The Living Sonic Organism:

An Interactive Live Performance Audio System

by

NUM

Abstract

The Living Sonic Organism (created by NUM) is an effort to create a live performance system borrowing features from different disciplines in sonic arts and employing multiple audio techniques. The project involves an immersive interactive sonic arts system that combines aspects of sound installation, interactive lighting design, and live sonic arts performance. The completed system was demonstrated with a live performance including three performers from different disciplines in music. The main idea of this project is to create a system that brings together elements from different concepts in sonic arts such as spatial audio, generative music, interactive audio system, and electroacoustic music. The system can be described as a living organism which interacts with the audience while being controlled by both humans and machines in real time. NUM designed a sonic environment which is alive and running from the very first moment that the audience enters the venue until they leave; a hybrid human-machine controlled system that can project sound through the performance space. In addition to sound art and digital audio, this project examines the relationship between sound and lights in music performances and how the use of lighting in live music can enhance the audience’s experience.

Chapter 1

THE LIVING SONIC ORGANISM: SYSTEM BREAKDOWN

The Living Sonic Organism is a hybrid human-machine system that can be employed as an audio system for sound installations as well as serving as a platform for live music performance. The principle goal for this system is to create tools and machines that can be used by sound artists, electronic musicians, instrument players and singers. The other important part of this system is the role of the audience who can participate in the performance through interactive interfaces and stations. The last part of this organism is the interactive lighting system which is in a direct relationship with the sound. The system, as its title proposes, is an organism consisting of the audience members, performers, and all the machines involved. Each of the parties have their own role in this living organism.

The system is designed in a way that makes it flexible for adaptation in different venues and facilities. The Living Sonic Organism can be customized depending on the venue's size, number of lights and speakers, and the number of interactive stations related to the size of the audience and the configuration of the space. The system is also flexible regarding the format of installation and/or performance as it is a hybrid of different disciplines in sonic arts.

1.1. Blocks of the System

To describe the system's mechanism, it is necessary to break down the system into its essential blocks and consider the communication between each block. The diagram below (see Figure 1.1) shows the main modules of the system, connections between the blocks, different analog and digital signals and their flow, and the role of performers and audiences in the system.

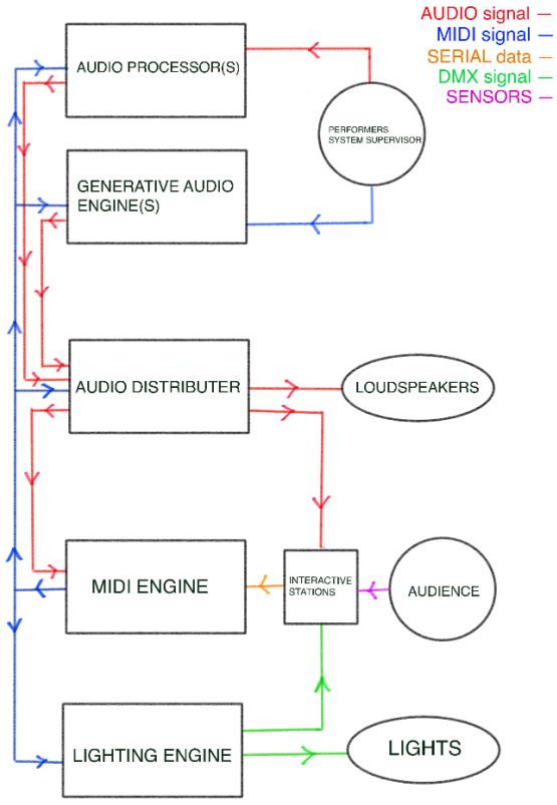


Figure 1.1 Blocks of The Living Sonic Organism

Each block can be modified based on the facilities available to the system designer. The same system flexibility applies to the numbers of loudspeakers, lighting fixtures, and interactive stations. The premiere performance of this system, which will be described in detail in next chapter, is one of the multiple possibilities that The Living Sonic Organism provides.

1.2. Audio Processor(s)

Audio processors function to receive and manipulate acoustic sources such as music instruments and voice. The other role of the audio processor is to combine the acoustic sound with the other prepared audio and live electronic sounds. Manipulating acoustic sounds in real-time and playing them back in space is one of the tools that makes this system interactive. For instance, a dialogue that can be built up between an instrument player or a vocalist with their manipulated sound and spatialized by the system, is one the benefits of having audio processors as a main block. The diagram below (see Figure 1.2) gives us a general view of the audio processor module and its various parts.

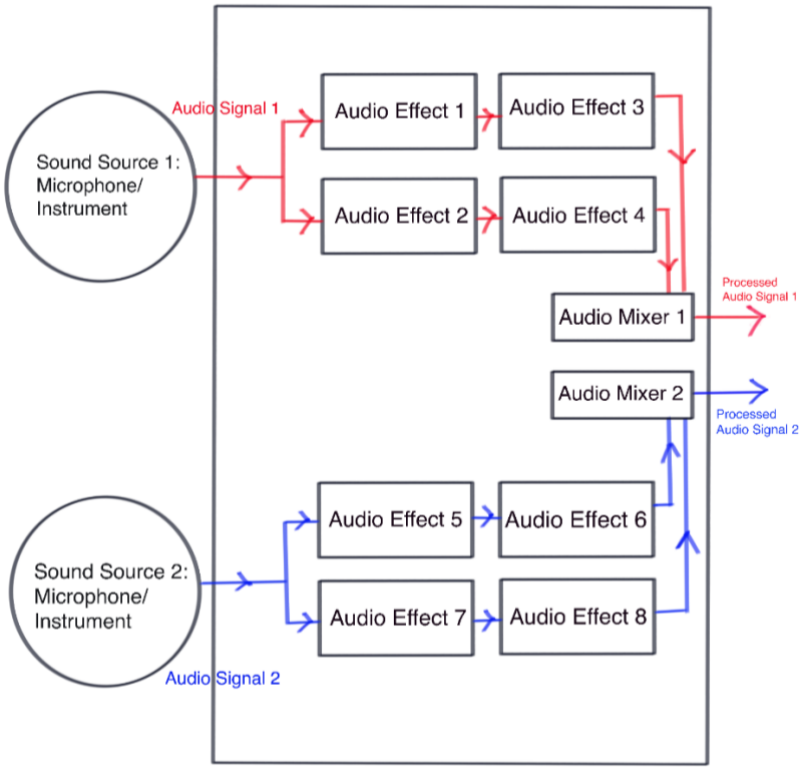


Figure 1.2 Audio processor module

Like other system blocks, the audio processor module can be modified depending on the performance design. For instance, it can contain more or less audio effect blocks, or it can accommodate multiple audio inputs and outputs. Types of the digital audio effects being used in the processor module also depends on each individual project that uses the system.

