - to control and dictate the output of the realtime synthesis process.*
>
> *Of course, the software design process predetermines the general structure and aesthetic of the sound, but the momentary output is unique. It is unlikely that the combination of wind speed, wind direction, solar radiation, and temperature that occur in this instance will be precisely replicated in any other moment. This chaotic variation is the very source of diversity, which I propose is the structure that creates such beauty in nature.*
>
> *Reeds uses the relatively static external facade of the sculptural form as a way of representing the paradox observed in organic plant life, where in contrast to the apparently static external face of the plant, is the hidden, dynamic activity of photosynthesis and nutrient gathering that keeps the plant alive, and drives it's growth.*
>
> *The Reed pod sculptures, appearing as lifelike presences on the Ornamental Lake at the Royal Botanic Gardens Melbourne, support two remote weather stations, gathering wind speed, wind direction, temperature, and solar radiation data. The meteorological conditions, vital to the plants' life processes, are transmitted back to a land-base where the data is transformed into eight channels of musical sounds that are broadcast*

back out to the Reed pods. These sounds give a voice to the secret activity of the inner life processes of the plant.

The viscous and fluid aesthetic of the sound material is an attempt to capture something of both the dynamism of the processes that maintain life and the ever-changing, silken thread that is the presence of life, the life force itself. The fact that the sound material is generated on the basis of meteorological conditions is a way of drawing as tightly as possible the bond between the processes of nature and the processors of the Reeds installation. The sound material cannot then be avoided, being the voice of the processes of nature.

Sound and music is in many ways a unique media, for it is not an external artefact. Sound literally penetrates the body. It is also impossible to concretely tie composed sound or music to a representation of anything beyond a communication of emotional states and journeys.

As an artist my interest lies in exploring ways of contextualising digital art processes within the natural organic environment. I have little interest in the purely synthetic, that is the synthesis of sound or images from a purely academic or theoretical viewpoint; but prefer, as is illustrated in the Reeds project, to take a fundamentally organic source as the basis for the synthesis process. In so doing, I hope that some quality of that organic material will permeate the work, thereby bringing the synthetic output at least a small way towards the organic world, and therefore within the human context.

2. The Design

In keeping with my humanist perspective, the technological structure of the *Reeds* installation is based on the concept of the organic life cycle. This design approach mirrors the cybernetic principal of the closed causal loop. A closed causal loop is one in which each of the elements contained in the loop act upon the others in a constant and varying fashion to maintain equilibrium. The only influences on a closed causal loop are the elements it contains.

I have taken particular inspiration from a key proponent of Cybernetics, Norbert Wiener, who conducted extended research into the application of cybernetic principles to the organisation of social systems (Wiener, 1948).

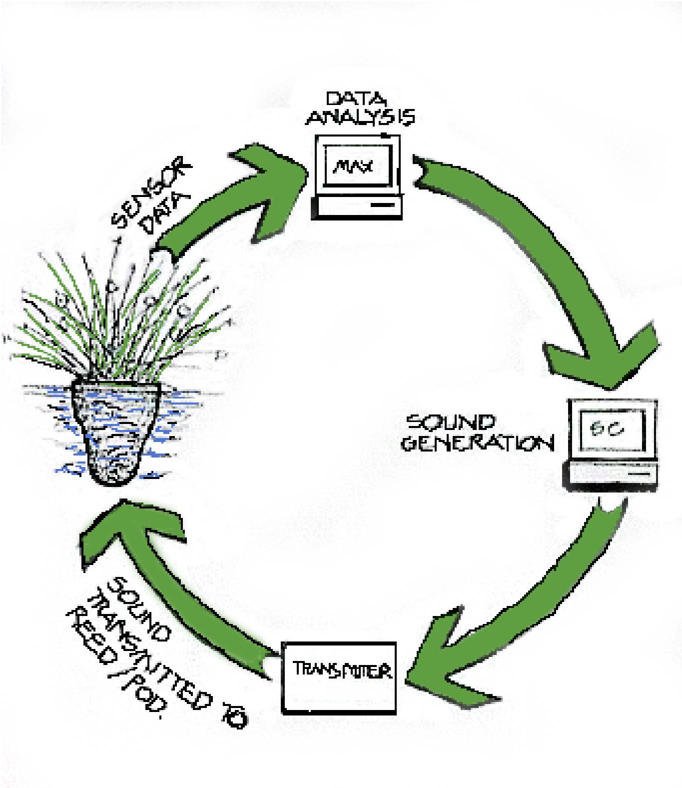

Figure 2 The *Reeds* life cycle.

I have taken the liberty of transplanting these ideas into the plant ecosystem. The idea that the system of nature implements and represents a continuous and dynamic cyclical process of communication, feedback and rejuvenation played an important role in the development of the conceptual design and resulting technological design of the *Reeds* installation. I was also interested in the way in which the Wiener text could be used to imply that a well-designed responsive installation may strive to represent patterns of social interaction, and in so doing provide a basis for the consideration of aspects of the human condition.

