Nature of Sound

An Interactive Sound Installation

Asli Binal

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Advisors: Kenneth J. Peacock, Robert J. Rowe

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Chapter 1: Introduction and History

Installation art, which was first introduced in the twentieth century, is a genre that can combine various types of materials and media in creating a work that is to be experienced in conjunction with the environment in which it resides. This form of art can be created using any type of material, and is not necessarily bound to incorporating a visual component. A sound installation, which is a form of installation art, usually incorporates an audio element to the work, which may originate from the site, or be generated by some other methods. It is the aim of the artist to create a relationship between the work, the site or environment in which it resides, and the audience. With installation art, the space in which the work resides is as important and an integral part of the piece as the other elements in the work.

I have created a sound installation titled, “The Nature of Sound”, which was designed with various factors in mind, such as the location, activity in the area, sound sources, equipment, audio processing tools which were available within the space. The use of music technology in this installation is the main focus of this paper, along with some of the technological solutions and ideas by artists working in this genre.

It occurred to me that people have always been fascinated with the nature of sound, and have tried to visualize or find other manifestations of this phenomenon. It is this curiosity which has lead me to investigate how I could create an installation using current technology to find my interpretation of the interplay between sound and sight.

The topic for my thesis will be a study of sound installations including a comprehensive history, and examination of existing installations. In addition, I would like to realize my own sound installation for display in a public space, preferably in the hallway of the Music and Performing Arts Professions in the Steinhardt building. By evaluating projects from the past and present, I will provide the reader with an overall understanding of how sound installations evolved over the years, and attempt to shed some light on the various technologies that were used to create these works. In addition, I will explain the technical details of my sound installation, and evaluate other technological tools that could have been utilized to build the installation. The most important tool that was used to create "Nature of Sound" was Max/MSP and Jitter. The code written in this environment will also be analyzed and described in detail.

1.1 Aeolian Harps

Though installation art is considered a fairly new genre, the same cannot be said about sound art. Music and the use of sound has been an integral part of most cultures for centuries, so it is not surprising that people have created ways to enjoy sound and sound generating objects. One such invention, which can be considered an early form of sound art, was a wind harp, or Aeolian harp. Though its origin is unknown, it has been documented that this instrument has been in use since the late sixteenth century. This contraption consisted of a large wooden box with a sound board, strings of various materials and thicknesses, stretched over two bridges and usually placed in a location which was exposed to wind, such as a hilltop or a roof, thus not requiring a human player. The Aeolian harp, named after Aeolus, the ancient Greek God of the wind would emit a sound, as wind would pass over the strings. These harps can vary in size and can be constructed from various materials, and were very popular during the Romantic Era. Even today, modern versions of Aeolian harps can be found around the world, including works at the Saint

Louis Science Center, Port of San Diego and a very sculptural version by a sculptor named Rodney Carroll, as seen in Figure 1.

Figure 1: Rodney Carroll's WindHarps

1.2 Automaton

An automaton can also be considered an early form of sound art. An automaton is as a 'self-operating machine' that does not require any electronics. Stemming from the Greek word for a self-moving object, or automatos, these machines are usually mechanically driven, and can be observed in many early toys, most commonly as wind-up toys. One of the earliest automatons that I found in my research dated back to 15th century B.C. in the form of a statue of Memnon, the King of Ethiopia, which would play a sound when struck by rays of light during sunrise and sunset.

1.3 Cymatics

Cymatics, is yet another word of Greek origin, which is also mentioned in some texts about sound art. The origin of the word is Kyma, which means wave; it is also the name of a popular sound design and generation tool in use today. The term Cymatics was invented by Hans Jenny, who was a Swiss scientist interested in studying the visualization of sound. One example of Cymatics is the well-known experiment of sprinkling sand on a cymbal, then causing it to vibrate either by striking or bowing it with a violin bow, and then watching the sand collect on the standing waves. This creates an elegant geometric pattern that is a direct visualization of the vibrations, known as Chladni patterns. Jenny would use audible sine waves in his experiments, and was interested in the patterns that these waves would create, using liquids, or powders. Though Jenny was rooted in science, practicing as a medical doctor, the numerous experiments he meticulously conducted in studying the visual attributes of waves could categorize him as an early sound artist. Jenny's predecessor, Ernst Chladni, is partially credited with the birth of the study of acoustics as a result of his years of study and experimentation with the visualization of sound. Another device, called the harmonograph, invented by Professor Blackburn, was also based on visualizing sound, by using pendulums to create a geometric drawing based on harmonic motion. Later in the same century, portable versions of this device could be purchased and taken to parties during the Victorian era as a form of entertainment. The original idea came form Jules Lissajous, who had observed in the mid-nineteenth century that by using a tuning fork, a mirror, and a beam of light, he could display the vibration on a dark screen, resulting in Lissajous figures.

Chapter 2: Works by Sound Artists Past & Present

2.1 Past

The body of work that can be categorized as sound art is so vast, that sound installations have become a separate art movement. The types of people that work within this medium include, and are not limited to, composers, sculptors, engineers, and non-musicians. It was the Futurist composer Luigi Russolo, who stated in his famous manifesto "The Art of Noises",

> "Ancient life was all silent. In the 19th century with the invention of the machine, Noise was born. Today, Noise triumphs and reigns supreme over the sensibility of men". [Worby from Emmerson, pg.146]

It is evident that Russolo's manifesto would encourage the future of music to incorporate machines of the new age and to consider them as modern instruments. In fact, musique concrete could be regarded as an offspring of Russolo's work with the Futurists, and his *Intonarumori*, or noise instruments, were some of the earliest sound installations [Schiff, pg 141]. Russolo's noise instruments were "mechanical devices which were partly sculpture and partly musical instrument", and the sounds created by these machines would be exhibited in theaters, and concert halls and create quite a spectacle.

As mentioned before, sound artists come from diverse backgrounds, and two of the most important pioneers happened to study music composition. Both Alvin Lucier and John Cage started with composition, but continuously experimented and explored acoustic phenomena and its relationship with the environment. Their works had introduced key practices and influenced many future sound artists.

Russolo's suggestion of using sounds from machines as modern day instruments, and Cage's introduction of aleatoric elements are two important aspects of contemporary sound installations. John Cage was one of the proponents of aleatoric or 'chance music' and his influence on the Fluxus movement, which produced the famous installation artist Nam June Paik, is undeniable. In my work, "Nature of Sound", there is an element of randomness that plays a significant role in shaping the resulting soundscape. Though the values from the motion detection algorithm are based on actual measurements, the auditory information is an aleatoric component. The use of chance can be seen in one of Cage's most famous works, which could also be regarded as a multimedia installation. Along with Hiller, Cage created *HPSCHD*, which incorporated harpsichords, computer generated sounds, audio processing of samples, and films shown at the same time. This multimedia installation would run several hours, and would change over time, as audiences would walk through the space.

Alvin Lucier's experimentation with resonance played a key role in shaping his sound installations. He embraced indeterminacy in his works by allowing the environment to mold the source sounds. In an installation titled *Music On A Long Thin Wire*, he stretches a long piano wire and places magnets and microphones on each end. By driving the wire with an oscillator, the various vibrations are captured and broadcast. Based on the characteristic resonance of the space in which the work is installed, the resulting sounds would change over time. Similarly in his installation, *I Am Sitting In A Room*, a recording of Lucier speaking is played back and re-recorded repeatedly, enabling the resonant frequencies of the room to amplify specific frequencies, until the original recording is impossible to distinguish. Similarly, the room's acoustic properties would again be the parameter that would greatly influence the outcome.

2.2 Present

2.2.1 Don Ritter

One of the advantages of researching a newer form of art is the access one has to current works and sometimes the artists themselves. I had the opportunity to conduct a written interview with Don Ritter, who has been creating installations for over twenty years. He is a member of the hybrid class of artists with both an engineering and fine arts background, and seamlessly integrates both disciplines in his works. In my interview with Don Ritter, I was able to gain further insight on two of his sound installations; *Intersection* and *Fit*. A brief background of these installations follows, along with the interview that was conducted via e-mail.

