Title

THE WAY PLANTS SING: DATA SONIFICATION AND GENERATING MUSIC THROUGH BIOELECTRICAL RESISTANCE

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THE WAY PLANTS SING: DATA SONIFICATION AND GENERATING MUSIC THROUGH BIOELECTRICAL RESISTANCE

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ABSTRACT

Data sonification is the translation of any set of data into sound. There are functional applications of this, such as heart monitors and morse code. In this project, I wanted to delve into the artistic application of data sonification. Specifically, I was most intrigued by devices that integrate data from plants. Some of these devices include MIDISprout, Music of the Plants, and some modular synthesizers. Inspired by these products, my goal in this project was to engineer a device that takes the bioelectrical resistance of plants and converts it into music within a digital audio workstation.

Once finalizing the device, I recorded four tracks of raw data. These four tracks all totalled to approximately fifteen minutes, two of which coming from a healthy snake plant and another from a snake plant on the brink of death. One of the two tracks per each plant was a MIDI recording of the plant in isolation, while the other was a recording of the plant being interacted with. This was to observe how the MIDI data changed depending on how often it was touched and how healthy it was.

This paper discusses in detail the importance of integrating data sonification into contemporary musical pieces, the process of engineering the device, and the compositional approach to the recordings.

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BEGINNING

This creative project was developed in hopes of defying the musical status quo, and de-programming composers of societal expectations that come along with music making. Essentially, the intention is to twist the common composer's game of playing with musical predictability and unpredictability, letting both of these elements exist on higher thresholds. As a songwriter, composer, and producer, I have been given the opportunity to explore many genres of music through composition. Whether I gain a greater understanding of these styles through instruction or hands-on experience, there is an unspoken standard that makes most of them similar. This would be the concept of full compositional control over every aspect of the music creation process.

There are several examples of this in action. Music students in higher education are typically given set guidelines for classical form, chord progressions, and proper counterpoint. Pop songwriting projects also have sets of chord progressions and common forms. With these standards in mind, it is up to the music makers to make each musical decision. If a composer is writing a solo violin piece, she or he must write the melodies, dynamics, tempo, meter, and key within the score. Even in collaborative studio settings, each member of the group controls one aspect of the track, such as delegating performance, writing, mixing, and mastering to different members.

Given this common mindset in music-making, I found it very intriguing to delve into a musical realm that rejects this principle and promotes greater creative exploration. Aleatoric music is an established genre of music defined by granting compositional elements to chance. One famous example is "Birds on a Wire" by Jarbas Agnelli. This piece was composed by creating a visual parallel between a power pole and the treble clef. The power pole Agnelli observed had five horizontal and parallel wires, which was very similar to the five lines on the treble clef. He captured an image of this power pole when many birds were sitting on it. Wherever the birds sat on the wires represented a note on the treble clef. The aleatory nature of the piece is demonstrated in the way that the music was generated by a visual out of Agnelli's control.

Another example of aleatoric music is La Monte Young's "Piano Piece #1 for Terry Riley" text score. Characteristic of the musical era it arose from, which is Fluxus, La Monte Young simply instructs the pianist to push the piano into the nearest wall as hard as physically possible. All notes that are pressed or extended techniques technically occurring happen in the music. It is instructed in the score that even if a wall breaks, you must continue to push the piano forward. Nothing relating to sound is planned in this circumstance. The music arising from this situation that La Monte Young has created is not deliberate and outside of the performer's control if the performer is honoring the piece fully.

Though both of these pieces tend to lean towards full randomization regarding the music generation, this genre of music can exist on a spectrum of randomization. This is what makes a technique in aleatoric music composition called limited randomization possible. Limited randomization is defined as taking one or more elements of the piece to randomize as opposed to randomizing the full composition. This method I found to be the most intriguing because it directly challenges the composer to create *with* generated music as opposed to exclusively making something that generates music.

