Sonic Transformation with Living Matter

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Abstract

Sonomatter (2017) is a sound installation and performance that transforms the bioelectrical signals from microorganisms into sound. This work starts with building Winogradsky Columns to make a small ecosystem out of mud and water and generate an electric signal with a Microbial Fuel Cell (MFC). As time proceeds, the microbes will create electricity and eventually die when they lack nutrients. A custom-designed *Bioelectricity-Controlled-Oscillator (BCO)* circuit converts the bioelectricity to sound at the same time, it consumes the (bioelectrical) energy to control the sound of the oscillator.

In this work, mud is seen as a matter that implies a circular relationship between life and death because life and death phenomenon happen in the same material. Mud takes in valueless things such as dead bodies and digest it into nutrients to grow living things. A poetics of microbial sphere can be described throughout the interaction between organic matters such as soil and water, and natural phenomenon such as respiration and oxidation in the mud. It describes a symbiotic relationship in a microcosm. The project is thus not only a metaphorical exploration of the interaction between living matters and natural phenomena, but it also explores the domain of energy harvesting as well as sonification.

Keywords

Microbial data transformation, BCO, sonification, biobattery, bioelectricity, control voltage, microcosm, Winogradsky Column, energy harvesting, dark fermentation

Introduction

Artworks using biomatters and living organisms have become very vigorous in recent contemporary media art. It seems to be a natural development stemming from an awareness of the ecological crisis, as well as the convergence of art and science which evolved into an artistic experimentation in new media and post media discourses. The concept of this project is post digital media – mixing different media [9] such as sound, analogue electronics, computer software and hardware and microorganisms – intertwine (wet) biological processes and (dry) technology [1]. In recent days, bioart is associated with technical and cultural boundaries of biology from speculative research to practical works. In this work, a biological material (soil/mud) has been translated into audible experience and this paper is to discuss its design and implementation as a work of art, *Sonomatter* where I utilize the bioelectricity, MFC, sonification and Winogradsky columns. Ecological perspectives such as sustainability of our biosphere, self-sufficient ecosystems, and energy harvesting domain are discussed as well. Also, I elaborate the audience responses from artistic presentations including festivals, exhibitions, talks and performances in Europe and South Korea.

Related Works

The theory of *Animal Electricity* by Luigi Galvani is the first scientific research about electrical potential in living organisms (1791). He discovered that frog legs twitched when a lightning rod is connected to frog legs.[7] Galvani's research around bioelectricity experiment was the origin of the current biosignal applications for medical purpose such as EEG, EMG and EOG.

In artistic musical works, Alvin Lucier premiered *Music for Solo Performer* in 1965. This piece uses an amplifier to pick up Lucier's brainwave signal to control the loudspeakers and percussion instruments. Lucier had to be in a meditational status in order for the amplifier to pick up alpha waves from his brain. Therefore, he explains sound as energy-controlled, non-deterministic translation which can be transformed by the performers' brain waves [5].

In recent times, there are many artworks of using MFC devices to implement bioelectricity. For instance, Gilberto Esparza used e-wastes and recycled it to make alternative energy in an urban environment contaminated by human beings. He found bacteria in severely polluted water in Peru and generated electricity to create light source for plants (algae). His work *Plantas Autofotosintticas (2014)* demonstrates an eco-friendly, self-sufficient, and self-energy circulation system that can generate photosynthesis from feedback.[4]

Guy Ben-Ary's artwork *CellF (2016)* uses cell's chemical activities (bioelectricity) to create an autonomous musical instrument. He extracted his own skin cells, turned them into stem cells, and then transformed them into a neural network. The neural network grew on a MEA (Multi-Electrode Array) system which has 60 electrodes and is connected to a custom-built analog synthesiser.[2]

Sonomatter

Sonomatter is an interdisciplinary project that uses a methodology from diverse fields: microbiology, sonification, MFC, and sound art. This project focuses on transforming a bioelectrical signal from soil bacteria into sound, connect-ing living matter to an analog circuit board and biological data to human perceptional experience. This project started with making a small ecosystem out of mud and water (Wino-gradsky Column) and measured the electrical signal with a Microbial Fuel Cell (MFC). A customized Bioelectricity-Controlled-Ociallator (BCO) has been designed to use bio-electricity to control the oscillator as a CV (Control Voltage). This work aims at creating a sonic transformation of living matters in real-time that can be a self-sustainable and reusable similar to a biobattery.