Ritter's website, www.aesthetic-machinery.com was an invaluable resource for providing information about his works and his background. Intersection, first exhibited in 1993, is a multi-channel work that includes eight speakers placed in facing pairs along the length of a dark room and infrared sensors that track the movement of the audience through the room. When a person enters the room, they are exposed to the sound of cars passing through a busy intersection, and based on where they are standing in traffic, they can trigger events, such as cars screeching to a halt or crashing into each other to avoid hitting them. In this work, Ritter explores the psychological effect that our sonic environment can have on people, and utilizes technology to create a virtual experience. He strives to create 'unencumbered interaction', meaning that the audience is not forced to use any physical interface to control the outcome of a work. By simply being present within the installation, interactivity is automatically enabled. In *Fit*, Ritter creates a work with interactive video and sound, in his own words:

> "Fit presents an interactive aerobics instructor as a video projected image with music. The aerobics instructor stands in silence when being viewed from a distance. When a viewer moves in front of the image, music begins and the instructor starts exercising; if a viewer stops moving, the instructor also stops exercising and the music becomes silence. Each time a viewer begins moving his or her body, the instructor begins a new exercise with music. If a viewer moves non-stop, over time the instructor will exercise faster and change every 6 seconds to increasingly quicker routines. If a viewer exercises for 30 seconds non-stop, the instructor and music are presented at a dizzying rate." [Ritter, www.aesthetic-machinery.com/fit.html. 1993]

Though Ritter has created dozens of works, for the purpose of this paper, I tried to focus on the installations that incorporated unencumbered interaction and requested the artist to talk about some of the techniques he used.

2.2.2 Interview With Don Ritter

Ritter, Don. Personal interview. December 9, 2005.

AB: Can you describe or talk about the platform and computer language used to create the custom software, Orpheus?

DR: It was written for an Amiga computer (1988), using the *Director* programming language from the Right Answers group. This is a different Director than Macromedia's product. After Right Answers went bankrupt, Macromedia began using the name Director for their software that had previously been called Video Works.

AB: Are you continuously updating Orpheus, and if so, what kinds of features are being added in newer versions of your custom software?

DR: No, not since Commodore, the manufacturers of Amiga, went bankrupt in1993. I have a software I created for a Mac called o8 which has some similarities to the original Orpheus. This version cannot respond as quickly as the Amiga version, but it can control higher quality video and longer durations. o8 is written using max/msp/jitter.
Installations/performances that use o8 are:
http://aesthetic-machinery.com/voxpopuli.html
http://aesthetic-machinery.com/digestion.html
http://aesthetic-machinery.com/badlands.html

AB: In the installation work "Fit", how was the motion or actions of the audience tracked and translated into useful data for decisions about the instructor's actions?

DR: An ultra sonic detector connected to a custom interface which converts the data into Midi. Created in 1993.

AB: Do you always create custom controls, and if so, what type of controls and equipment do you create?

DR: I typically create interfaces and not detectors, These interfaces permit me to use commercially available detectors (infra-red, ultrasonic) within the installations. These interfaces are similar to those now being

sold by Making Things. My analog-midi interfaces which I began creating/using in 1993 still work fine. If I needed new ones, I would probably buy them from MakingThings.
http://www.makingthings.com/teleo.htm

AB: Is there a set of equipment, tools, or software that you can't live without?

DR: It takes many hours to learn any tool, so I like the tools that I have experience and competence with. Right now I am very dependent on Final Cut Pro, Peak, Max/msp/jitter, and After Effects. My completed works all use hardware and software that is dedicated to the individual works. I have 8 Amigas in my studio which are each dedicated to older works: Fit, Intersection, etc. As long as they don't break down, all is fine. These older systems are much more reliable than newer Macintoshes or PC's. Intersection uses a 1990 Amiga that has been shipped all over the world, running up to 5 months every day without crashing or having any problems. In general, I can't live without reliability, although new computers may be faster and be capable of technically higher quality imagery and sound, they are typically less reliable than equipment from 15 years ago.

AB: When creating an installation, do you come up with a concept first, or do you try shape the work to evoke certain reactions or emotions from the audience?

DR: They typically come unexpectedly. Ideas just pop into my head without any specific desire. I write new ideas ideas as a single line of test or sketch them out. I then spend much time, often years, developing them. I don't try to evoke certain emotions in a work, but rather determine what could be evoked.

AB: If you were to create *Intersection* now, how would you approach the project from a technical standpoint, and what software and/or hardware controls would you choose to work with?

DR: I would probably use max/msp with an 8 channel sound card. As input, I would use infrared cameras.

AB: How were the sounds used in *Intersection* created? Were the sounds processed or manipulated during the show?

DR: I began with recordings of cars from a sound effect CD (a 1967 Ford Galaxie 500) and edited them using sound editing software. These sounds are stored and controlled by a Roland S550 sampler with 8 audio outputs. During the installation, the samples are played at different rates and their fade in/out is controlled by a computer through Midi. This installation is being exhibited right now:

AB: In your opinion, how can the Internet be used in installation works without encumbering the audience, and do you feel that incorporating this technology can add to the work?

DR: An unencumbered interface to a computer can be used with any application on the Internet. Telecommunication technologies available through the Internet can be valuable.

AB: Do you prefer to create an installation for a specific site, or create a work that can stand on its own in any environment?

DR: I have never created a work for a specific site. They are always slightly different when exhibited depending on the architecture of the exhibiting space. I would gladly design an installation for a specify location if it was offered.

AB: Do you think that technology is just a tool to create the work, or does it take on a character, which might add to the work?

DR: Yes, it is a tool, which does add character. In technology-based artworks, the emphasis is usually on the technology being used with less on the consequences of using a technology.

2.2.3 Max Neuhaus

When an audience member asks, "What about interactive sound installations?" during a lecture at the University of Miami, Max Neuhaus responds:

> "I have never done that. I have thought about it quite a bit. I think things of that kind are public instruments rather than artworks." [Neuhaus, pg.74]

His approach to installing a sound work begins with the selection of a site, such as the pedestrian island in Times Square, or a metro tunnel in Paris. As a result, the sound generation for the site is tuned according to the environment in which it will reside, some works temporarily, and others permanently.

Contradicting himself in his inscription, Neuhaus describes one of his earlier works, *Drive In Music*, as the 'first sound installation I ever did'. Set up in Buffalo, New York in 1967, he placed a series of short-range radio transmitters with antennas along the road, each creating a different sound, and broadcast over a single AM station. People driving the length of the road could then tune into this station to hear the work evolve. Since the car would be moving past the transmitters, the resulting mix would be based on the strength of the signals that were within the range of the moving vehicle. In addition, Neuhaus also took the attacks and decays of the sound into consideration by cleverly placing the antennas diagonally and perpendicularly to the road. If a person chose to drive back and forth through the work, they would hear the sounds in reverse; since a gradual decay, caused by a diagonally placed antenna would result in a gradual attack when approached from the opposite direction. The sounds generated were sine waves of varying frequencies, determined by weather conditions. Neuhaus states that AM radios were more common at the time of this installation, but he has proposed an FM version for the city of Los Angeles. The instructions for the exhibit were distributed at the Albright Knox Art Gallery, with a map of the route, as seen below.

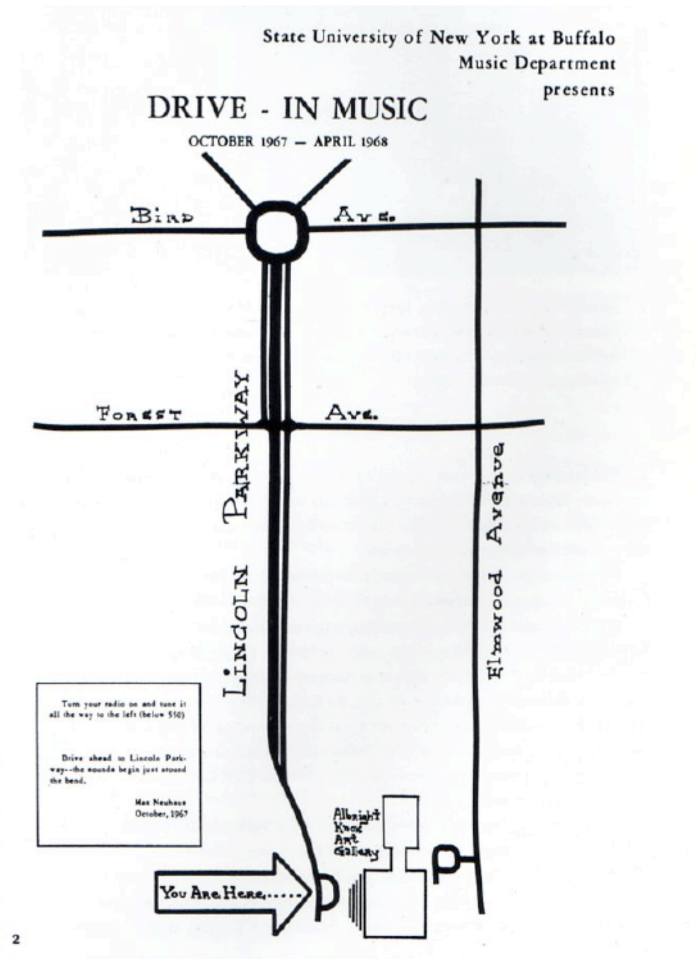

Figure 2: Drive-In Music map by Max Neuhaus

The type of equipment that is used for each piece varies from work to work. In one untitled work designed for a public botanical garden with a large dome, he utilized sixty-four independent synthesizers and the same number of speakers to create a chorus of percussion-like sounds with a single bell-like sound that would travel through the space. To create the auditory illusion of the traveling bell sound, he would project the sound from different places at different times. In order to shape the timbre of the synthesized percussion sounds, he created a customized interface consisting of a battery-operated television set and a light pen. Using this pen, he could select and modify the parameters of the synthesizers on the screen of the television set. This portable system is one of the key tools that is used by the artist because he often works in large environments and is constantly having to tune the parameters of the synthesized sounds from anywhere within the space. In addition to this interface, Max Neuhaus rarely uses conventional speakers, opting to use a variety of customized equipment like large base reflex boxes, horns with directive patterns, and in the case of the Museum of Modern Art piece, a large subsonic horn embedded below ground in a ventilation chamber.