1.3. Generative Audio Engine(s)

This block of the system is formed by several generative audio engines that can be fed by audio samples or synthesizers in order to create non-stop sonic textures, generate rhythmic patterns, layers of melodies and harmonies, or textured noises. The following diagrams show the generative audio module in detail and the types of machines that have been created for the first version of the project. Generative audio engines can be used in both performance and installations modes of the system; however, they are the tool for creating stand-alone sound installations by The Living Sonic Organism.

1.3.1. The Generative Drum Machine

Inspired by the classic drum machines which play a significant role in electronic music history, NUM created an engine which can generate an ever-changing stream of rhythmic patterns, so-called electronic beats. This machine, created in the Max for Live platform, can be fed by a maximum of 16 audio samples or synthesizers to create generative rhythmic patterns. There are some controls regarding the functionality of this generative drum machine. One is the speed control, and the other is the ability to control various elements of each sample via MIDI.

The generative drum machine is formed by two parts: the generative MIDI sequencer that generates MIDI notes (developed in Max for Live) and a virtual container for storing the 16 individual audio samples (created in Live) to be triggered by the MIDI notes received from the MIDI sequencer (see Figure 1.3). Simply said, the generative drum

machine is a virtual drummer that plays ever-changing rhythmic patterns out of the audio samples that user uploads to the machine in advance.

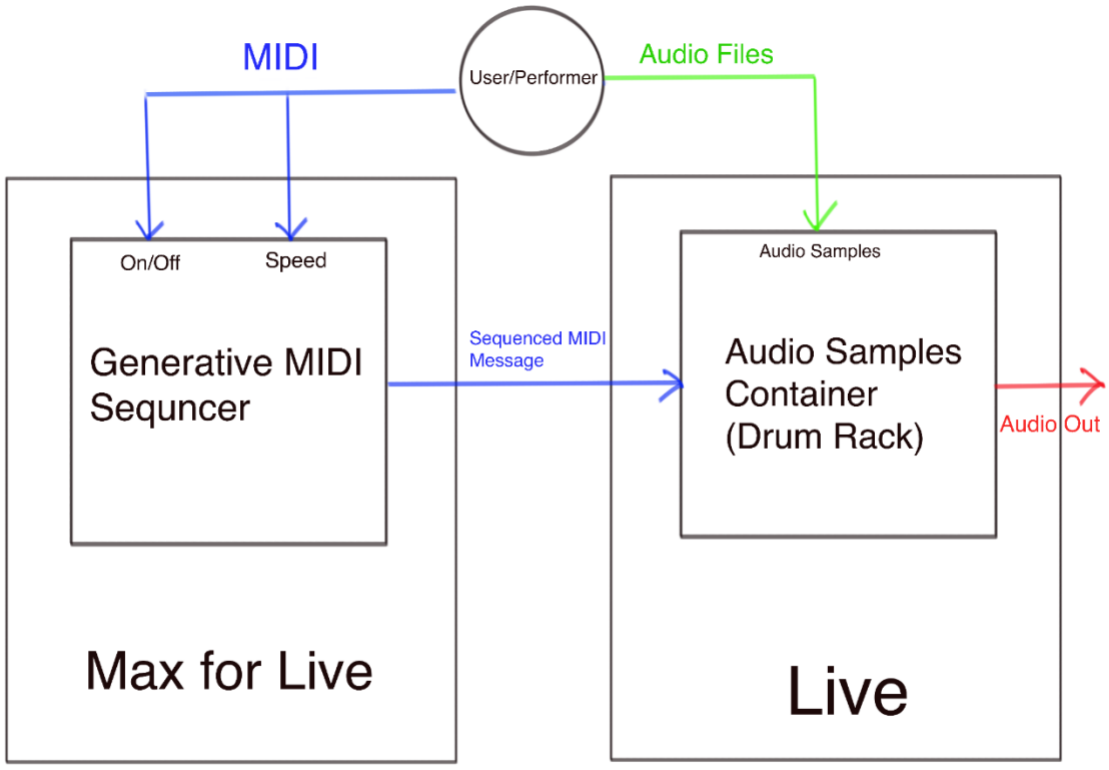


Figure 1.3 Blocks of the generative drum machine

The virtual audio container that is used for this machine is called “drum rack” which is one of the virtual instruments provided by Live (see Figure 1.4). It is possible to add audio sampler or synthesizer to each of the blocks of the drum rack and create rhythmic patterns with the help of the generative MIDI sequencer. Each of the blocks of the drum rack can be triggered by a unique MIDI note; this is how the MIDI sequencer created in Max/MSP talks with the drum rack in Live.

Figure 1.4 Generative drum machine in Live

1.3.2. The Texture Machine

The Texture Machine is a rhythmic patterns generator like the generative drum machine, however, there are some major differences between the two. Firstly, the Texture Machine can be fed by 112 audio samples instead of 16: Secondly, the number of samples being used can be controlled by the artist; and lastly, the user can scroll through the audio samples. These possibilities make the Texture Machine a flexible tool to create generative soundscapes, elaborate rhythmic patterns, drones, or complex harmonic textures. The Texture Machine, like the generative drum machine, uses Max for Live as the main platform and has the same control procedure in Live for use by a performer (see Figure 1.5).