It is my view that the patterns of relationship in an interactive, responsive sound installation are made explicit and coherent through many iterations of the closed causal loop discussed above, each one rendering the nature of the relationship with greater detail. It was exactly this sense of coherence that I was seeking to explore. Would this soundscape maintain such a sense even though the control inputs would be dynamic and chaotic? Would the sonic landscape generated by the weather conditions make explicit " a coherent underlying pattern"? In this sense I was very interested to see whether the cybernetic mantra "the whole is greater than the sum of the parts" would be proven by the musical outcome being both coherent, engaging and perceptibly related to both the current weather conditions, and the momentary changes of the meteorological states in the immediate vicinity of the sound installation.

It is within this context that I decided that the weather data, which acts as the foundation for this responsive, interactive sound installation, should form the generative seed of the life cycle. Gathered by small remote weather stations (installed in the pods floating on the lake), the momentary weather characteristics are transmitted to a land-based computer, which having analysed the incoming data uses the results to 'conduct' the sound synthesis software.

The sound synthesis software consists of a number of algorithms that generate music in realtime, producing eight channels of digital audio. These eight channels of sound (which emanate from the reed pods) are then broadcast as high quality stereo audio back out to the reed pods using Sennheiser EW300 in-ear monitoring systems. The return of the audio signal to the reed pods, and its dispersion to the listener/observer/spectator completes the life cycle. This cycle is illustrated in Figure 2.

To flesh out this technological life cycle, I will separate the process into stage headings as follows:

2.1 Collection of Weather Data.

As mentioned above, each of the two weather stations report four pieces of weather data:

- Wind Speed
- Wind Direction
- Temperature
- Solar Radiation

This data is collected using custom built weather stations comprising sensors manufactured by Davis Corporation[6], and data processing, transmission and reception units designed specifically for this project by Microscan[7], Australia.

The weather sensors output a sliding voltage scale, which represents their current state, with the exception of the wind speed sensor, the output of which is calculated on the basis of the number of rotations per 1.25 milliseconds (one rotation equals 1.00615 metres of air movement). A data processing board, inside the reed pod hosting the weather station, converts this data to an ASCII data set in the form:

Battery Voltage, Temperature, Solar Radiation, Wind Direction, Wind Speed

This data set is transmitted by the weather station once every ninety milliseconds to a land based receiver, which, having performed a checksum to ensure data integrity, pipes the data into a Macintosh computer as RS232[8] data.

[6] Davis Corporation weather station and sensor product information can be found at http://www.davisnet.com/weather/products/index.asp
[7] Microscan, see http://www.microscan.com.au

2.2 *Weather Data Analysis*

The weather data is fed into a software application, developed in Max (see Figure 4), that analyses the incoming data and dynamically scales it, before passing the result in the form of MIDI Continuous Controller messages to a SuperCollider patch, containing six audio synthesis algorithms (Figures 11 & 12).

A sub-patch (Figure 5) of the *Reeds* Max patch (Figure 4) polls the serial port every ninety milliseconds to collect the incoming serial data from the weather stations. The weather data is transmitted as machine units, which have a range set by the manufacturers, of 0 to 4095.

The machine units were converted into weather measurements in order to get a clear understanding of the range of weather activity.