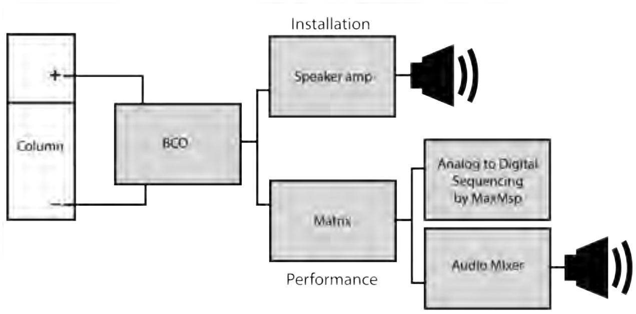

Figure 1: Sonomatter setup diagram for Installation and Performance.

Bioelectricity and Microbial Fuel Cell

Bioelectricity refers to electric potentials and currents produced by living organisms. A microbial fuel cell (MFC) is a device that converts bio-electrochemical to electrical energy by the metabolic activity of microorganisms. The bioelectricity is constructed by using an anode and a cathode. Most of MFC models have a membrane between two compartments, oxidation occurs on the anode side and reduction occurs on the cathode side. The electrical potential or charge occurs in between the anode and the cathode, and can be measured by connecting these two electrodes. This device is considered as *biobattery* that can store energy powered by organic compounds. A MFC device has been installed in each Winogradsky Column to create a complete self-harvesting energy system and to operate the BCO circuit that can variate the sound of the circuit. The variation depends on the amount of electrical energy (voltage, current) generated from microorganisms in Winogradsky Columns.

The bioelectrical signal from the soil microbes in a Winogradsky Column ranges from few millivolt (mV) to 1.127 volts (V) in my experiment and it maintains an average range between 0.5V and 0.7V for more than a year so far.

The bacteria grow based on two molecules – oxygen and hydrogen sulfide. And these two sections are also divided into anaerobic zone and aerobic zone. An anode is placed in anaerobic zone and a cathode is placed in aerobic zone, in the

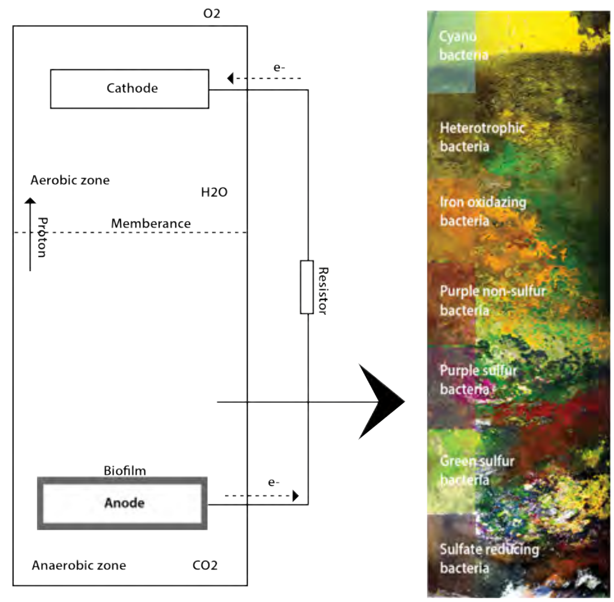

Figure 2: A MFC design and bacteria layers in Winogrdasky Columns.

water on the top of the columns. The MFC creates electricity basically by oxidation of bacteria on the electrodes which cause to form a biofilm. Higher power production was observed when biofilm formed on a graphite anode. To utilize higher voltage, *Sonomatter* uses 99% carbon felt electrodes. Carbon felt electrodes are used to avoid corrosion and chemical reaction from electrode material as well as to facilliate forming the required size. Bigger electrodes produce bigger current, but the size of the electrode is not related to the amount of voltage. I made different anode electrode sizes that has a thickness of 6.35mm. The sizes differ from 1cm x 1cm to 8cm X 8cm.