Chapter 3: Technology in Sound Art

In the beginning of this paper, it was mentioned that several different technologies were evaluated before embarking on the final design of the installation. It is common for most installation artists to create custom controls and tools to achieve desired functionalities. For example, in “REACH”, Janney uses beam switches and Ritter mentions designing custom interfaces to interact with ultrasonic and infrared sensors. During the planning stages of my installation, I created a brief overview of movement sensing mechanisms before I decided on using a USB web camera. The following section summarizes some of the most common technologies used when creating an interactive sound installation.

3.1 Sensors & Controllers

O’Sullivan and Igoe have written in detail about the types of sensors and detectors that can be built for projects in their book “Physical Computing”. Since the main function of these devices is to translate one type of action to useful information in another format, they refer to these converters as transducers. As we know from audio technology, most common transducers include microphones, which convert an analog sound into an electrical signal, which can be recorded or even amplified through another transducer, the speakers.

The writers state that a transducer, which can directly plug into the computer, will be the least complicated method to collect information to use within the installation. If the design requires a customized device, which is not a stand-alone I/O, then a microcontroller will also be required in order to interface between the computer and the transducer.

3.2 Detecting Movement

For sensing movement, the most basic solutions are switches that trigger when two pieces of metal touch. Some suggestions are to place a switch in a normal looking object that the audience could interact with by applying pressure to the item by stepping on it, or pushing it, causing the metal parts to touch, triggering the switch. One of the recommended switches takes the form of a metal strip on the floor, with a layer of foam with holes, and another strip of metal that comes into contact with the bottom layer when a person steps on the mechanism. However, the main disadvantage is that over time the wear and tear on the device might make it unreliable, in addition to the fact that the device is noticeable, unless it is hidden under another object like a rug.

One of the most common switches that I observed in installations was a beam switch, like the ones used in Janney's "REACH". This photoelectric switch is comprised of one light source, with a sensor on the opposite side, which detects an increase or decrease in the strength of the beam of light. When someone walks through the light switch, they break the contact of the beam to the target sensor, causing an event to trigger. These types of switches can also be configured to have the light emitter and sensor on one end, and a mirror that reflects back the beam on the opposite end.

In addition to beams of light, magnets are also used in switches, forcing an encased pair of thin metal wires to touch when a magnet is nearby. The most common use for magnetic switches is to detect the presence or the absence of an object, since the magnet can be placed on the item that can be moved around, and the stationary area can hold the pair of metals that close the switch when the magnet is nearby.

Infrared (IR) sensors are another common motion detection method used in installation works, like the ones Ritter employs to detect the movement of people in his installations. Some burglar alarms also use this technology to measure changes in the infrared light to determine if something is moving in the space. A digital version simply detects if there is motion, whereas an analog sensor can determine the proximity of the motion by returning a variable voltage measurement that can be converted to a distance measurement. The IR sensor emits an infrared beam of light, and can be adjusted to detect a larger or smaller area by changing the lense that emits the light. There is also another component that reflects the IR beam, and the intensity of this reflection is retrieved to determine if there was movement (digital), or the proximity of the motion detection (analog).

The other popular position detection device is an ultrasonic sensor. The difference here is that instead of sending a beam of light, these sensors emit an ultrasonic sound that travels until it hits a target, and is reflected back. Based on the distance of a target, the time in which the ultrasonic sound is reflected back determines how far away a target is, so a faster return translates to proximity.

3.3 Use of Digital Camera to Analyze Movement

As a sound artist working with technology, I found it quite useful to explore some of the research papers published by the International Conference on New Interfaces for Musical Expression, or NIME. A joint research effort by McGill University's Marcelo Wanderley, and Jensenius and Godoy from University of Oslo's Department of Musicology, produced a paper titled "Developing Tools for Studying Musical Gestures Within the Max/MSP/JITTER Environment". The team created a set of tools using

Max/MSP and Jitter called *Musical Gestures Toolbox* to analyze how people mimic musical performances. Participants with varying degrees of musical backgrounds were filmed while playing 'air piano' along to some recordings. These captured performances were then analyzed by the software tool for elements such as speed, density, and direction of the gestures as they related to the music. The result of this type of research would be useful in the design of interfaces for new instruments, since certain similarities were found between the gestures of performers of varying musical background.

Before the toolbox was created, the team of researchers evaluated various environments that could be used to create the software to conduct the research. One of the choices was EyesWeb, a Windows based software application which was developed for 'exploring and developing models of interaction by extending music language toward gesture and visual languages, with a particular focus on the understanding of affect and expressive content in gesture.' [EyesWeb website]. Though Wanderley had used EyesWeb for creating analysis patches in previous projects, the inability to create a standalone, cross-platform application compelled the team to use Max/MSP/Jitter to create new analysis tools for this particular study. Using the Max environment, the tools could be developed quickly and the extensive library of jitter functions enabled the video and audio to be captured and manipulated in real-time. When analyzing gestures, the cropping of the video image to focus on specific areas of movement and adjusting the playback speeds of video and audio were important features to include. Using Open Sound Control (OSC) messages from within Max, the non-video data could be captured and written into text files, so it could be studied after the video was captured.

The paper does not divulge the details of the motion sensing and detection algorithms, but it does demonstrate that variables such as the quantity of motion, center of gravity and noisiness of the video are captured and graphed along with the noisiness, brightness, loudness and pitch estimation of the audio for comparison.

Chapter 4: “Nature of Sound”: A Sound Installation

4.1 Concept Behind “Nature of Sound”

The idea behind my sound installation, “Nature of Sound”, was partially influenced by the works of Max Neuhaus and various installations that I happened upon in public spaces in Manhattan and galleries like the Tang Museum at Skidmore College and also at Art OMI. The main quality that I find appealing in a sound installation is the way in which a work can engage an unsuspecting audience in a space that one might not usually associate with viewing or *hearing* art. At the 34th Street N/R subway platform, there is a work titled “REACH”, by Christopher Janney, that uses sensors and beams of light to detect a break in the beam to trigger various sounds. This interactive work is skillfully installed in two facing beams stretching over the tracks, and as passengers walking along the platform break the beams of light, they activate pleasant sounds that fill the noisy space. This interaction came as a surprise to me, and encouraged me to investigate other sound installations in the city. Once I walked over Max Neuhaus’ piece, over the grates of a pedestrian island in Times Square, hearing the slowly changing drones emanating from below, I was inspired to create an installation that could change the soundscape of a space inside the Steinhardt Building. The work I envisioned would be unobtrusive, and subtle, but would encourage the audience to interact and aim to figure out how the sounds are created. Through use of spatialization and audio processing, I want to fill the space with sound in a disorienting manner.

As with any form of installation art, the tools and media used for creating the work are only limited by the artist’s imagination. By understanding the site in which the work is to be installed, certain limitations and requirements are established in order for the work to be successful. The hallway on the seventh floor of the Education Building on West 4th Street is a common space with doors to classrooms and offices. This was an important factor to consider when designing the soundscape, as the amount of volume and chaos of the interplaying sounds would need to be taken into consideration due to the proximity of people working in offices and attending classes. Over the past year, I have casually observed, while working in one of the offices, that the amount of traffic in this hallway is always greatest between classes, during lunch hours, and at the end of the day. This prompted me to consider the possibility of increasing the volume and the layers of sound when the hallway is full of activity, and decrease the amount of sounds during a lull in activity in the hallway. In order to keep the work interesting and evolving, there also needed to be an element of randomness, which influenced how sound files would be chosen and processed before they were played back.