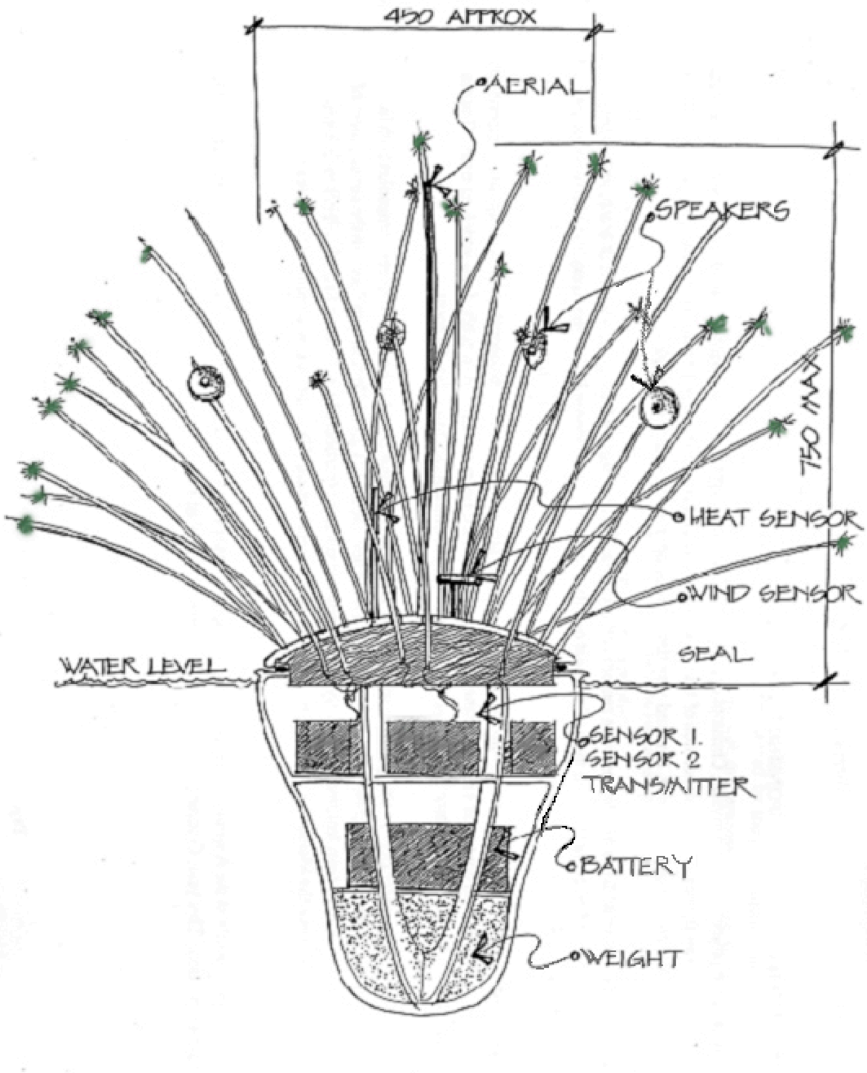

Figure 3 Plan view

It was important to gauge the maximum and minimum range for each weather characteristic in order to scale the synthesis processes appropriately, in this sense the machine units were meaningless. The conversion of the data to standard units of measure (degrees celsius, wind speed in metres per second, etc.) had the benefit of providing minimum and maximum measurements to the user interface, which were used to make subjective judgments about the timbral quality of sound synthesis outcome when equated to the dynamic of weather activity. The scripting language Pyrite[9] was used for this purpose, and the patch can be seen in Figure 4, named pMinMax, with the code presented in Figure 11. Having the ranges displayed in the user interface provided an historical view of the days activity and assisted in setting the range of variation the sound synthesis software should address in order to get the best resolution of change in the audio timbres.

The sound synthesis algorithms were mostly based on Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform[10] (IFFT) algorithms.

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[8] RS232 was developed in the 1960s and specifies a serial data communication protocol.

[9] Pyrite is a scripting language, developed by James McCartney that runs inside Cycling7 MAX.

[10] FFT stands for Fast Fourier Transform. A Fourier Transform captures information about the frequency spectrum of a sound and stores it as time domain data. Inverse Fast Fourier Transforms are an approach for turning time domain signals into frequency spectra, and hence sound. (Roads, 1966).

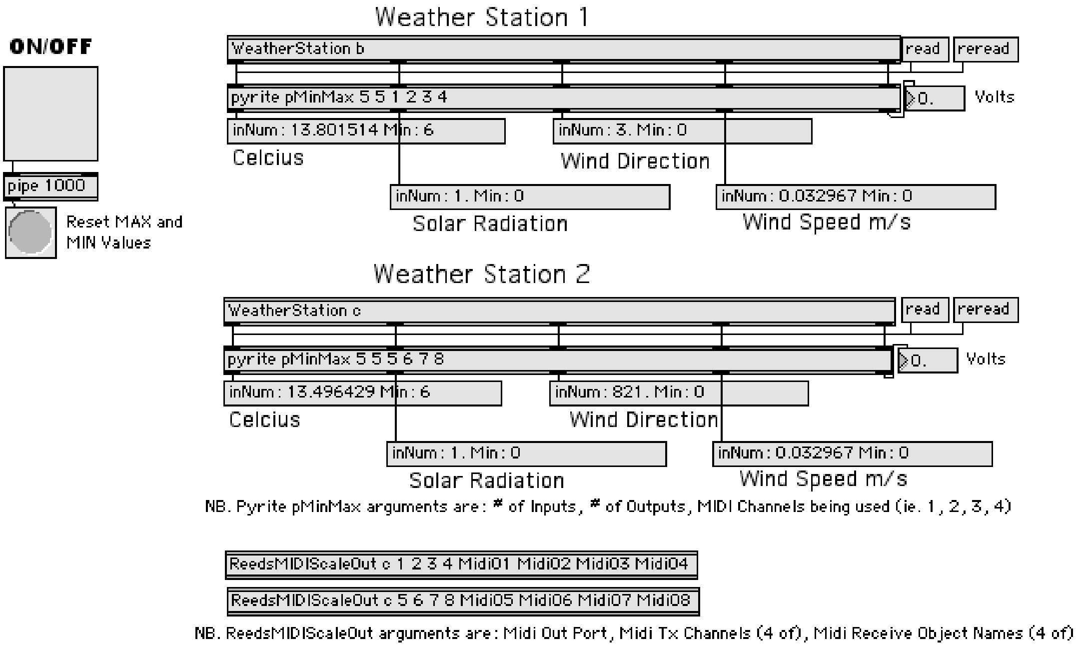

Figure 4 The top level Max patch for the *Reeds* project.