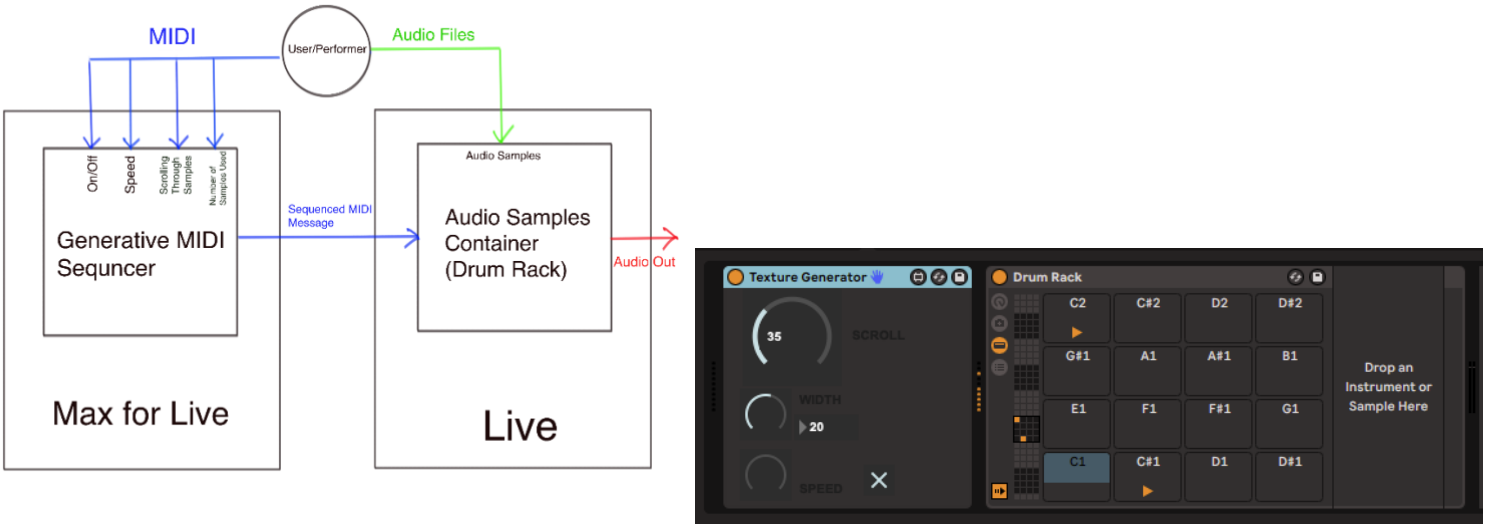


Figure 1.5 Blocks of the generative texture engine and the module in Live

1.4. Audio Distributer

The audio distribution module is the heart of the audio system. Depending on the size of the space and number of interactive stations, the audio distribution block is the place where all audio sources are being integrated and distributed in the space. We used Live for the spatial audio distribution in the premiere performance, however, it is possible to use other platforms for the spatial audio distribution, as there are situations where the space/venue has its own installed spatial audio system using platforms other than Live. For instance, it is possible to use platforms like Logic Pro, Spat Gris, Reaper, or Max/MSP for the spatial distribution.

1.5. The MIDI Engine

The MIDI module is a hub to generate, convert, send, and receive MIDI signals. The very first role of this module is to receive serial data from the interfaces in the interactive stations and to convert them into MIDI signals. These MIDI signals can then be used to

trigger audio and lighting components in order to make the stations interactive for the audience members. The process of receiving serial data and converting it into MIDI signals takes place in Max/MSP. This process, which will be reviewed in detail in the following sections, is the process of receiving the sensors data from the interactive stations through serial communication and converting those numbers into MIDI notes and messages. These MIDI signals are then used in Live for control of the audio part and in QLC+ for the lighting part of the interactive stations.

The other type of conversion that is made in this module is an audio to MIDI conversion. We can measure loudness of an audio signal in Max/MSP and then when we have the loudness as a number, it can be converted into MIDI signal. Based on the number of interactive lights employed in the performance design, several audio sources can be assigned to individual lights. The audio to MIDI conversion and the distribution of this resulting MIDI signal is controlled in Max/MSP while the conversion of the MIDI signal into a DMX signal, which is compatible for lighting control, is controlled in the lighting engine that is built in the QLC+ lighting platform.

Other than the aforementioned roles, the MIDI module is responsible for receiving MIDI data from several hardware MIDI controllers and transferring them into other modules in Ableton Live. The number of MIDI control lines and types of parameters will be different based on the performance/installation design and performance space modifications.

1.6. Lighting Engine

As mentioned in the previous sections, QLC+ is the computer platform used in this system for communicating with the lights in the performance space. There are several types of lights embedded in this project. 1) Ambient lights give color and mood to different sections of the space. They can be steady or interactive based on the performance design. 2) Spotlights are used on each of the interactive stations in order to provide a focus for these components of the performance space. The lights help the audience visually recognize the stations in space. 3) Station's Interactive Lights will provide colors and effects based on the buttons being pushed, and knobs being spun when an audience participant starts to interact with the stations. This interaction happens through the sensor data triggered by the audience translated to MIDI by Max. Max sends this MIDI data to QLC+ which translates these MIDI signals into a DMX signal.

QLC+ is the platform that translates MIDI messages sent by Max into DMX512 signals which control the lighting fixtures in terms of color, intensity, and brightness. A USB to DMX adapter feeds the signal to the series of lighting fixtures.

1.6.1. Other Interactive Lights

As mentioned in the MIDI engine section, with the help of Max/MSP, we can translate audio signals into MIDI messages. By mapping those generated MIDI messages to lighting parameters in the QLC+ environment, we can automate as many lighting fixtures as needed dependent on the character of the audio signal. The audio

distribution module is responsible for feeding audio signals into the MIDI engine to generate MIDI messages for the interactive control of the lighting fixtures. With the help of audio filters available in Max/MSP, we can filter out certain parts of the sonic spectrum of each audio source and assign their intensity to a lighting fixture's color intensity or brightness.