Winogradsky Column and Microbial Fermentation

In this project, soil bacterial activity demonstrates the self-regulation between different kinds of bacterial growth based in anaerobic zone and aerobic zone. The whole fermentation process in the mud shows a significant amount of life activities that can illustrate a prosperity of microscopic world.

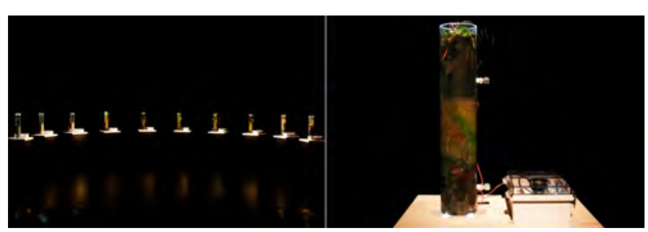

Figure 3: Sonomatter installation in Seoul, South Korea. Photo by Sey Parc.

In order to culture different types of microorganisms, I made Winogradsky Columns invented by Sergei Winogradsky (1856-1953) [3]. Winogradsky column is a microbial garden that can grow a much larger number of microbes than normally found in nature. For this project, I designed custom-made transparent cylinders, and made ten columns measuring 50 cm in height in South Korea and ten columns measuring 30 cm in height in Netherlands and Austria. In order to make a mud base, I mixed mud with carbon sources such as newspapers and sulfur sources such as egg yolk and cheese. The rest of the bottle is filled with collected mud and water. After incubating these columns under sunlight for one to three months, it goes through chemical processes that allow the growth of different microorganisms such as Clostridium, Desulfovibrio, Chlorobium, Chromatium, Rhodomicrobium and Beggiatoa, as well as many other species of bacteria, cyanobacteria, and algae – colors can be visible to human eyes. [6]

Sonic Transformation and Bioelectricity-Controlled-Oscillator (BCO)

A methodology of sonification is used for translating the electrical energy of microbes into sound, with a focus on transforming imperceptible data to acoustic signal. In order to perceive the micro-bacterial activity, I developed a module, called BCO that can convert the bioelectricity into sound in audible scale. In the process, I tried to avoid using computational processes and artistic compositional decision to minimize the manipulation on the data of the bioelectrical signal. As a result, the BCO is different from signal processing in computational environment. A physical circuit board translate the biosignal from microbes through an amplifier and an oscillator with simple controls. It has two knobs to control the amount of electricity from microbes and pitch of the oscillator.

Figure 4: Circuit box. Photo by Sey Parc.

In terms of a mechanical design of the BCO, it uses bioelectricity as control voltage to operate an oscillator. Control Voltage (CV) is a direct current (DC) electrical signal, used to control the values of components in analogue circuits the same function as any other electronic music instruments such as synthesizers, drum machines and sequencers.

In the circuit, I placed an instrumentation amplifier chip for amplifying bioelectricity. The amplified energy is connected to a Hex Schmitt oscillator chip and the amount of bioelectrical voltage influences the pitch and duration (pulse).

For the performance setup, I use these two potentiometers and a matrix interface (DIFAS) developed by Lex van den Broek [8] for sequencing with ten columns. This device can convert analogue signal to digital signal, and the incoming signal to BCO circuit can also be routed to the computer musical software MaxMsp. This setup is only for the performance to make fast sequencing between columns. For the installation, no additional computer musical software is used and the sound comes from the built-in speakers of the circuit boxes.