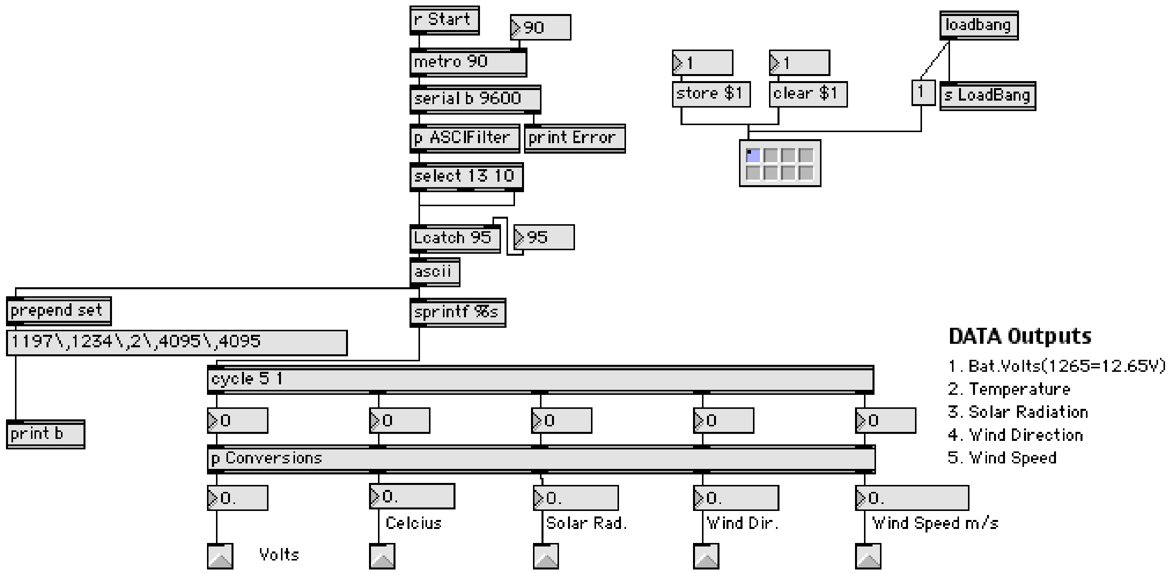

Figure 5 The RS232 data input sub-patch, converting the incoming machine unit (0 to 4095) figures to units of weather.

2.3 Sound Synthesis

As mentioned above, the realtime sound synthesis was achieved using a SuperCollider patch[11], that directly mapped the machine units from the weather sensors as pulse inputs to Inverse Fast Fourier Transform (IFFT) and Fast Fourier Transform (FFT) techniques. A detailed explanation of FFT techniques is beyond the scope of this article. In brief, a Fourier analysis produces a report of the frequency makeup of a sound, and the associated amplitude of each frequency. An IFFT applies a

[11] Developed with assistance from Graeme Gerrard

Fourier analysis to an additive synthesis process, where oscillators (usually combined using additive synthesis) recreate the sound using the frequency and amplitude information in the analysis file.

Each of the instrument algorithms in *Reeds* is allocated one or more of the weather data streams (eg. instrument one uses wind speed and solar radiation from weather station number one) that control variables within the algorithm, thereby changing the pitch, texture or intensity of the sound. Instruments one and two (sig1, sig2) produce a stereo signal that is dynamically panned across the installation, whilst the other four instruments (sig3, sig4, sig5, sig6) produce a single audio channel. The audio is directed to the eight analogue audio outputs of an ASIO[12] compatible multi-channel digital audio interface[13].

Each of the sound algorithms produces differing timbres. They are designed to augment one another, and to produce a range of timbres from gentle, water drop like sounds to roaring wind like sounds. The sound is generally mapped to make the density of sound follow the wind speed, and the weight of sound (pitch for instance) follow the solar radiation readings, with filter settings varied according to the wind direction and temperature characteristics.

The relationship between the momentary weather conditions, and the sonic outcome is crucial. The system must preserve the nuance of each meteorological gesture. It is my view that this can only be done by using realtime synthesis. The triggering and collaging of pre-recorded material may be able to represent the macro level meteorological activity, but it cannot enunciate the intricate nuance of unique moments, for surely the exact combination of multiple weather parameters is unlikely to be repeated. How then can a finite sound pallet suffice as a true expression of momentary phenomena? Two other installations approach the sonification of weather data. Owain Rich's WeatherPlayer[14] generates a RealPlayer audio stream twenty-four hours a day, seven days a week. The audio stream is made algorithmically by mixing pre-recorded audio samples in accordance with current sensor readings. Similarly, Natasha Barrett's Displace:Replace II[15] generates its score by triggering four and eight channel audio files for playback in an ambersonic cube. The audio files are mapped in intensity to threshold bands, but serendipitously, these mappings are augmented by the control computer if the weather does not change for four minutes, and completely recomposed if there is no change for thirty minutes.