1.7. Interactive Stations

Interactive stations are one of the key features that make this system function as an organism. The purpose of the interactive stations is to encourage the audience members to participate in the performance/installation, to be part of this living sonic organism not just a passive listener/observer. During the performance, participants' interaction via the stations builds up a dialogue with the performers and makes the system more alive and dynamic. In addition, while the system is functioning as an audio installation, the only human part of this hybrid sonic system is the audience members who are generating sound via the interactive stations.

1.7.1 Building/Assembling the Stations

The interactive stations are made of three main components: (1) the user interface (2) a lighting fixture, and (3) a loudspeaker. The diagram below (see Figure 1.6) shows features and various parts of an interactive station and their connections.

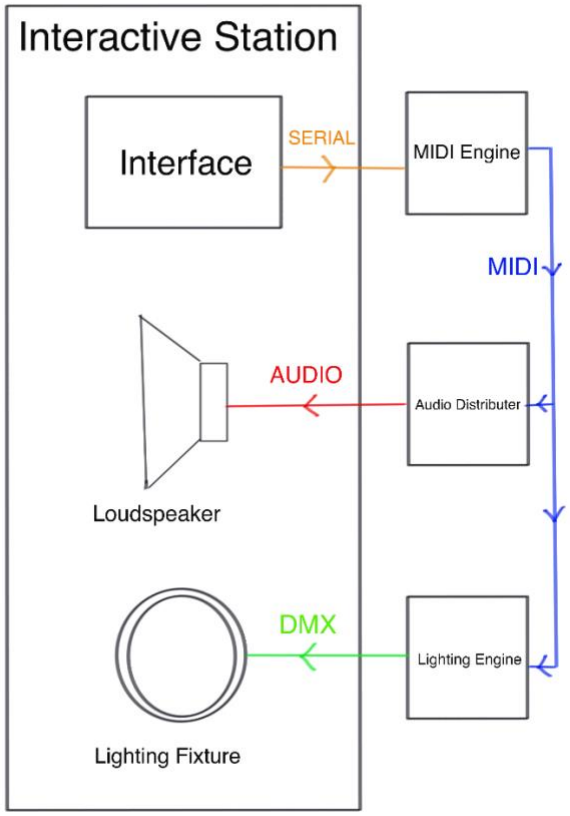


Figure 1.6 Blocks of the interactive stations

Each of the stations includes an individual loudspeaker that provides two benefits: firstly, from a spatial audio point of view, each station is an individual sonic source in the space, exactly like the acoustics of a musical instrument; and secondly, the stations are more accessible and engaging for the audience if the sound originates exactly from the same spot where the interfaces are located.

Depending on the performance design, the audio samples can be queued based on a timeline during the performance or one of the performers, can change the sound for the stations as a response to the music and the way that the audience interacts with the stations.

1.7.1.1. The Interfaces

As mentioned, each station includes a simple interface which is straightforward and easy to use. One of the features of this project is that the audience is given a sense of exploration of the space and the sonic possibilities of space. We designed small interfaces which contain three buttons and two knobs (see Figure 1.7). Each button plays an individual continuous sound when pushed and held down, and by spinning the knobs all the sounds will change accordingly. For instance, for the premiere performance, we assigned the knobs to audio effects such as space processors (reverb, delay, etc.), spectral filters, and pitch modulators.

During the sound design process for the stations, it was necessary to choose distinctive sounds for each button and ensure that the changes that the knobs make would be obvious to the audience. The interactivity of the system and the role of the stations will therefore be clearer for the participants since they can observe exactly what they are contributing to the sonic environment.

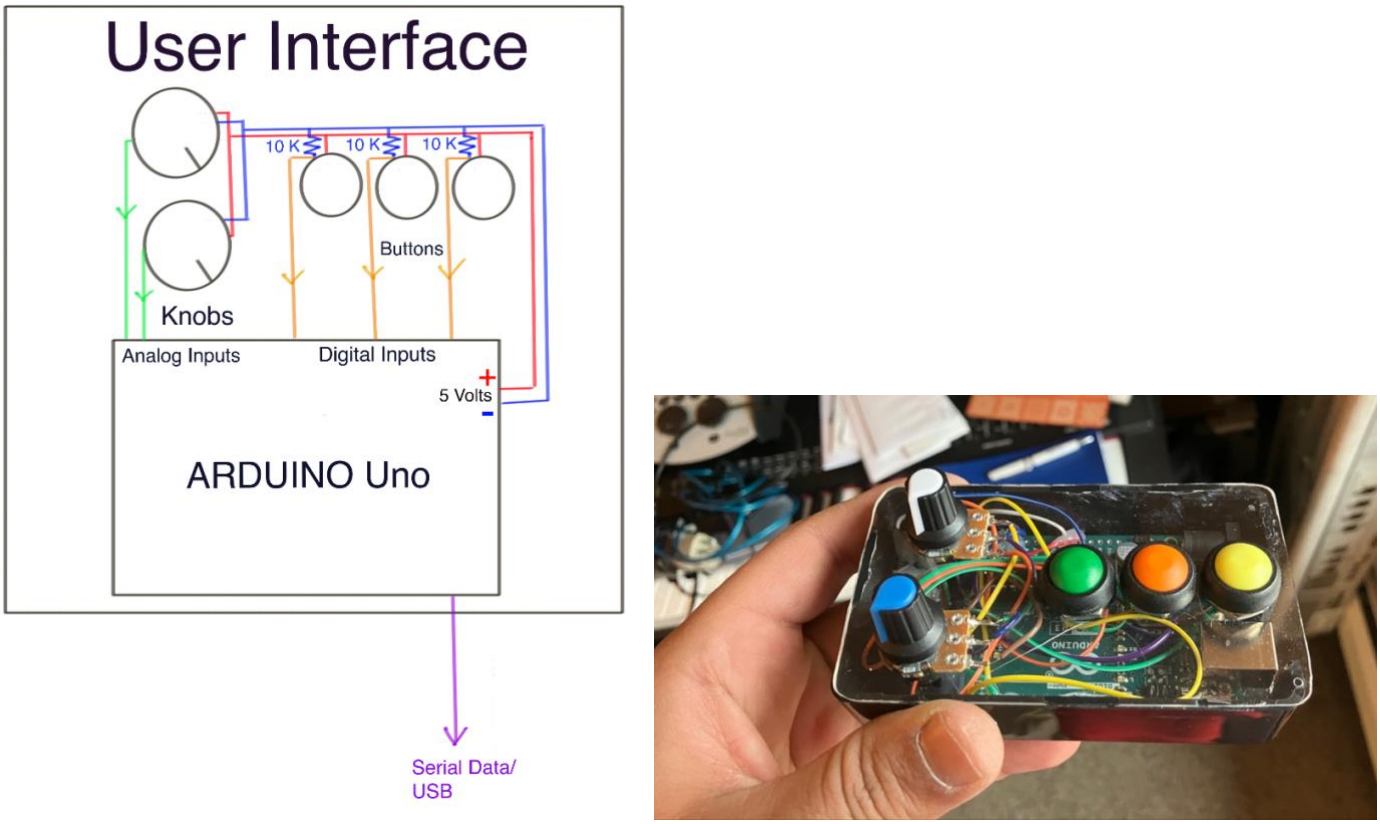
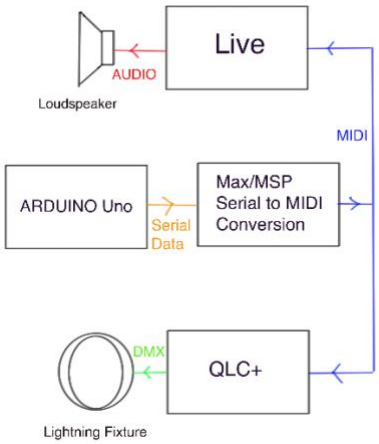