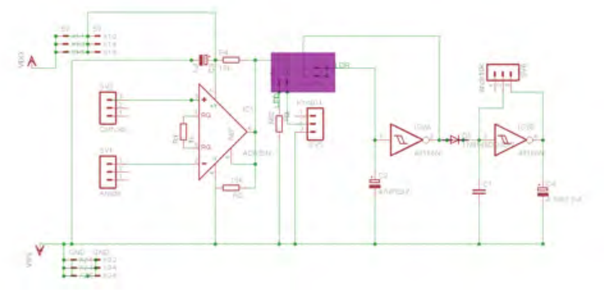

Figure 5: The BCO circuit consists of two parts: oscillator (CD40106BE) and instrumentation amplifier (AD620). There are two potentiometers (1K Ohm, 10K Ohm) to control the energy and pitch respectively: one to control the amount of energy from the bioelectricity and the other one is for the pitch of oscillator.

Figure 6: Matrix: Digital Interface for Analog Signals by Lex van den Broek. Photo by Sey Parc.

Artistic Representation

Sonomatter has been shown in many different artistic events such as exhibitions, festivals and performances in South Korea and Europe. I typically utilize five to ten columns. I have found that the sound is getting slower as time proceeds because microbial process takes more time to generate electricity than normal electricity generation. However,

after disconnecting from the circuit for eight to ten hours, bio-electricity level is back to normal value.
For the performance, I tested several different setups with and without a visual projection. For the sound, I controlled the pitch and pulse by controlling the amount of bioelectri-cal energy from microbes of each columns. Also, by adding more bioelectrical energy such as putting my fingers or dis-connecting and connecting a cathode, the value of bioelec-tricity is changed and this is directly connected to the sound. The higher voltage makes faster pulse and the lower voltage makes the slower pulse. For the visual element, I used an en-doscope camera to project flickering LED lights and explored the interior of the columns. LED lights are placed under a wooden frame which made for mounting a column and it is synchronized with audio signal.

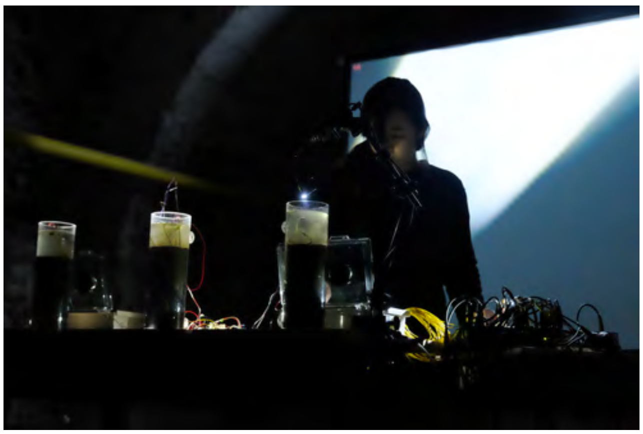

Figure 7: Sonomatter performance in Linz, Austria. Photo by Florian Voggeneder.

I have also performed a toxicity test. After injecting 1mm of Clorox onto the anode, the voltage dropped immediately to almost zero and the BCO circuit could not measure any voltage from microbes. However, the voltage value is gradually increased and reached its normal value again after two days. I tried to use this dramatic change during the performance, but I decided not to add this to maintain the columns for a long time.
The responses from the audience of my work is positive. Also, people remained in the exhibition space for a longer duration of time as the sound from each column made harmony and echoed magnificently, creating a certain meditative atmosphere. I also sometimes guided the audience to interact with bioelectricity from the columns by touching the surface of water or the cylinders. Such interaction can make different speed of sound instantly. In doing so, audience can understand how the mud makes the sound through the circuit.
The audience from the sound and music domain wanted to focus on the details of a sound structure. They preferred to listen only to the sound instead of the visual projection. An electronic music teacher in the Netherlands said a sonical dynamics of this work is interesting because it is from a very small range of scale, normally between 0.6v and 0.7v. Also another member of the audience in South Korea has said that the performance was like a microbial orchestra where I was the conductor controlling the each individual column, similar to being a pet trainer.

Figure 8: The audience after performance in Seoul, South Korea. Photo by Sey Parc.

Acknowledgement

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