A Synthetic Cicada Soundscape Controlled by Breath

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Abstract

This paper describes an interactive installation featuring a generative soundscape with breath control, that aims to capture the feeling of being in a forest full of cicadas. Inspired by a period of deep listening to cicada stridulations – in which I found the spatio-temporal pulsation of the sound mass reminiscent of breathing – this installation uses breath control to give a sense of breathing with a forest. The sound mass consists of multiple generative sources, each loosely modelled on an individual cicada stridulating. Each 'cicada' comprises a temporal hierarchy of pulse trains modulating a carrier frequency, with a simple sonic spatialization algorithm applied to give the sense of immersion in the sound mass. The algorithm is implemented in the Extempore audiovisual programming language, and utilizes an architecture in which each sonic parameter is inherently stochastic, much as the sound production mechanisms of actual cicadas exhibit natural variation.

Keywords

generative, soundscape, ecoacoustics

1 Introduction

As I travelled and camped down the East coast of Australia this summer, a standout feature of the experience was the sheer volume of cicada stridulations [3]. The spatio-temporal pulsations of this sonic mass seemed musical in its phrasing, and felt to me like the sound of the forest breathing. In a literal sense our breath is entangled with the forest as we inhale oxygen that the forest has exhaled. This interactive sound installation is inspired by the notion of breathing with the forest, and aims to emulate that feeling through a breath controlled synthetic sound mass reminiscent of a forest full of cicadas.

The musicality of a cicada sound mass has been discussed by other authors, such as Steven Feld [2], and David Rothenberg [5], who goes as far as to claim that human rhythm evolved through long exposure to insect sonifications.

The intent of this installation is artistic and experiential, rather than an accurate emulation of the physical mechanisms of cicada sound production. The goal was to capture the essential features of the soundscape as I experienced it, and replicate this synthetically using a parsimonious generative model.

The purpose of creating a synthetic version, rather than using field recordings, was twofold. Firstly I was interested in understanding the essential features of the sound mass that I was experiencing. Creating synthetic versions of sound or music provides a means of interrogating their essential features. Secondly, creating a generative model facilitates parametric manipulation, and in particular allows for the external control of auditory properties of individual sound sources, that would be difficult to achieve using raw field recordings.

NIME '25, June 24–27, 2025, Canberra, Australia

2 Generative Model

A simple generative model of a cicada sound mass was implemented in the Extempore audiovisual programming environment [7]. The sound mass is comprised of multiple virtual cicadas, each with a simple sound generation algorithm. Each cicada source has a simple sound spatialisation applied, allowing for them to occupy perceptually different places in the sound stage, aimed at creating a sense of immersion.

There have been numerous investigations into the synthetic modelling of insect sonifications [1], which mostly aim at accurate reproduction. As mentioned above, the goal of this project was more artistic, and instead of aiming for fidelity to physical sound production mechanisms sought to parsimoniously capture the essence of immersion in the cicada sound mass as I experienced it, and particularly the feeling of breath-like musical phrasing in both the intensity and spatial distribution of the sound mass.

Brown et al. [1] noted "rapid envelope repetitions" as a salient feature of some animal sonifications, and this seemed applicable to the cicadas that I listened to. Cicadas generate sound through various mechanisms, including rapid contraction of the tymbal organ [8] and stridulation [4], which generate pulse trains [6], i.e. rapid repetitions of amplitude envelope pulses. The cicada's body acts as a resonator, so that the resultant sound roughly comprises a carrier wave (with frequency related to the size of the cicada) amplitude modulated by a series of pulse trains.

The approach I took in synthesising an individual cicada's sound was to modulate a carrier sinusoid with a temporally hierarchical series of pulse trains. The fastest pulse train corresponds to the rate of physical scraping of the stridulatory organ (or tymbal organ). Periods of stridulating appear to occur in bursts, which can again be modelled by a pulse train of longer period. And finally the volume of sonification seems to fade in and out slowly, with a pause in between, which can again be modelled by a pulse train of even longer period. Combining three levels of a simple pulse train amplitude modulation created a sound that seemed to me to capture some of the essence of an individual cicadas sonifications.

