LISTEN (AWAKENING): A COMPOSITION WITH AUDITORY DISPLAY

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ABSTRACT

For the ICAD conference 2004 in Sydney a sonification of ECG and other data was carried out to merge the boundaries between artistic sonification and scientific auditory display. Listen (Awakening) attempts to create in sound the activity of the brain becoming aware of a piece of music and gradually building in its subconscious reaction and appreciation. Certain constraints were put on the sonification exercise. It was to be data driven and time constrained to the original length of the piece of music by David Page [1]. With these limitations the challenge then was to make the result sonically and musically interesting as well as conveying to the listener the human physiological response to music in an auditory display. The resulting composition consists of 15 sound files which will be mapped during the performance directly to the 15 speakers in the Sydney Opera House Studio. A 16^{th} sub-bass channel will convey the low frequency content of the music.

1. INTRODUCTION

In this exercise CSound [2][3] is the main synthesis tool used for mapping the information to sound. The approach taken was to use the data files as control values which could modify various instrument parameters. CSound is very flexible in its ability to utilise a virtually unlimited variety of synthesis and signal processing methods and this was necessary to extract as much sonic information from the data as possible. The original data was sampled at 500Hz meaning the chosen instrument parameters would vary at a control rate of this frequency. It was convenient to set the sample rate at five times this, i.e. 40000 Hz, and then to up-sample the wave files for compositional structuring. The data was initially passed through Matlab for normalization and further manipulation occurred in Csound to achieve the most musical result. To find suitable mappings for the data to sound parameters the Sonification Mappings Database [4][5] was consulted. It currently however has no entries specifically related to the task at hand. Suitable mappings were therefore chosen thorough experimentation, trial and error. Further editing of the rendered audio files was then carried out in Nuendo [6] to create fades, cross-fades and spatialisation. Each of the fifteen sound files (except payling15.wav) has portions of silence within it, this to impart musical structure and dynamics into the piece. Complete unedited or faded audio files are available for each channel on request from the author.

2. SOUND SYNTHESIS

Five main synthesis techniques were used for the composition. The main techniques are.

1. Granular synthesis. Used to manipulate audio samples by pitch shifting etc. The most effective use of this technique is through the use of, ECG and ERBS data sets. They proved most effective for indexing the sample points and upon each beat either a partial or total cycle of the audio sample is played. Examples of this technique are found in speakers 2, 5, 7 and 10.

2. Additive Synthesis. Various data sets were used to manipulate the strength of different harmonics. The pitch in these cases was determined by the Electrodermal activity sensor. Examples can be heard in speakers 11, 12, 13 and 14 in the upper level.

3. Formant Wave Synthesis (FOF). This allows realistic vowel sounds to be synthesized. Normally the formants would be fixed in position to generate a specific vowel. The position of the formants in this case however is dictated by the data and is changing throughout the performance. Examples can be heard in speakers 1 and 6.

4. Frequency Modulation (FM). The fundamental frequency was fixed and the modulation depth and frequency was chosen by the data. This technique allows rich harmonic sounds to be generated in a very simple way. Examples are in speakers 3, 4, 8 and 9.

5. Simple Audio gate triggering. This technique was used most notably on the ECG heartbeat data to trigger a bass drum sound for each beat of the heart. This track can be heard directly above the studio in speaker 15 mounted on the ceiling.

3. SPEAKER MAPPINGS

The sound files are mapped to the speakers with the same number. e.g. payling01.wav is played through speaker 1, payling02.wav is played through speaker 2 etc.

A full listing of sound file to speaker number mappings is shown in Table 1.

Audio File Name	Speaker Number
payling01.wav	speaker 1
payling02.wav	speaker 2
payling03.wav	speaker 3
payling04.wav	speaker 4
payling05.wav	speaker 5
payling06.wav	speaker 6
payling07.wav	speaker 7
payling08.wav	speaker 8
payling09.wav	speaker 9
payling10.wav	speaker 10
payling11.wav	speaker 11
payling12.wav	speaker 12
payling13.wav	speaker 13
payling14.wav	speaker 14
payling15.wav	speaker 15

Table 1. Sound File to Speaker Position Mappings

Fifteen sound files were produced from various data sets taken from 26 sensors laid out in the 10-20 standard for EEG placement [7] and other physiological activity sensors [1]. The sound files were located at speaker positions which would give maximum spatialisation possibilities and also to locate the sound in a similar proximity to the sensor positions. Table 2 gives a full breakdown of the data sets used, how they were mapped to sound synthesis parameters and to which audio files they relate to.