Figure 1.7 Blocks and final built of the interfaces

The MIDI messages generated by Max through pushing the interface buttons, or spinning knobs on the interfaces, then trigger audio samples and effects in Live, and colors and lights in QLC+. Both platforms, Live and QLC+, recognize Max as a MIDI source which let us assign the knobs and buttons on the interfaces to different parameters in Live and QLC+; parameters such as playing back audio samples or turning a lighting fixture on by pushing a button, or changing room in a digital reverb within Live size by spinning a knob (see Figure 1.8).



1.8 Signal flow of the interactive stations

Chapter 2

THE PREMIERE

The premiere of The Living Sonic Organism took place on July 28, 2023, at the F.R. Matthews Theatre on the University of Calgary's main campus. The Premiere was an invitation-based hybrid performance/installation event hosting 40 participants. The performance part of the event included NUM in collaboration with Dr. Jeremy Brown on woodwinds. NUM who come from sonic arts and electronic music backgrounds and created the system, was accompanied by Brown who is a jazz improvisor.

Brown's role in this hybrid performance was to be a free woodwind improvisor who is in constant dialogue with the electronics, electroacoustic sounds, and lights in which he is immersed. One of the layers of sound that was spinning around in space during the performance was a real-time digitally-made shadow of Brown's instruments' sounds built by a complex audio effect patch that I made in Live and controlled throughout the performance.

The benefit of using generative audio engines was that at any point the system's functionality could go back and forth between sound installation and live performance system. In other words, at any point in time, the performers can stop performing and let the generative engines continue to compose music in the space. Furthermore, the

system can be programmed to automatically rotate and relocate different sound sources in space and change lighting in different zones during a predetermined timeline, which makes it more applicable as a stand-alone generative installation system.

As a trio, we had three rehearsal sessions before the premiere in the actual space with the audio and lighting setup. As mentioned, Brown was supposed to improvise on along with the electronics during the performance. However, his entrances and exits were predetermined in the composition, and during the rehearsals he started to define the instruments, techniques, and sounds he wanted to employ in different parts of the composition. The role of the audience is also to serve as improvisors. The only difference between the audience and the improvising performers is that the sounds that the audience can improvise with are predetermined by the composer for the system and chosen by one of the performers at any given moment throughout the performance. The audience at any moment participates in the performance through the sounds that are being provided by the composer via the interfaces at the interactive stations.

2.1. The Premiere: Audio and Lighting System Setup

For the premiere performance, we did a three-day setup of the lighting and the audio systems in F.R. Matthews Theatre. The drawings below (see Figure 2.1) show the loudspeakers, lighting fixtures, recording cameras, microphones for audio processing and recording, and placement of the performers and interactive stations in the space.

