Microbial Sonorities

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Abstract

Microbial Sonorities explores the use of sound to investigate the bioelectric and behavioral patterns of microorganisms. The piece features a hybrid biological-electronic system wherein variations in electrical potential from an array of microbial fuel cells are translated into rhythmic, amplitude and frequency modulations in modular electronic and software-based sound synthesizers.

Introduction

Microbial Sonorities explores the use of sound to investigate the bioelectric and behavioral patterns of microorganisms. Based upon inquiries into emerging bioenergy technologies and ecological practices as artifacts of cultural exploration, the piece features a hybrid biological-electronic system wherein variations in electrical potential from an array of microbial fuel cells are translated into rhythmic, amplitude and frequency modulations in modular electronic and software-based sound synthesizers.

Research Focus

The research focuses on three primary areas: (1) *Microbial Fuel Cells (MFCs)*: these are devices that generate electricity from the metabolic reactions of bacteria found in diverse environments such as lakes, compost and wastewater. [1] (2) *Modular hardware and software synthesizers*: The bioelectrical fluctuations of the MFCs are used as modulation and trigger sources for a Eurorack-based modular synthesizer and/or a custom-designed software synthesizer built in Max/MSP (cycling74.com). This entails building electronic circuits to amplify the electrical signals generated by the bacteria and software to translate the signals into control voltage (CV) sources appropriate for the synthesizer. (3) *Machine Learning*: Machine-learning Algorithms are used as a way of interpreting the shifting electrical patterns generated by the

Fig 1. *Microbial Sonorities* installed at Washington State University, Pullman, Washington, USA in 2016. The modular synthesizers are shown in the center behind the microbial fuel cells.

bacteria. Pattern recognition/classification is used to trigger synthesizer presets and CV gate signals while statistical regression is used to predict variations in electrical potential. If a comprehensive understanding of the bioelectrical patterns can be attained, it will be used to inform the development of a sonic compositional system that is dictated by these patterns. In essence, allowing the bacteria to "express" themselves sonically.

System Overview

The current system set-up typically consists of four MFCs, a Eurorack modular synthesizer system, an Arduino microcontroller (arduino.cc) and the Max/MSP graphical coding environment (cycling74.com). The biomatter used for the MFCs is usually fresh compost or if possible, benthic mud from a local lake or other aquatic body. Voltage from each MFC is amplified and connected to an analog input on the Arduino. In some cases it may also be plugged directly into the control voltage input on one of the Eurorack modules.

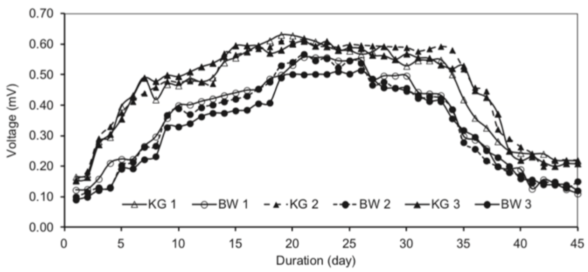

Fig 2. Typical voltage curves for a microbial fuel cell. The horizontal axis represents time (in hours) while the vertical axis represents voltage (in millivolts). Taken from [2].

The piece operates on two temporal scales. The first, which I call "immediate," consists of a simple linear mapping of voltage to pitch for each MFC. Transient voltage spikes are also detected and mapped to sound. The second time scale, "longitudinal," is a longer-term (24-48 hours) mixing of Eurorack synth patches. Each MFC is assigned a synthesizer patch according to its current "life stage." A life stage is simply a point in the overall voltage curve over which a typical MFC travels over the course of 24-48 hours before it "dies" (i.e. when the bacteria run out of organic matter to metabolize; see fig. 2). [2] Four life stages have been identified and assigned a synthesizer patch. A regression curve, using a neural network, was then created to mix/transition between the four different sounds/patches. Training data for the network was created simply by drawing a curve in Max's itable object that matches a typical MFC voltage curve. The x coordinates of the itable represent discreet time steps (0-50 hours), while the y coordinates represent voltages (0-1000 millivolts). While the piece is running, a running average of the voltage is kept for each MFC and sent out to the neural network application once every 30 minutes via OSC (opensound control.org).

Conclusions & Future Work

In addition to exploring different scales and construction materials for the MFCs, other features beyond voltage and electrical properties (e.g. chemical properties) are currently being investigated. Overall, the use of sound and machine learning as methods of bridging human and microbial lifeworlds and exploring the material agency of microorganisms continues to be an exciting area worthy of continued, playful investigation. More information on the project is available online at ccastellanos.com/ projects/microbial-sonorities/.

References

1. Bruce E. Logan, *Microbial Fuel Cells* (Hoboken, N.J: Wiley-Interscience, 2008).

2. M. Azizul Moqsud et al., "Bioelectricity from Kitchen and Bamboo Waste in a Microbial Fuel Cell," *Waste Management & Research: The Journal of the International Solid Wastes and Public Cleansing Association, ISWA* 32, no. 2 (February 2014): 124–30.

Biography

Carlos Castellanos is an interdisciplinary artist and researcher with a wide array of interests such as cybernetics, ecology, embodiment, phenomenology, artificial intelligence and transdisciplinary collaboration. His work bridges science, technology, education and the arts, developing a network of creative interaction with living systems, the natural environment and emerging technologies.

Castellanos is Assistant Professor and director of the Digital/Experimental Media Lab in the Department of Art, Kansas State University.