4.2 Tools of the Trade

The initial phase of the project required an evaluation of various technologies to accomplish the main tasks that were required for this project. It was evident that motion detection would be the most important task in order for the installation to work successfully. The early options were to build custom sensors like the ones described in the book "Physical Computing". Another option was to use a USB device called "Go! Motion", designed for science classes to teach students physics concepts. Designing a set of custom sensors would require a workshop with equipment that I did not have available, as well as a longer schedule and an electronics background. In addition, creating the interface between custom sensors and the computer had to be taken into consideration, thus it became evident that an embedded solution would be a better model for my installation. By uniting the motion detection and audio processing technology in one program, I was also able to eliminate the possibility of having to troubleshoot separate elements. After evaluating the 'Go! Motion' device, I realized that the data captured by this device would need to be imported into my sound processing application, at which point it was evident that, not only could a USB web camera detect motion, but it could be used seamlessly within the Max/MSP and Jitter environment. Working in this environment allowed me to create a single application that would control all of the components in the sound installation. The fact that researchers and other installation artists who needed to track or sense motion have worked in this environment also influenced my decision to choose Max/MSP/Jitter for the piece.

4.3 Hardware Requirements

In addition to using a web camera for detecting motion with a Jitter patch, the installation also needed to support multiple channels of output. Since the built-in soundcard only supports stereo output, an audio interface was required to enable four simultaneous channels of sound to be played back at one time. Once installed, the audio interface was configured for quadraphonic output, which simply means four channels of independent sound. The following section contains the list of hardware equipment required for running the sound installation:

1. Macintosh Computer with:
    - OS 10.3.9
    - 512 MB Memory
    - 1.25 GHz PowerPC Processor

2. Mac supported Web camera with a USB interface
3. M-Audio Firewire 410 Audio Interface (multiple outputs)
4. Four speakers
5. Display or Monitor (optional)

4.3.1 Schematic for "Nature of Sound"

Before the installation could be set up in the 7th floor hallway of the education building, a schematic representing the correct placement of the required equipment had to be created. The diagram shown in Figure 3 includes the placement of the four speakers, along the length of the corridor. The web camera will be mounted above the doors entering the hallway, next to, or above the current security camera. An audio interface to enable multi-channel output will be connected to the Macintosh computer via a Firewire cable, and this equipment will be secured in one of the offices adjoining the hall. The location of the optional monitor is unknown at this time, since it will be installed by the Music Technology department for other uses.

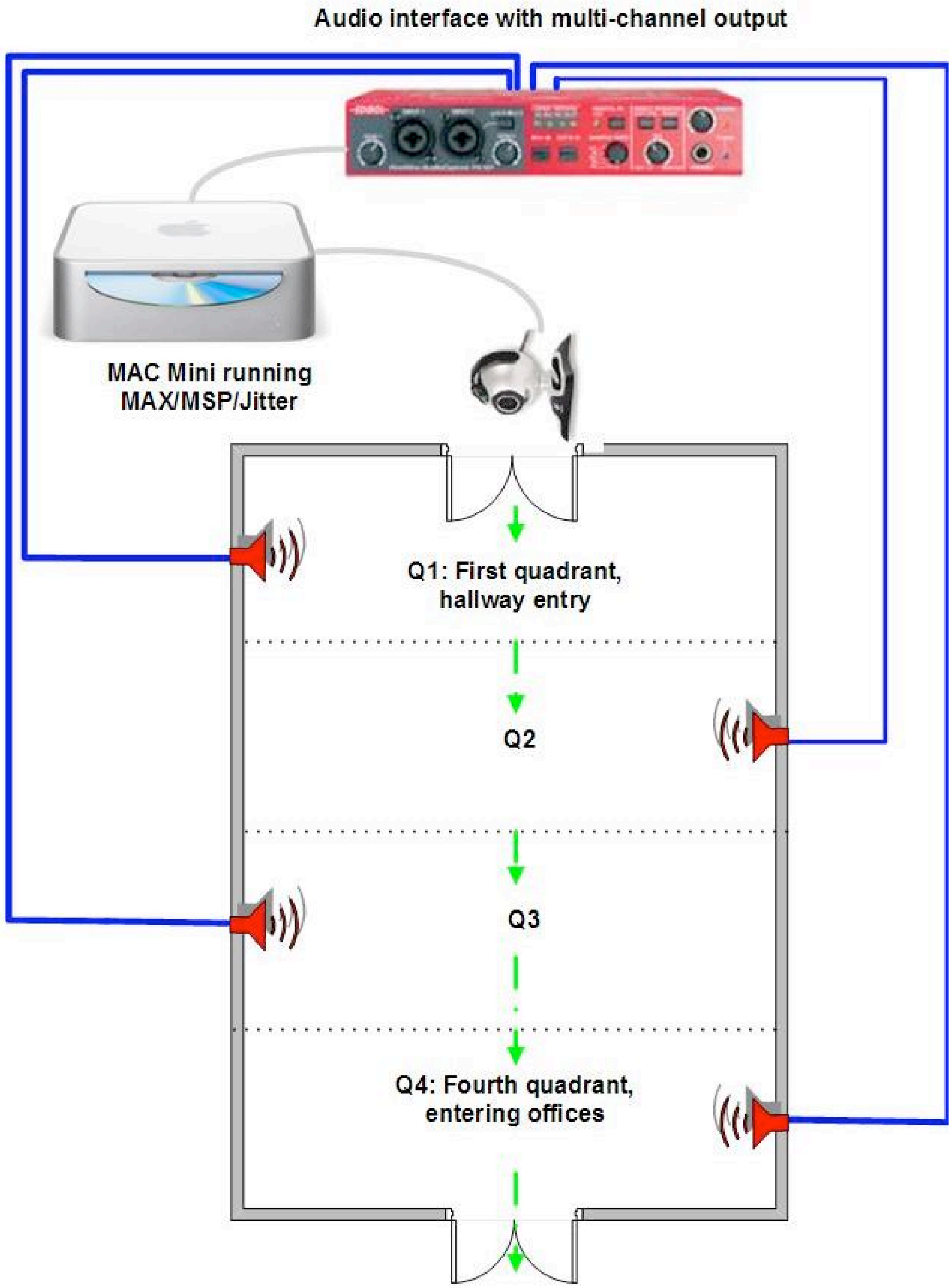

Figure 3: Schematic for the installation

4.4 Software Requirements: Max/MSP and Jitter

The software used for creating "Nature of Sound" is Cycling74's Max/MSP 4.5 and Jitter 1.5.2 for OS X. The main patch consists of several sub-patches, but the top three important functions are:

1. Capturing and processing live digital video
2. Logical unit for queuing sounds based on movement in video capture
3. Audio processing and playback on four channels

Each of these main tasks contain greater detail that can be further broken down into sub-patches, as will be demonstrated in Chapter 5. Starting with a project plan, a list of tasks guided the design of the Max patch. This approach enabled the project to be written in several phases, and kept the patches quite modular. One of the greatest advantages of modular design is that each component can be executed on its own, so for example, the lack of a digital camera would not prevent the programmer from testing the audio component. The original list of tasks was as follows:

1. Using Jitter, test digital camera input with the tutorial for grabbing video
2. Modify existing frame differencing sample patch to detect motion on live video capture
3. Separate the captured video into quadrants; each with its own output matrix
4. Extract useful information such as the mean Red/Green/Blue values from each of the matrices

5. For each quadrant, load a list of sounds ahead of time, and choose one randomly for playback when motion is detected for that quadrant
6. Once stereo playback works after detecting motion, map each quadrant to a specific speaker for multi-channel audio output
7. Design and implement audio processing that will be used for the soundscape

Note: Once these steps were completed, additional tasks were added for future versions of implementation. See section titled, Future Enhancements.

4.5 Future Enhancements

During the design phase of the installation, I had a list of tasks that had to be completed and another list of features that were optional. One such feature was the ability to load different sets of sound files based on an environment variable at runtime. The idea was to create a web based interface that a user could access from anywhere, and select the soundscape for the hallway. This would enable another level of interaction with the installation, since any participant could decide on the types of sounds that would be triggered in the site where the installation is set-up. In order to accomplish this, a web server with the interface would need to be created, and a direct connection between the server and the machine running the Max patch would have to be established.

Another element that would be beneficial is to use multiple web cameras. This would allow me to analyze smaller areas of space in greater detail, and in turn, translate this information to trigger and modify a greater number of sound parameters.