Conversely, it was clear when observing the *Reeds* installation, and even more so in the gallery installation *PlantA* (which used the same technology) that what appeared to be static weather conditions established a deep listening opportunity. There was always some variation, no matter how small, in the solar radiation or one of the other sensors. These micro-scale variations, whilst they may not be sufficient to create changes in Owain or Barratt's score, are reflected in the realtime synthesis outport of *Reeds* and *PlantA*, and in fact it becomes increasingly seductive to listen on a more and more subtle level, delving increasingly into the microscopic plant domain.

See **Mapping**, below for more detail on the sound mapping approach.

2.4 Broadcast

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[12] ASIO (Audio Stream Input/Output), developed by Steinberg, is a cross-platform, multi-channel audio transfer protocol ASIO is a trademark of Steinberg http://www.steinberg.net/en/

[13] Such as the Digidesign DIGI001 - http://www.digidesign.com/products/digi001/ or MOTU828 http://www.motu.com

[14] See http://www.weatherplayer.com for further information

[15] See http://www.notam02.no/~natashab/dr2/displacedII.html for further information

The audio signals produced by the SuperCollider software were fed to four Sennheiser EW300 In-Ear Monitor[16] transmitters. The EW300 transmitters each broadcast stereo audio of high quality. Sennheiser EK300 stereo receivers, installed in six of the reed pods receive the broadcast signal (each receiver has its own reception frequency matched to one of the four broadcast frequencies (each carrier frequency hosting a stereo signal)). The stereo signal of each receiver is then separated into its two mono components, which are fed to the two adjacent reed pods. See Figure 6 for details of the channel allocation and spatialisation.

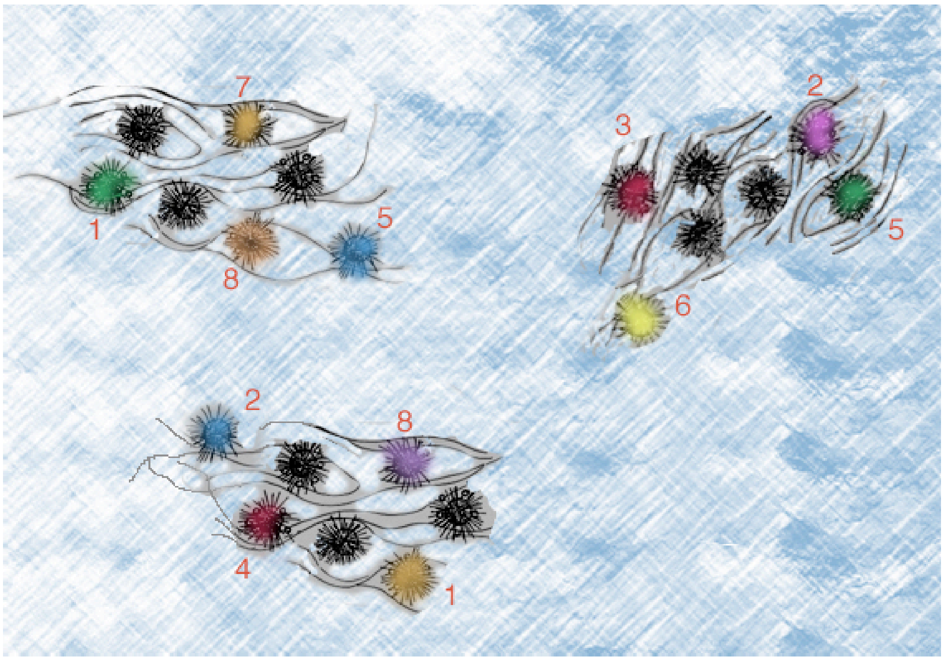

Figure 6 The sound diffusion audio channel allocation for *Reeds*

2.5 Diffusion

Each sounding reed pod contains a battery powered 40-Watt amplifier. The amplifier feeds five loudspeakers: one ten inch full range (20Hz – 20KHz) Misco waterproof loudspeaker, (built into a hat on top of the reed pod) and four small 40 mm speaker drivers (clipped to the reed stems) which are fed via a crossover, to ensure they only receive signals over 2000Hz. The main speaker carries the full range signal, whilst the smaller 40mm drivers carry the high frequency material that give the crisp edge to the sound. The speakers are placed in a position that allows the sound to bounce across the water surface.

The eight channels of sound were dispersed across the reed pods so that panning either of the stereo signals (sig01, sig02) would cause the sound to travel across the installation space. This was achieved by allocating these audio channels to loudspeakers in different reed pod clusters, spreading the stereo signal across the installation, which created a sense of movement, of sound journeying across the installation space, and also helped to establish homogeneity of the sonic landscape of the entire installation. The other four synthesis instruments output mono channels. They were grouped according to their timbrel quality so that the texture of the soundscape varied as one walked around the shore from one side of the installation to the other.

[16] The Sennheiser EW300 is designed to transmit foldback signals directly into the ear of a musician for the purposes of stage monitoring. See http://www.sennheiser.com

The numbered dots in Figure 6 show a bird's eye view of the sounding pods, and their audio output allocation, and Figure 7 indicates the allocation of synthesis and audio channels.