File Name	Data Set	Parameter Mapping	Comment
payling01.wav	Fp1	Formant 1	Formant vowel synthesis technique. Frontal data sets used for formant positions, ECG data for amplitude envelope.
payling01.wav	F7	Formant 2	
payling01.wav	F3	Formant 3	
payling01.wav	Fz	Formant 4	
payling01.wav	FCz	Formant 5	
payling01.wav	ECG	Amplitude	
payling02.wav	VPVA	Amplitude	Granular manipulation of a sound file speaking 'listen'. Glissandi translates to pitch and index is sample position.
payling02.wav	VNVB	Glissandi	
payling02.wav	HPHL	File Index	
payling03.wav	T3	Modulation Depth	Simple FM Modulation using 2 oscillators. Fundamental pitch fixed at 100 Hz
payling03.wav	Mass	Modulating Frequency	
payling04.wav	T5	Modulation Depth	Simple FM Modulation using 2 oscillators. Fundamental pitch fixed at 100 Hz
payling04.wav	Mass	Modulating Frequency	
payling05.wav	O1	Glissandi	Granular manipulation of a sound file speaking 'ICAD'. Glissandi = Pitch Shift, index = sample position
payling05.wav	Oz	Fundamental Pitch	
payling05.wav	Erbs	File Index	
payling06.wav	Fp2	Formant 1	Formant vowel synthesis technique. Frontal data sets used for formant positions, ECG data for amplitude envelope.
payling06.wav	F4	Formant 2	
payling06.wav	F8	Formant 3	
payling06.wav	Fz	Formant 4	
payling06.wav	FCz	Formant 5	
payling06.wav	ECG	Amplitude	
payling07.wav	Oz	Fundamental Pitch	Granular manipulation of a sound file speaking 'ICAD'. Glissandi = Pitch Shift, index = sample position
payling07.wav	O2	Glissandi	

payling07.wav	Erbs	File Index	
payling08.wav	T6	Modulation Depth	Simple FM Modulation using 2 oscillators. Fundamental pitch fixed at 100 Hz
payling08.wav	Mass	Modulating Frequency	
speaker 9	T4	Modulation Depth	Simple FM Modulation using 2 oscillators. Fundamental pitch fixed at 100 Hz
speaker 9	Mass	Modulating Frequency	
payling10.wav	HNHR	Index to wav file	Granular manipulation of a sound file speaking 'listen'. Index is sample position.
payling11.wav	FC3	1st Partial Strength	Additive Synthesis. 4 harmonic partials mapped from Front Left and Central probes, pitch varied by sweat response
payling11.wav	FCz	2nd Partial Strength	
payling11.wav	C3	3rd Partial Strength	
payling11.wav	Cz	4th Partial Strength	
payling11.wav	EDA	Pitch	
payling12.wav	FCz	1st Partial Strength	Additive Synthesis. 4 harmonic partials mapped from Front Right and Central probes, pitch varied by sweat response
payling12.wav	FC4	2nd Partial Strength	
payling12.wav	Cz	3rd Partial Strength	
payling12.wav	C4	4th Partial Strength	
payling12.wav	EDA	Pitch	
payling13.wav	CP3	1st Partial Strength	Additive Synthesis. 4 harmonic partials mapped from Left Rear and Central probes, pitch varied by sweat response
payling13.wav	CPz	2nd Partial Strength	
payling13.wav	P3	3rd Partial Strength	
payling13.wav	Pz	4th Partial Strength	
payling13.wav	EDA	Pitch	
payling14.wav	CPz	1st Partial Strength	Additive Synthesis. 4 harmonic partials mapped from Right Rear and Central probes, pitch varied by sweat response
payling14.wav	CP4	2nd Partial Strength	
payling14.wav	Pz	3rd Partial Strength	
payling14.wav	P4	4th Partial Strength	
payling14.wav	EDA	Pitch	
payling15.wav	ECG	Trigger for Kik Drum	3 cross faded files tracking heart rate and breathing. ERBS tracks through a sound file speaking 'Listen'
payling15.wav	ERBS	Index to wav file	
payling15.wav	Resp	SubBass Pitch	

Table 2. Table showing how Data Sets are mapped to the sound files and speakers. Column 3 shows the data sets which were used to create the individual sound files. Details of the sensor positions and data can be found in [1]

4. CONCLUSIONS

The biggest challenge in undertaking this composition was to generate variety from many data sets that contained similar values. This has been achieved by taking alternative approaches to sound synthesis, using similar parameters mapped to different sound qualities. It is hoped that the listener will be able to glean different information from different files but also to make the connection between them all. Furthermore mappings that are considered successful can be entered into the Sonifications Mapping Database for future reference. The musical merit of the piece is in the ear of the beholder, most benefit may be gained from moving around the studio to obtain several auditory ‘pictures’ of the music.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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