Chapter 5: Technical Specification

The main motivation for using Jitter in this sound installation stems from the ability to work in a single environment that could support both motion detection and audio processing. There is a sample patch that comes with Jitter called jit.op-framedifference.pat, for demonstrating how frame differencing works. This patch was originally designed to work with a movie file as input, using the jit.qt.movie object, which I replaced with the jit.qt.grab object in order to apply the frame differencing algorithm on the captured live video feed. Frame differencing compares a starting frame with a subsequent frame. In the case of this patch, the absolute difference between the subsequent frame and the current frame is calculated using the operation 'absdiff'. This operation returns the absolute value of difference, which is then compared against a threshold value. If it is greater than the threshold, then the value passes, and appears as motion on a black background. When there is no motion, and the absolute difference between frames is the same, the output to the screen is black. In the areas where the frames differ, a visible outline of the movement will show up on the screen. Since the entire frame is broken into smaller quadrants, it is then possible to visually detect motion in different parts of the space. There is also a 'jit.alphablend' function, which takes a picture of a grid and mixes this image with the live video capture. The reason for drawing the grid on the video is to highlight the four quadrants in which the motion is being detected. In addition, by viewing the motion in specific areas of the screen, audiences might figure out that each section corresponds to a single speaker. Figure 4 shows the main patch window, in edit mode, with all the technical details that are discussed above.

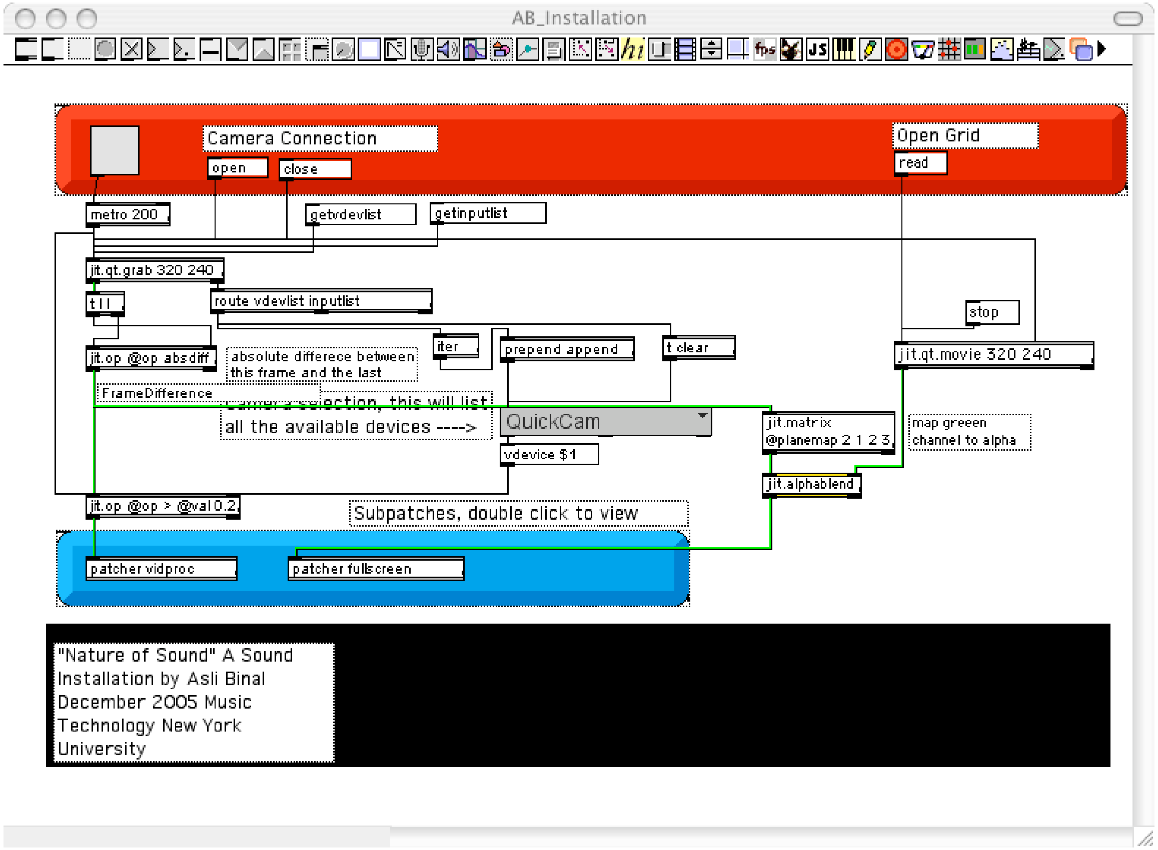

Figure 4: Main patch exposed (Edit mode)

For the final version of the installation, the technical details of the main patch were hidden from the user, in order to create a simple user interface. On the red bar at the top, the camera connection can be opened and closed, and on the right side, clicking the button labeled ‘read’ under the caption ‘Open Grid’ will be used to load a grid.pict file resulting in a full-screen image with vertical lines showing the four quadrants.

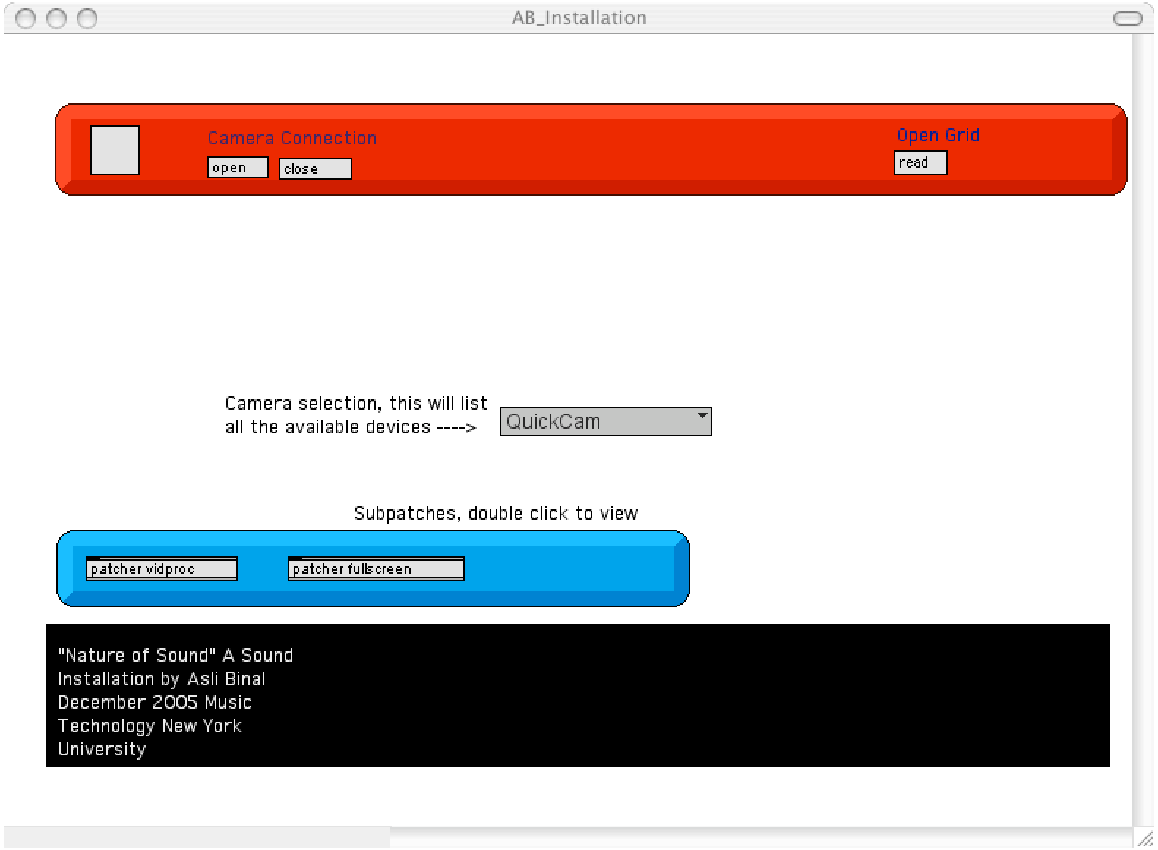

Figure 5: User interface for the main window for the patch.

5.1 Fullscreen Video

For the initial showing of the installation, it was suggested that a visual component might heighten the audience's experience. To incorporate a visual component, the live video would be processed and shown on a fullcreen with a simple sub-patch called '[fullscreen]'. This feature could be toggled on or off by hitting the spacebar, which has an ASCII key value of 32 (Figure 6).