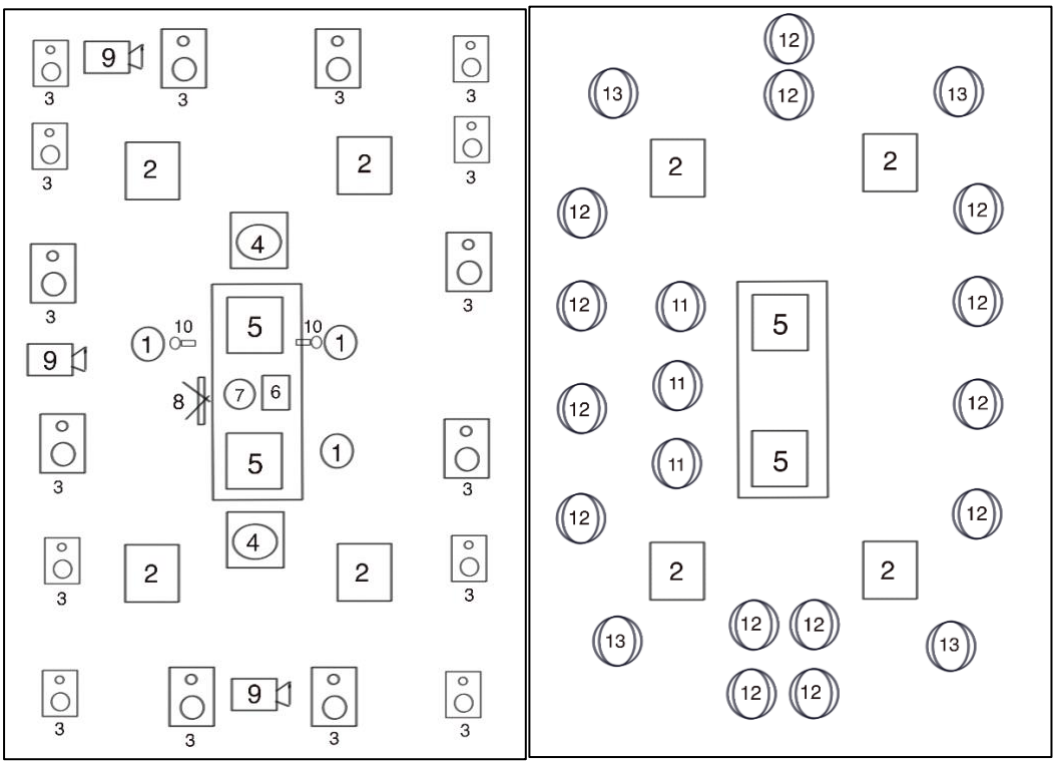


Figure 2.1 Equipment and performers placement in the premiere

As shown in the setup plan, the performers are in the center of the space. This provides us the ability to oversee spatial mixing throughout the performance, with a clear sonic image of the real-time spatial mix. Being in the center of the space helps us to move the sounds around freely without being worried about making mistakes in loudness or

placement which would occur if the artist was located in an uneven proximity to the loudspeakers.

2.1.1. Loudspeakers

We used 22 loudspeakers for the premiere, as shown in the setup plan, as listed below:

1. The main spatial sound module includes 16 loudspeakers around the perimeter of the space. Technically, the setup includes 8 pairs of speakers with each pair sharing one of 8 individual audio signals being sent from the audio distribution module to the main spatial sound module. Each pair consists of 8030 and 8040 Genelec studio monitors. Genelec loudspeakers are one of the most accurate speakers available to audio professionals in terms of clarity, especially in the high frequency spectrum. Genelec audio systems are amongst the best options for quality spatial audio systems for mid-sized spaces.
2. The sub-bass module includes 2 Genelec 7360 subwoofers covering the sound lower than 100 Hz which is perceived partly by the human body and not the sense of hearing.
3. The interactive stations include 4 loudspeakers, one per each station. The loudspeakers used for the stations are Genelec 8030.

2.1.2. Lighting Fixtures

As shown in the plan, we have used 22 lighting fixtures in space as listed below:

1. Performers' spotlights include 3 intelligent lights (LEDs), one per artist.
2. Side lights include a group of 11 LEDs and 3 dimmers, covering the sides of the space.
3. Interactive station spotlights include 4 dimmers.

2.1.3. Wiring and Connections

The diagram below (see Figure 2.2) shows the wiring and connections of the various parts of the system and the type of signal each part communicates:

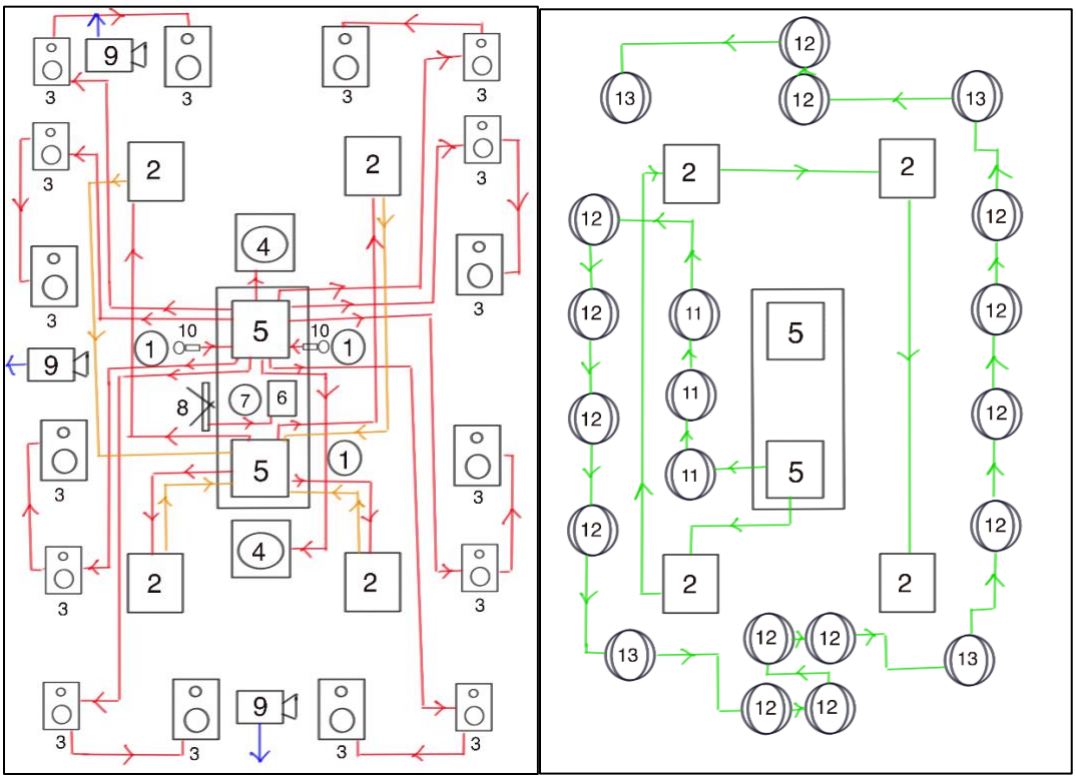


Figure 2.2 Wiring and connections in the premiere performance

2.2. The Premiere: Composition

The composition for the premiere performance consists of five parts. The first part is a hybrid passage which begins as a sound installation, continues for approximately ten minutes and transforms into a hybrid performance by performers walking into space, going to their instruments/workstations and starting to perform. There are no distinct borders between parts of the composition and each part transforms into the next with a gradual and smooth sonic and lighting transition. It should be mentioned that composing for The Living Sonic Organism is not only limited to sound but can be structured for lighting design as well. One of the performers can perform the lights via a computer-based interface designed in Max, the same way that they play an instrument. Like sound, light composition can be based on predetermined elements, improvisations, or a blend of both. The graphic score below (see Figure 2.3) shows different layers of sounds and lights, and their appearance throughout the performance (x axis is time, and y axis loudness/intensity)