Synthesis Instrument	**DIGI001 output**	**Broadcast Channel**
Sig01	Output 1, Output 2	1, 2
Sig02	Output 3, Output 4	3, 4
Sig03	Output 5	5
Sig04	Output 6	6
Sig05	Output 7	7
Sig06	Output 8	8

Figure 7 Synthesis and Broadcast Channels.

Given the cybernetic, social and ecological context within which this piece was designed, it was important not only to set the amplitude of the sonic outcomes so that the installation became part of the landscape, but it was equally important to develop synthesis algorithms that reflected in some way an extension of the sounds that already existed within the environment. The natural soundscape for the lake in the Botanic Gardens, Melbourne, consisted of a wide range of bird sounds (calls, landing on water, fighting etc), the sounds of people at the cafe and walking around the lake, children playing, trucks and cars on the expressway on the other side of the Yarra river, small boat horns, overhead aircraft, and other less frequent momentary sounds.

These considerations left me with two almost irreconcilable intentions:

1. to directly convert the machine unit outputs from the sensors into musical material using FFT and IFFT techniques, and
2. to create sonic timbres that reflected the existing sonic landscape of the site.

This conundrum was resolved through careful adjustment of the way in which the sensor data was mapped to the sound algorithm parameters, as discussed below. Additionally, I applied various filtering approaches to make sure that the timbres of the sounds were rich and engaging whilst never becoming harsh or repressive.

Two trials were undertaken at the Botanic Gardens over the six months prior to the exhibition, involving single reed pods. A further trial was undertaken with one group of seven reed pods on site for a week, approximately six weeks prior to the final exhibition in order to test the scale of the sculptural elements and the sound spatialisation principles I had developed. The trials provided an opportunity to test the sound material in situ, and created an occasion to test the weather patterns on site (i.e. the range of variation), and the way in which these weather characteristics could best be scaled to create engaging and perceivable variations in the sonic landscape. One particularly interesting outcome of the trials was the discovery that sound algorithms developed in the studio did not carry well in the outdoor context. It was clear that whilst a great deal of design and testing work could be done offsite, the final sound algorithm development and the refinement of the mappings of the weather data to the sound synthesis algorithms would need to be done on site.

In consideration of the needs of the wildlife for which the Botanic Gardens' lake is home, each reed pod that contained audio equipment was fitted with light sensitive switches so that they turned on at dawn and off at dusk, thereby conserving battery power, and allowing the wildlife the tranquillity of the night.

3 Data-Sonic Mapping

The weather data was mapped to the six sound synthesis algorithms in such a way that the incoming high resolution pitch bend MIDI data could be re-scaled to suit the sound synthesis parameter to which the weather characteristic was being mapped. This flexibility provided the opportunity to quickly and easily alter the response patterns of the synthesis algorithms dependant on the range of weather conditions being experienced, which could clearly alter from site to site and from season to season. It also provided the opportunity to experiment on site with different mappings of weather characteristics to synthesis parameters, which proved invaluable when finalising the synthesis algorithm design. These mappings were achieved within Supercollider as follows:

```
// weather station 1: temperature; mapped to sig3: src1
	in1Args = [1, 10, 2000, 'exponential', 1];
// weather station 1: solar radiation; mapped to sig1: centerFreq;
	in2Args = [2, 100, 8000, 'exponential', 1];
// weather station 1: wind direction; mapped to sig1: clockRate;
	in3Args = [3, 1, 200, 'exponential', 1];
// weather station 1: INVERSE wind direction; mapped to sig2: amp3 - varies amplitude envelope
	in3Args1 = [3, 20, 1, 'exponential', 3];
// weather station 1: wind speed; mapped to sig2: src1
	in4Args = [4, 2, 1000, 'exponential', 1];
// weather station 2: temperature; mapped to sig3: src
	in5Args = [5, 10, 100, 'exponential', 1];
// weather station 2: temperature; sets the amplitude in sig3 in inverse proportion to impulse frequency
	in5Args1 = [5, 8, 4, 'exponential', 1];
// weather station 2: solar radiation; mapped to sig4: src
	in6Args = [6, 10, 10000, 'exponential', 1];
// weather station 2: wind direction; mapped to sig5: src
	in7Args = [7, 20, 160, 'linear', 1];
// weather station 2: wind speed; mapped to sig6: Impulse.ar(freq);
	in8Args = [8, 0.2, 2.0, 'linear', 1];
```

All of the sound algorithms used FFT or IFFT synthesis methods. The idea was to auralise the time domain information coming from the weather stations, i.e. current wind speed, solar radiation, wind direction and temperature. This mapping converted the changes in weather conditions into the impulse rate used as the source for the IFFT stage. The impulse rate is the main characteristic in defining the IFFT output. It is defined as follows in sig3 (the third instrument):

```
// inverse transform
	out = IFFT.ar(fftsize, 0, cosineTable, nil, window, src, 0);
```

where *src* is provided by the temperature sensor on weather station 2.