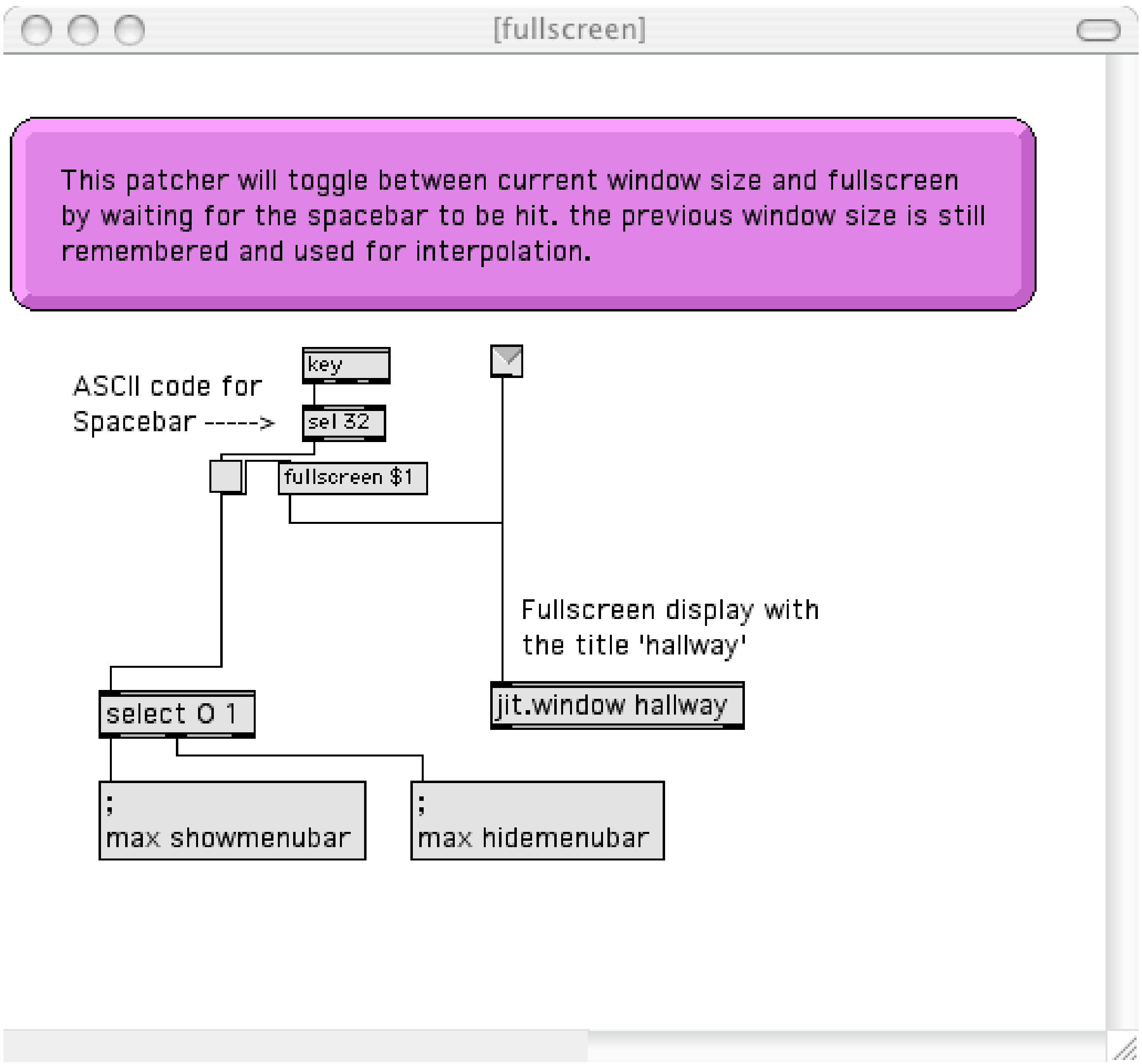

Figure 6: Sub-patch to trigger fullscreen video

5.2 Sub-Patch: Vidproc

The vidproc sub-patch is responsible for analyzing the input matrix by splitting the full-screen into four quadrants. The captured video is sliced into four equivalent vertical matrices, which each have their own set of analysis routines. The jit.scissors object enables the programmer to separate, or cut up the input matrix into several smaller matrices, by specifying the number of rows and columns; in this case, one row, and four columns.

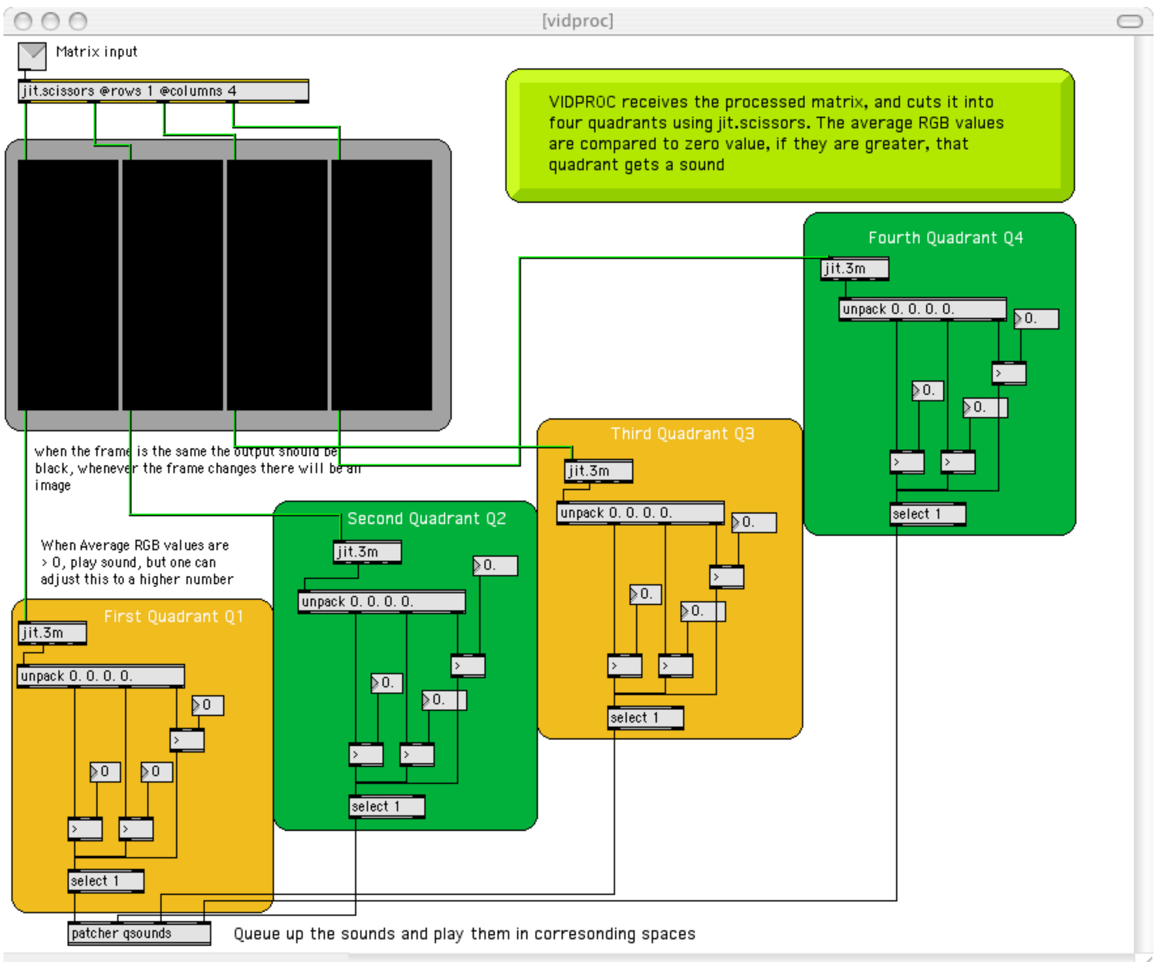

Figure 7: Sub-patch vidproc

The jit.scissors object is connected to four separate 'pict' objects, which display the video received for that portion of the image. Each of the four matrices is connected to an object that extracts important information about the mean values for the Alpha, Red, Green and Blue pixels in a given matrix. If any of the mean values for a quadrant is greater than zero, then we know that motion is detected in that matrix. When this case occurs, the sub-patch qsounds is called.

5.3 Sub-Patch: InitSounds

This sub-patch initializes all of the sound files that will be used through the duration of the installation. They are categorized into four groups and loaded into lists named; quad1, quad2, quad3, and quad4. The loadbang object at the top of the page sends out a bang event to all of the 'preload <soundfile>' message boxes, which in turn connect to their corresponding 'sflist~ <quad*n*>' object, where *n* is the number of the quadrant.