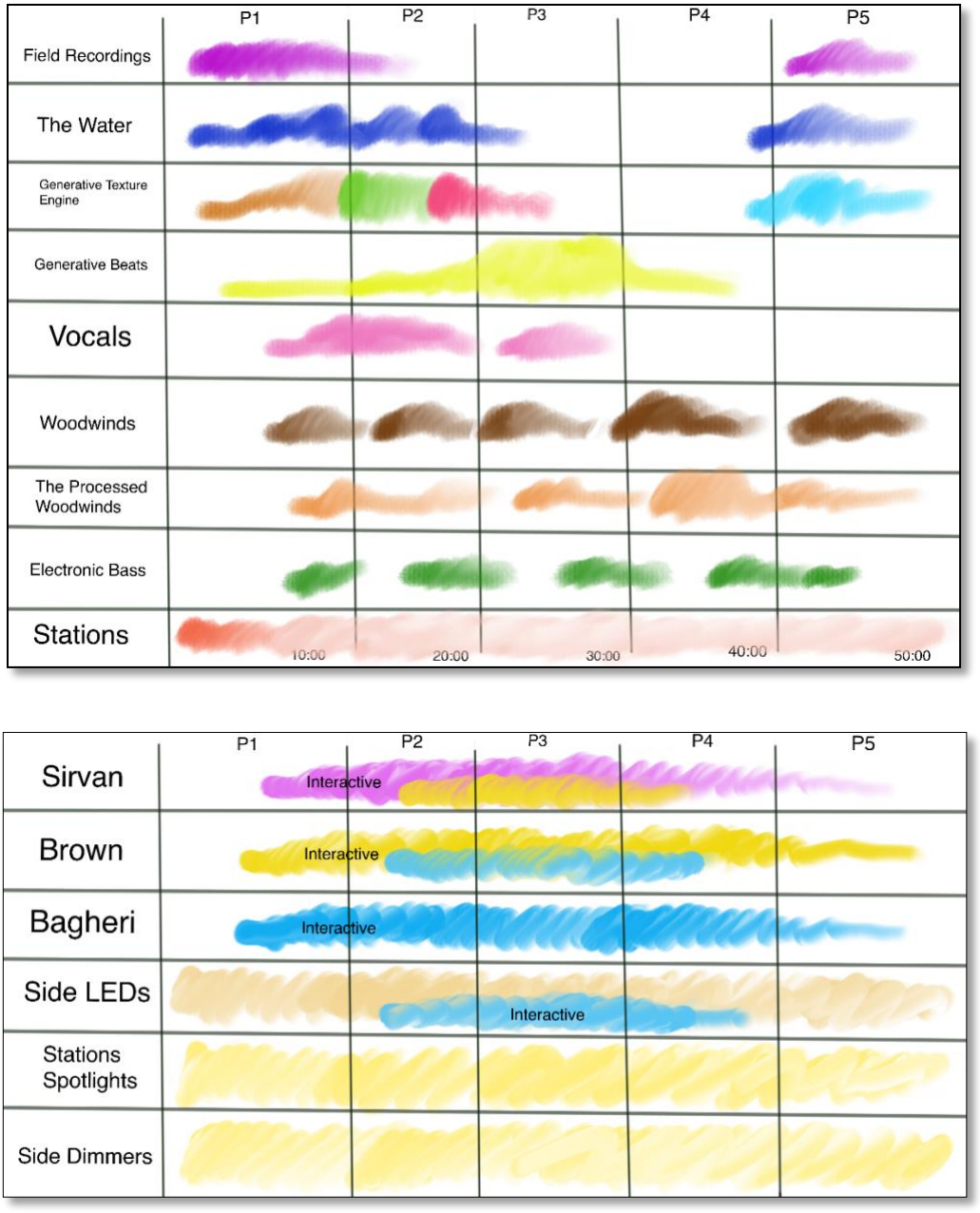


Figure 2.3 Graphic score for sound and light

As shown in the graphic score, the composition includes 9 layers of sound and 6 zones of light. Some of the sonic layers are made of several layers themselves such as the generative texture and drum machines, which in the next section will be discussed in detail. Regarding lights, each performer has a spotlight on them that is activated by the

sound they play. There are ambient lights on four sides of the space which alternate between stationary or interactive states. The interactive stations' spotlights are activated throughout the event. The stations' interactive lights, like their audio components, are shown as improvisatory elements in the score since they are based on the audience's interaction.

2. 2.1. Sonic Elements

As shown in the graphic score, there are 9 sound sources used in the composition:

1. "Field recordings" (recorded by NUM) which is a prepared, long, audio loop played back during the whole performance. The audio is a manipulated sound of a person walking through a rural area full of bird songs, dog barks, and noises of the person walking on different surfaces in a forest. By employing electroacoustic music techniques, we processed and changed the original field recordings in a way that gives the listener a sense of surrealism.

It is possible to manipulate listeners' perception by applying a complex network of digital audio effects such as spectral filters, artificial reverberations and echoes, and automating different parameters. For instance, it is possible to alter the size of the space in the listeners' perception by automating the "space size" parameter in a digital reverb module, or by automating the dry/wet (original and effected audio) ratio in a digital echo simulator. Listeners

will feel their proximity to the sonic object change. Through the digital audio techniques discussed above, I manipulated the original field recordings of the rural environment and used it as one of the main sound sources for spatial audio distribution.

2. “The water” is an audio recording of a water stream and, similar to “field recordings,” we manipulated it through digital audio processing techniques. There are several reasons for using the sound of water in this composition. First, from a spectral point of view, the sound of streaming water is rich, and it covers almost all the audible frequency range. From this perspective, it functions in a similar way to pink or white noise while having a more textural and detailed quality. Because of its rich frequency spectrum, the use of electroacoustic music techniques such as applying spectral audio filters, changing speed of the audio sample, or modulating its pitch, always results in fascinating sonic textures and character.