The weather characteristics were chosen both for their importance to plant life (they are the main characteristics that define the growth rate of plants, with the exception of rain), and for their compositional value.

Wind speed and wind direction change dynamically over large ranges in very short periods of time. Small gusts can swing through 360 degrees, and range widely in speed.

Solar radiation changes in a much more gradual way. I had expected the solar radiation to be the most docile variable, changing very gradually over the duration of the day, remaining high during the peak sunshine hours and then diminishing. I had thought that the solar radiation would define the form of the entire day, creating a kind of pedal point for the other more dynamic variations. During the testing periods, I was greatly surprised to find that the solar radiation was in fact one of the most dynamic variables. Clearly the human eye constantly adjusts for variations in solar radiation, something a scientific sensing instrument does not do. Cloud movement, and other changes in the weather saw the solar radiation constantly sliding up and down its range. Obviously, some days were sunnier than others, and therefore the range of movement was generally higher on those days than when the skies were overcast, but the dynamics of change were consistent in all weather conditions. Unlike the wind characteristics, solar radiation never jumped from one point to another, it moved smoothly up and down in a step like manner.

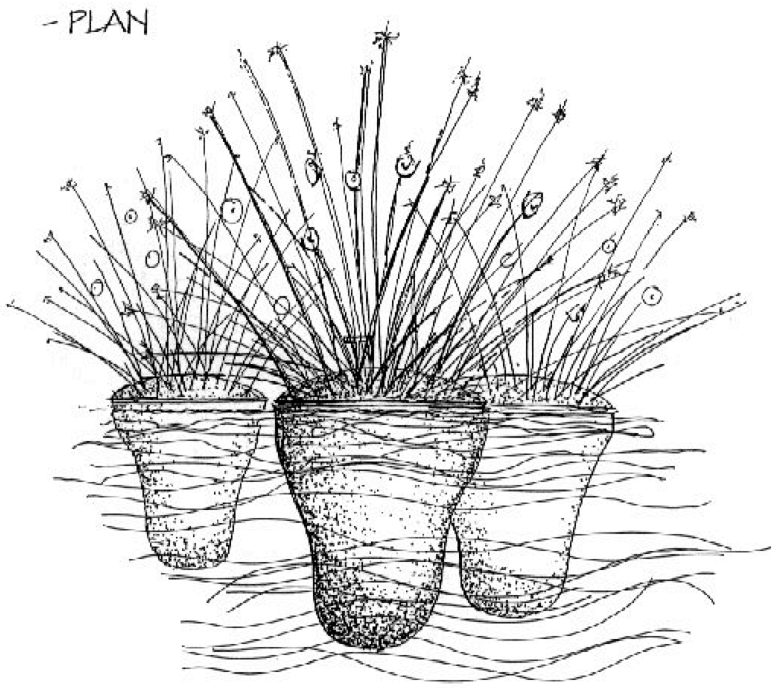

Figure 8 One of the original concept drawings for *Reeds*.

Temperature, as I had expected, changed gradually, moving up and down in small sequential steps. Temperature was the most graceful of the weather characteristics being sensed for the *Reeds* project, generally forming an envelope shaped by cool evenings, cooler nights, followed by rising temperatures during the day as the sun heated the earth, followed by a reduction in temperature leading towards dusk and into the night.

As indicated above, the weather characteristics were selected in the hope that they would have differing temporal structures, the compositional intention being that the more gradual, step like features (temperature and solar radiation) would provide a gradually varying underscore on which the faster changing features (wind speed and direction) would add points of interest and orchestration dynamics.

4. Conclusion

Reeds continued my exploration of organic, natural controllers for interactive sound installations, providing a platform for the testing of multiple, chaotic controllers, working simultaneously to generate a soundscape which continued to draw on the dynamic orchestration principles I had developed in my previous interactive environment installations, MAP1 and MAP2.

Reeds also illustrates an ongoing interest in making the technology invisible. I went to great lengths to develop battery-powered amplification and broadcast systems, so that the reed pods were entirely self-contained, displaying no obvious source (except for the weather stations and the small high-frequency loudspeakers) for the sounds they emitted. My motivation was to ensure the aural experience was the primary outcome, and not to display the technical wizardry, computer programming and hardware development that had made the project possible. In keeping with my intention to reflect on the human condition, I believe it is important to hide the pragmatic achievements inherent in realizing an interactive work like *Reeds*, and indeed the challenge of writing articles like this is to go beyond the technological developments and communicate something about the artistic intention.

I visited the *Reeds* installation at the Melbourne Botanic Gardens every day, and as the exhibition occurred during the season of spring, observed a wide range of weather patterns. I noted, for instance, situations where the sunshine and temperature were high, but the wind speed was almost non-existent; by contrast, there were similar temperature and sunshine levels on days when the wind contained strong gusts and violent changes of direction. All of these provided very different sonic outcomes. It was obvious, if one sat and watched the installation for even a short time, that the changes in the weather stations (you could easily see the anemometer) caused variations in the musical output; pitched notes became more noise like as the wind increased, and/or the pitch rose with increased solar radiation intensity. Many of the relationships were very subtle, but were nevertheless perceivable if one spent sufficient time observing the installation.