How can limited randomization in music be manifested in the electronic music world? One method is through data sonification, which can be defined as translating data into sound (Schedel). Essentially, data analysts and composers alike can extract any set of data and assign each of the results to a specific musical element. There have historically been functional purposes for data sonification. One of these examples includes heart monitors or EKGs. Each heartbeat by the patient that is hooked to the machine elicits a beep (Schedel). The intention for this is to allow nurses to hear if there are any life-threatening irregularities with the patient's heart while still being able to perform other necessary tasks (Schedel). Morse code is another tried and true method of data sonification (Schedel). By translating each letter of the alphabet into blips of sound, secret messages can be communicated only to those who understand (Schedel).

Though these are practical functions of data sonification, there are endless possibilities for artistic applications as well. A great example of this is NASA's Exoplanet Discovery data sonification video (5,000 Exoplanets). Over the course of thirty-three years, NASA has discovered five thousand exoplanets. The data that NASA used in this instance was the date and location for each of the exoplanet's discoveries, with the first discovery being around thirty-three years ago in 1991. For musical reasons alone, NASA made each of the planets represent a pitch on a synthesizer and the year of discovery contributed to the timing of the note. This resulted in an ethereal composition accompanied by a beautiful visual of space.

I found data sonification to be the most fascinating way to approach limited randomization through composition, though some specific examples caught my attention. I gravitated most toward data sonification projects that involved plant data. Some of these projects involve modular synthesizers, but considering that I work primarily in music production software, I wanted to make something that could work with any instrument in my software instruments. That's how I discovered devices such as MidiSprout, Music of the Plants, and PlantWave. These devices take information from plants via electrodes and convert that into audible sound. I found the concept really to be full of artistic potential and wanted to learn more about how it is accomplished.

To understand the basic premise of the device, an understanding of some electronic terminology is necessary. The information that devices such as MidiSprout, Music of the Plants, and PlantWave are collecting is electrical resistance. This indicates the measure of opposition to the flow of electricity within conductors. This would be considered an analog signal as opposed to a digital signal. This electrical resistance needs to be translated into digital signals that my computer can comprehend as musical pitches. These digital signals are known as MIDI signals or musical instrument digital interfaces. Understanding these concepts, the core objective of this device is to convert the electrical resistance of plants into MIDI data.

Knowing that making this device is possible, what is the reason for pursuing it in the first place? In self-reflection, I have found three core reasons. Starting this project, I held no experience in electrical engineering and very minimal experience in coding. As a producer, having a greater understanding of music technology would make music-making much more intuitive. It grants the possibility for me to create more MIDI devices in the future with controls up to my preference as a composer. Another reason is the expansion of my creative limitations. With roots in the pop songwriting world, playing with a method that would defy song structure and chord progressions would give me a challenge.

One of the biggest flaws with this approach is the price of these instruments. Considering the creative liberty and inspiration that these devices grant, I wanted to make one myself that can allow myself and others to create. The idea of taking one signal and converting it into another has been done a thousand times over. Realistically, I knew that I could make one of my own. In that process, I can make a device that would serve small artists who are not able to afford the shiny manufactured devices that I found inspiration in.

In regards to the project as a whole, the device itself is one pivotal step in the right direction. After making the device, I wanted to demonstrate what the raw data sounds like as well as how the technology can be applied in full compositions. As a whole, the project would be a device that allows for the bioelectrical resistance of plants to be converted into MIDI and musical evidence of its functioning and artistic application. This evidence would include four raw MIDI recordings of a plant, as well as two compositions that are built upon these recordings.

There were four necessary steps for me to execute this project. Of course, I would initially need to create the prototype for the device which was converting signals. Considering my minimal experience in music technology, this would end up taking the bulk of my research time in learning the fundamentals of electrical engineering. Once the device was functioning and accomplished what I needed it to do, I could choose the plants to record for my raw data. I decided to choose two snake plants, one that was lively and one that was dying, to compare the raw data. I did two recordings of each plant, one where I left it isolated and another where I touched it repeatedly. After comparing and completing these recordings, I needed to take the bulk of these recordings to chop up and layer artistically for my compositions.

The components of the device are functionally separated into two main categories: hardware and software. The hardware of the device relies on two parts primarily: the computer chip and the breadboard. The breadboard is essentially a hub for all connections between electronic devices, inputs, and outputs. The computer chip that I chose for this was the Arduino Leonardo. The reason is this is a chip that allows for MIDI connections, and one part of a company that is loved by MIDI controller engineers (the company being Arduino). The connection is then made possible through the wire connections between these two pieces.