3. “Generative Texture Engine” shows the appearance of the sound created by this engine throughout the composition. Different colors, as defined in the legend, show the different sample zones loaded into the machine. For this performance, we used 64 samples divided into 4 zones each of which contained 16 samples. The zones are listed below:

- Zone 1: a mixture of pizzicatos on electric guitar, and field recordings

- Zone 2: long notes and chords recorded on electric guitar

-Zone 3: long voice notes (Sirvan's voice)

-Zone 4: arpeggios recorded on several digital and analog synthesizers

4. "Generative Beats" are created by the generative drum machine discussed in the previous chapter. As described, the generative drum machine can be fed with a maximum of 16 audio samples or synthesizers. NUM used 16 audio samples for this machine which were a blend of percussive electronic sounds and glitches, field recordings, and her voice.

5. "Vocals" is Sirvan's voice going through a selection of digital audio effects and spatially distributed by the audio distribution module (see Figure 2.4). The effects selection that we made in Live for digital processing Sirvan's voice is shown below.

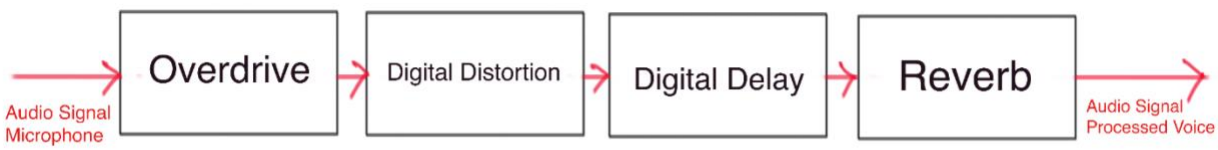


Figure 2.4 Sirvan's voice processing module

6. “Woodwinds” is the part where Dr. Jeremy Brown joins the spatial composition with his instruments. As discussed in the previous section, Brown’s role is as a free improvisor on acoustic instruments in contrast to the rest of the sounds that are being generated or manipulated with machines and coming to life as sound through loudspeakers. The contrast between acoustic and electronic sounds in space benefits the system in many ways. First, it elevates the sense of liveness for the audience as they can see the performer playing the instrument. Furthermore, processing the instruments’ sound in real-time gives the audience an instant sense of live electronics as they can hear the acoustic source directly and the artificial tale of the acoustic sound moving around in space via the loudspeakers.

7. As discussed in previous sections, “The Processed Woodwinds” is the part of the composition where we digitally process Brown’s instruments and move the manipulated sounds around the space. The effect selection that we made for digital processing his instruments is shown below (see Figure 2.5).

Figure 2.5 Brown’s instrument processing module

8. “Electronic Bass” is the bass line for the composition played by Bagheri with an analog bass generator called Volca Bass.

9. “Stations” part in the composition are the predetermined sounds for the interactive stations. As previously discussed, each station has a hand-crafted interface consisting of three on/off buttons and two spinning knobs. Each of the buttons plays one sound at a time and each of the knobs is connected to one or two parameters of an audio effect. We created 36 audio samples in total for all the interactive stations such that pushing any button on an interface could play back a unique sound which is the mix of three different sounds. Throughout the performance Bagheri was responsible for changing the sounds for each of the stations by changing the mix of three samples pre-loaded into the station’s audio module created in Live.

2.2.2. Hybrid Compositional System

From a compositional point of view, The Living Sonic Organism is also a hybrid system. Firstly, the composition should include both sound and light, and secondly the composition is always a blend of predetermined elements and improvisation. Even if the performers perform a precisely-scored composition with no improvisation, the interactive stations remain unpredictable for the composer as they will be played by the audience.

The hybrid nature of The Living Sonic Organism makes it a very flexible system to work with. It can switch between different states: installation and performance, predetermined and improvised, or pure electronic and live electroacoustic. Furthermore, the spatial and immersive aspects of the system offer the potential for use in other performative

disciplines in art. The system has the potential to be combined with disciplines such as theatre, drama, or dance.

Another feature that should be considered in this system is its spatial compositional component. The composition for this system should not only be structured for sound but also for locating that sound in space. The illustration below (see Figure 2.6) shows the spatial aspect of the composition for the premiere performance.

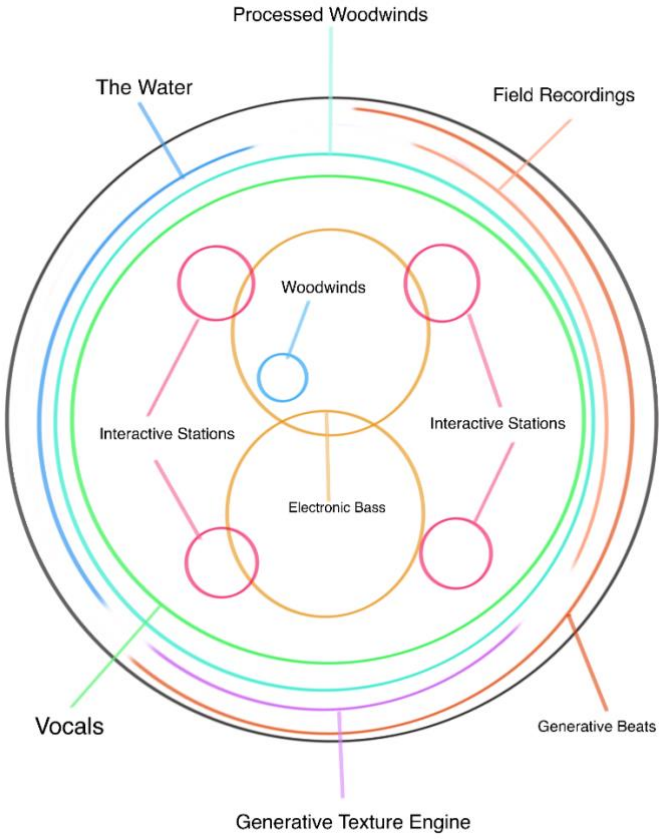


Figure 2.6 Spatial audio distribution map

As shown in the diagram, each of the sound sources has its own placement in space, either static or animated.