From the perspective of musical composition, it was useful to consider the different temporal structures associated with each of the weather characteristics in *Reeds*. The different rates of change of each of the weather inputs helped create homogeneity in the soundscape. It was aurally pleasing to have some elements that changed rapidly and others that evolved slowly. I started to consider how this approach might be applied in combination with dynamic orchestration techniques[17] to generate a more richly evolving soundscape within interactive, responsive environments.

On my many visits to the installation at the Botanic Gardens, I often discuss the public’s reaction to the *Reeds* installation with the Botanic Gardens staff, and on occasions discussed the work directly with members of the public. Many people enjoyed the work as a novelty, but some visited it regularly, observing, as I did, the changing weather conditions and the subsequent variation in the sonic landscape. For these people the repeated experience did seem to provide a point of contemplation, a catalyst for thinking about their place in the world, the beauty and splendour of the organic environment that surrounded them, and more immediately, the noises that surround the site; the appropriateness of the freeway on the far side of the Yarra river at the bottom of the Botanic Gardens, the incessant noise of aircraft overhead, or the sounds of the different bird calls, the splashes of the ducks and waterfowl landing on the water, the squawks of the birds fighting for pieces of bread that children fed them from the shore, or, on a peaceful afternoon the shear tranquillity of the environment, the stillness, the sense of suspended animation as the twilight settled into dusk. These outcomes, unquantifiable as they are, and by no means empirical evidence, suggest that my artistic intentions had been met. They also hint at the potential for sound installation works to act as a conduit to consider and re-evaluate the nature of the world of which we are part.

[17] Paine, G, “Interactivity, Where To From Here”, Organised Sound 7.3, 2002

Figure 9   The pods for *Reeds* being assembled on the edge of the lake for the exhibition on the Ornamental Lake at the Royal Botanic Gardens, Melbourne,

Figure 10 The pods for the weather station reed pods being assembled on the edge of the lake, for the exhibition on the Ornamental Lake at the Royal Botanic Gardens, Melbourne.

```
var     TempMAX = 4095, TempMIN = 0,                    -- temperature
        solarMAX = 4095, solarMIN = 0,                  -- Solar Radiation
        windDirMAX = 4095, windDirMIN = 0,              -- Wind Direction
        windSpeedMAX = 4095, windSpeedMIN = 0,          -- Wind Speed
        scaleMin = 0, scaleMax = 16383,
        oldVolt = 0;
-- the scale of 0 to 4095 is the 12 bit high resolution pitch bend range

var Out1, Out2, Out3, Out4;

-- Set all the reporting window min and max figures
bang {          TempMIN = 6, TempMAX = 40,                      -- temperature
                solarMIN = 0, solarMAX = 2400,                  -- Solar
                windDirMIN = 0, windDirMAX = 4095,              -- Wind Dir
                windSpeedMIN = 0, windSpeedMAX = 300,           -- Wind Speed
                oldVolt = 0; }

-- initialise all the MIDI outputs channels 1 2 3 4 WS1 || channels 5 6 7 8 WS2
init { arg inName1 inName2, inName3, inName4;
                Out1 = ((\Midi0).spell $ inName1.spell).unspell;
                Out2 = ((\Midi0).spell $ inName2.spell).unspell;
                Out3 = ((\Midi0).spell $ inName3.spell).unspell;
                Out4 = ((\Midi0).spell $ inName4.spell).unspell; }

-- Methods for checking input data and sending out updated messages when new data arrives
inlet1 { arg inNum;                                                     -- Volts
                IF inNum !== oldVolt THEN
                oldVolt = inNum;
                oldVolt.out(5);
                END.IF }

inlet2 { arg inNum;                                                     -- Temperature
                var a;
                a = inNum.asInt;
                a.map( TempMIN, TempMAX, 2000, scaleMax).out(Out1);
                [\set 'inNum:', inNum, 'Min:', TempMIN].out(1); }

inlet3 { arg inNum;                                                     -- Solar Radiation
                var a;
                a = inNum.asInt;
                a.map(solarMIN, solarMAX, 3500, scaleMax).out(Out2);
                [\set 'inNum:', inNum, 'Min:', solarMIN].out(2); }

inlet4 { arg inNum;                                                     -- Wind Direction
                var a;
                a = inNum.asInt;
                a.map(windDirMIN, windDirMAX, scaleMin, scaleMax).out(Out3);
                [\set 'inNum:', inNum, 'Min:', windDirMIN].out(3); }

inlet5 { arg inNum;                                                     -- Wind Speed
                var a;
                a = inNum.asInt;
                a.map(windSpeedMIN, windSpeedMAX, scaleMin, scaleMax).out(Out4);
                [\set 'inNum:', inNum, 'Min:', windSpeedMIN].out(4); }
```

Figure 11 The Pyrite script used in the *Reeds* Max patch.

References

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