A clip soldered to one end of the wire is connected. The other end of this wire has been soldered onto a custom potentiometer. A potentiometer is an electronic component for breadboards that allows for manual changes in the electrical resistance entering. Examples of these include knobs and faders on a mixing device. I decided to purchase a rotary potentiometer (a knob) and physically remove the hood. Beneath the hood was the metal center of the potentiometer that reads the varied analog signals depending on how the knob is rotated. Considering there was no more knob, I soldered this wire to that metal center. I then connected the potentiometer to the breadboard by sticking its three pins into the terminal strip. This was when I had to grab three wires and stick one in each of the rows in alignment with the three pins. One wire connected the potentiometer's ground pin to the ground on the breadboard bus strip, another from the power pin to the power on the bus strip, and the wiper pin to the Arduino.

Connecting the wiper pin to the Arduino Leonardo is what makes the connection between the breadboard and the computer chip. Putting the wire from the wiper pin into A0 on the Arduino will be important regarding the coding later on. The connection between the Arduino Leonardo and the breadboard was finalized by using two wires to connect the bus strip of the breadboard to the chip. One wire stuck in the ground was connected to the Arduino's ground, while the other wire was stuck into the power supply and connected to the Arduino's power. The physical aspect of the Arduino is accomplished.

The software is then coded into the Arduino Leonardo chip. Having no experience with coding, I took to YouTube to learn from MIDI expert The Nerd Musician on how to program a MIDI controller. The way a link between the physical device and digital audio workstation is made is through an Arduino IDE (Silviera). The Arduino IDE is a program that serves as a headquarters for coding Arduino-compatible devices and uploading said code onto devices (Silviera). Through these videos, I understood the fundamentals of reading C++ code and how certain functions contribute to my desired objectives.

Though I understood the basic concepts, I was pursuing an unconventional project that didn't have an exact precedent. I needed advice on how to expand on these basic concepts to develop the prototype. Thankfully, David of Industry Coder was willing to have a one-on-one discussion with me in regards to reviewing the code I had at the time. I was clueless about the fact that I had not included a proper midi event packet in the code (David). An event packet is a string of code that defines the intended function of the code. In this instance. the event is clarified within the realm of midi events.

Once finalizing the code, I was able to pursue the artistic endeavor of this project. I purchased the two snake plants and recorded them for fifteen minutes twice. The first recording for both of the plants was in complete isolation, meaning the plants were far away from any sort of contact. The second time both of the plants were recorded with constant, repetitive contact from me. This means I was poking and grabbing the leaves of the plants for fifteen minutes each. Changing the conductivity by introducing another conductor into the mix (me) resulted in much more dynamic and interesting midi note generations. The differences were minute regarding the way the healthy and unhealthy plants reacted to both circumstances.

The final aspect of the project was taking my artistic spin on these recordings. With the two recordings, I was able to make two compositions. One is with the data from the lively plant, one is with the data of the dying plant. I layered the MIDI recordings of each plant when they were touched and untouched. The untouched recording serves as a bass drone in both pieces. The recordings of the touched MIDI were sampled and cut into different sections of the composition. On top of this, I layered audio samples to create more sonic textures and interest. Most of these samples were either percussive or foley, such as screams, fire, and water sounds.

Ultimately, this was all to prove that engineering a device that can convert the electrical resistance of plants into music is possible. This also demonstrates how this data can be applied by composers to create music that would have been unexpected before. Though I achieved my objective, this is only the beginning of this project. I will work towards isolating the electrical resistance from surrounding electromagnetic forces and condensing the size of the device, working towards making musical data sonification even more convenient and possible.

LIVELY PLANT MUSIC:

https://soundcloud.com/ronna-zon/lively-plant-final/s-GdeiwKjtpVV?si=a0345c291ef24f61970e4a42ab5558ac&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing

DYING PLANT MUSIC:

https://soundcloud.com/ronna-zon/dying-plant-final/s-567ZA3tc6iA?si=da69438840ab4fbb824151c9302f59b0&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing

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