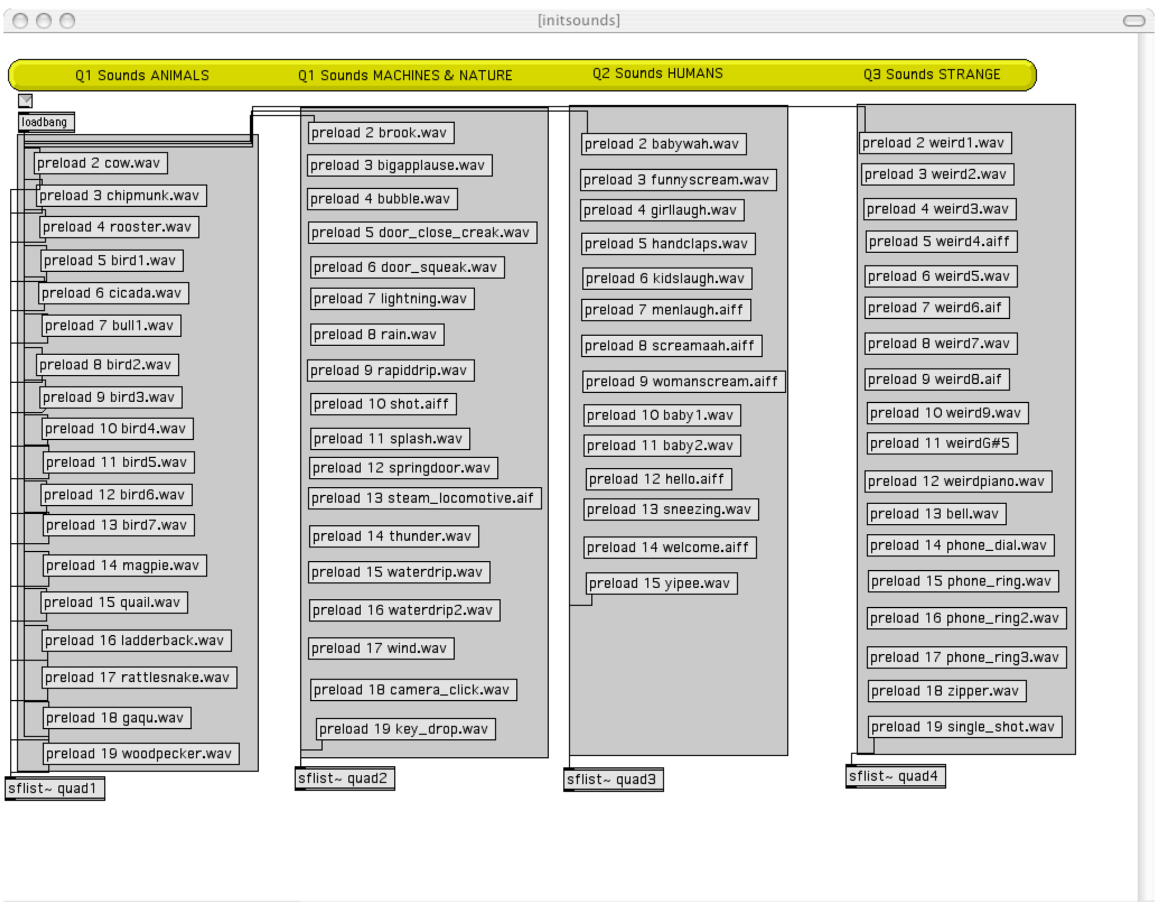

Figure 8: Sub-patch InitSounds

In a sound file list, index one is reserved and therefore the files that are loaded into the list have to have an index of two or greater. These indices are important for the vidproc object, because, a random number will be generated between 2 and the maximum index for each quadrant, and this will represent the index of the sound file to play. This sub-patch will get called when the main Max patch is loaded, causing all sounds to be loaded at startup.

5.4 Sub-Patch: QSounds

The qsounds sub-patch is very important, as it is the main logical unit for the sounds that will get played back over the four channels.

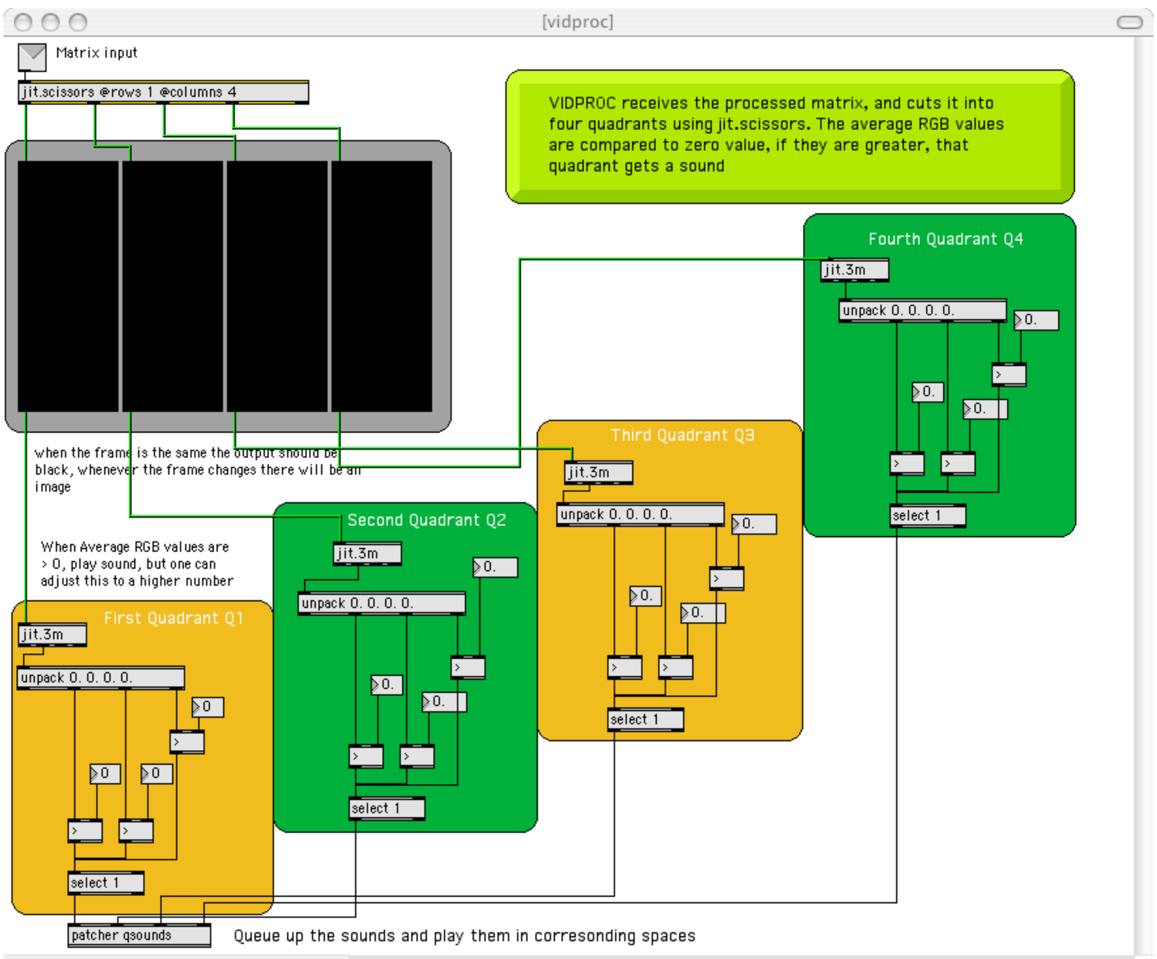

Figure 9: Sub-patch qsounds

There are four inlets into this patch, one for each of the quadrants in which motion was detected. The 'urn' object is used to randomly select a sound file assigned for the quadrant, which is then sent to the quadrant's sound processing module, <procsound*n*>, where *n* is the quadrant number. By using urn, rather than random, we cycle through all of the sounds before hearing them again.

5.4.1 Sound Sources

There were two main resources that I used for obtaining the sound files in this installation. I wanted to include sounds of various animals, including a wide variety of birds, and found a website that was devoted to field recordings of sounds in nature. The page is called www.naturesongs.com, and is constantly updated with photographs and field recordings by nature enthusiasts. The second resource was 'The Freesound project'. I came upon this site through the music technology group's web page at the Pompeu Fabra University in Spain. The Freesound Project is a website that contains a large database of sound samples which can be searched using keywords and downloaded and used by any person. This collaborative effort offers researchers access to thousands of sound samples, and encourages users to upload their own field recordings, and non-copyrighted samples. The sounds are released under the 'Creative Commons Sampling Plus License', which states that users can sample and transform the downloaded sample in any manner, so long as they are used for noncommercial purposes.

5.5 Sub-Patch: Audio Processing with <procsound>

Below are the four sub-patches used for processing the audio.