2.1 Stochastic Parameters

One salient feature of many animal sonifications is inherent natural variation. Cicada stridulatory organs have 'ribs' that create the sonic pulses as another body part is scraped over them. These ribs are not completely uniformly placed, nor is the speed of stridulation completely regular. On a larger temporal level, the rate at which bursts of stridulations are performed is also not completely regular. In order to capture the essence of this natural sound mass, I opted to create a sound processing architecture that utilises a fundamentally stochastic parameter as a basic unit.

The sound processing functions used in this generative soundscape are an oscillator (for the carrier wave) and a series of envelope modulators. Each of these is defined as a 'closure' in the Extempore language, and has parameters (such as frequency) either as closure variables or function inputs. Each time the value of a parameter is accessed, the returned value is the underlying stored value plus some randomly distributed noise (of specified distributional width). For the sake of efficiency, a simple binomial distribution is used to create a 'bell' curve, rather than using a normal distribution. This binomial distribution is achieved by averaging three random uniform numbers.

Full code for the generative algorithm is available at https://gitea.offig.com/lfsadmin/Cicadas.git

2.2 Pulse Train

The basic function from which the synthetic cicada sound is created is simply a train of 'raised cosine' pulses. The generative algorithm for an individual cicada comprises three levels of pulse trains of increasing temporal period.

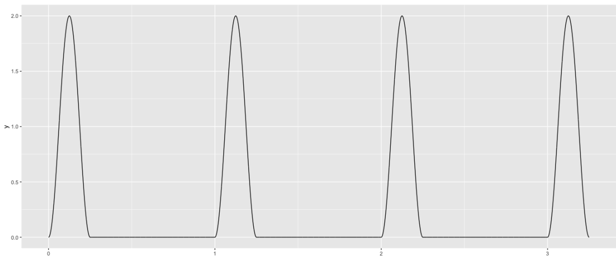

Figure 1: Raised Cosine Pulse Train

2.3 Spatialisation

To give the impression of being immersed in a forest of cicadas, the algorithm creates multiple individual cicada sound sources, and applies a simple spatialisation algorithm. This algorithm uses simple left/right delay and gain adjustment to give a sense of distance and position in the stereo field. Whilst rudimentary, this does give sufficient sense of space to create the desired feeling of spatially distributed individuals, and also the sense of fading into the distance and to the edges of the stereo field as the user breathes out.

3 The Breath Controller

The breath controller is a waist-expansion sensor, using conductive rubber with variable resistance on stretching, connected to an ESP32 microcontroller, which wirelessly sends OSC messages to a computer generating the soundscape. The raw sensor data is smoothed and subject to an adaptive trend detection algorithm. When the user is breathing out, the generative algorithm gradually moves the individual cicadas further away and towards the edges of the sound stage, and visa versa for breathing in.

4 The Installation

The generative soundscape and breath controller combined form an installation intended as a meditative experience for a single listener experienced through headphones. More elaborate incarnations of this installation would be possible. For example, instead of headphones, a multichannel speaker array could be used. The installation could also make sense as a multiperson experience, with multiple breath controllers. In this configuration, each listener might 'control' a single synthetic cicada.

5 Reflection

A demonstration of the installation is available at https://tobygifford.com/BreathingWithTheForest. My impression of the result is that it does succeed in capturing some of the essence of the natural soundscape as I experienced it, particularly the sense of breath-like pulsation. I had first imagined utilising more cicada sources. However, greater numbers of sources did not noticeably improve the overall impression of the soundscape. It may be that a multi-channel configuration of the installation with more sophisticated sound spatialisation would facilitate larger numbers of virtual cicadas without 'muddying' the soundscape.

Figure 2: The installation.

6 Conclusion

This paper has described a breath controlled interactive sound installation, that is intended to create a sense of breathing with forest, something akin to the feeling I get when listening to a sound mass of cicadas. It adopts a parsimonious model of cicada sonification, utilising three heirarchical layers of pulse train amplitude modulation of a carrier wave. All sonic parameters are inherently stochastic, to help create a natural sound.

7 Ethical Standards

No conflicts of interest are declared for this publication. This work involved non-invasive field recording of cicada soundscapes.

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