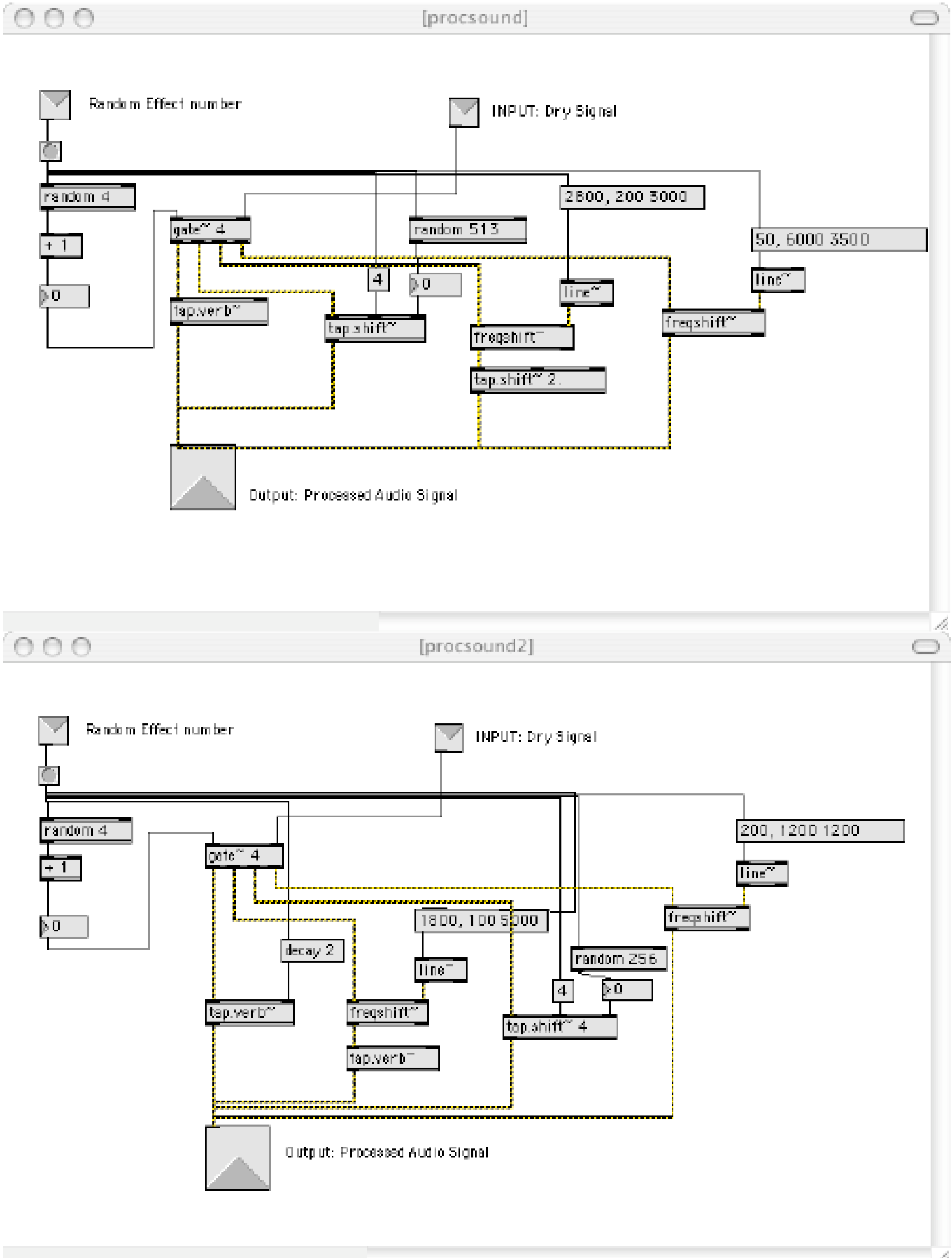

Figure 10: Procsound sub-patches for the first and second quadrants.

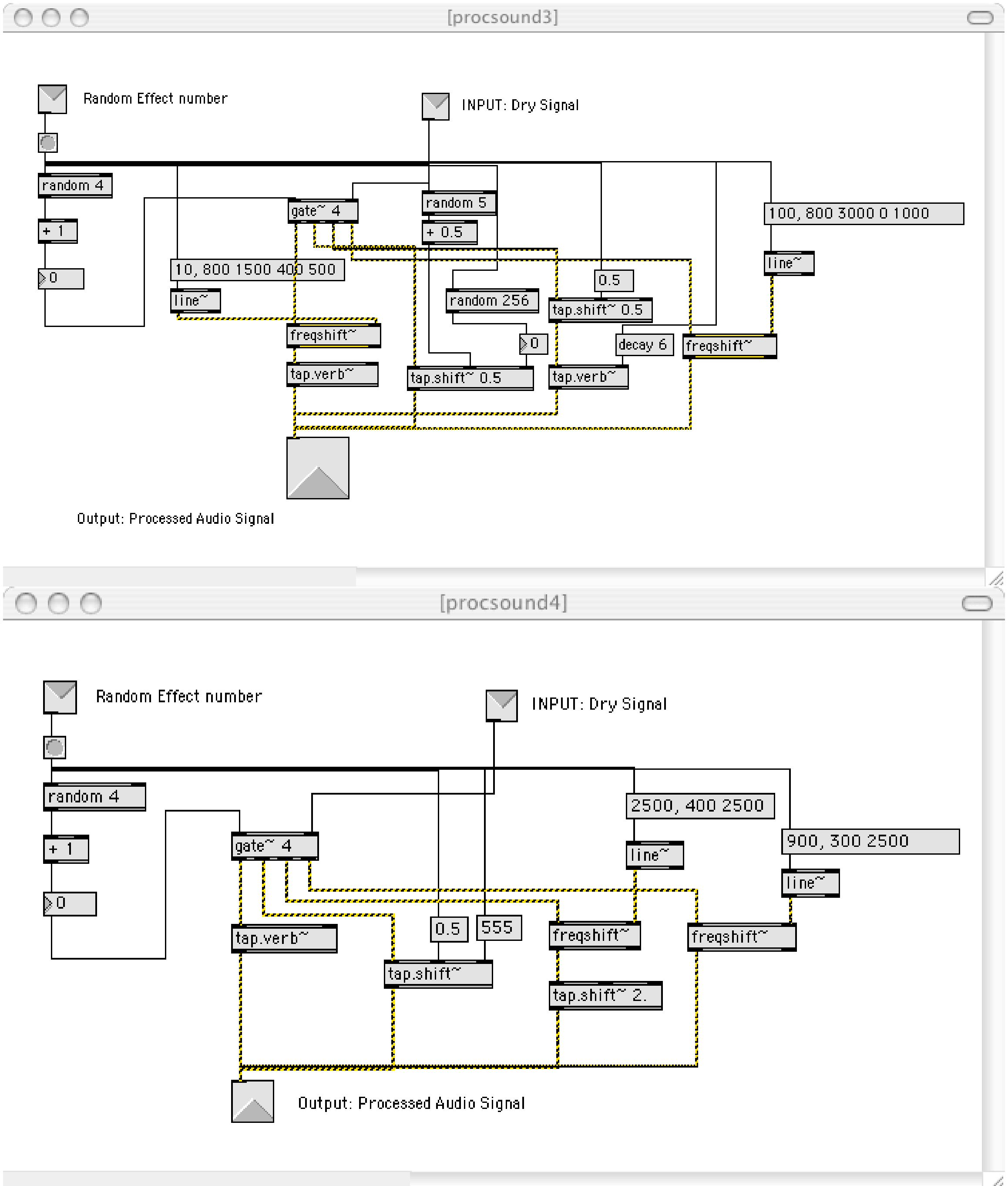

Figure 11: Procsound patches for third & fourth quadrants.

The audio processing used in this installation included the use of a library called ‘Tap Tools’, available from , as well the freqshift~ object, used for pitch shifting in the time-domain. By varying the parameters to these objects, and randomly selecting values for some of the arguments, a large variety of effects were achieved. In all of the procsound sub-patches, there is an input value of a randomly selected number from one through four, which determines the audio processing that will be applied to the second input, which is the audio signal. In ‘procsound’, the effects consist of a simple reverb, a pitch-shift of a signal by four times its normal speed, a frequency shift then a pitch shift, and finally a frequency shift with an envelope. These are the basic audio processing functions that are used throughout the procsound patches. By varying the delay or decay time for tap.verb~, the reverberation object, we can extend the sound, or cause it to feedback. In addition, by supplying the frequency shifter with a line object containing information about signal ramp, the sound can be shifted in a number of ways. One future enhancement would be to create a greater set of audio processing options, and to create all of these using only the MSP library.

Conclusion

Over a period several months, I was able to see an idea come into fruition, and perhaps this was the most exciting aspect of creating “Nature of Sound”. However, the real challenge is still ahead, as the installation is set-up in the site and the audience interacts with it for the first time. Throughout the research, it was evident that each sound artist approached his or her projects differently, using technology as a tool, and never limiting their ideas or imagination. There are no rules or right answers in creating sound installation art, it is dictated by the artist and requires a lot of patience and fine-tuning before the work is completed. As software and hardware tools continue to evolve, and collaborations over networks become faster, the number of artists who will embrace technology will be greater, and the future of sound art is likely to flourish in exciting and unexpected ways.

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