The Argus Project: Underwater Soundscape Composition with Laser-Controlled Modulation.

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Abstract

In this paper we describe and analyze *The Argus Project*, a sound installation involving the real-time processing and spatialized projection of sound sources from beneath a pond's surface. The primary aim of *The Argus Project* is to project the natural sound sources from below the pond's surface while tracking the changes in the environmental factors above the surface so as to map this data onto the real-time audio processing. The project takes as its conceptual model that of a feedback network, or, a process in which the factors that produce a result are themselves modified and reinforced by that result. Examples are given of the compositional process, the execution, and processing techniques.

1. Introduction

One of the remarkable possibilities of environmental sound installation as well as soundscape composition is the opportunity for the artist/composer to incorporate objective scientific observation as an important generative substance of the work's aesthetic content. Whether this comes from the use of natural field recordings or the sonic retrieval of atmospheric disturbances, a natural ecosystem is a palpable point of departure to search for rich and unpredictable sound sources. Our purpose with *The Argus Project* is to work with ecological sound sources in a mode similar to what sound artist and composer David Dunn describes as an "intensification of environmental sensing and the compositional analysis of environmental ambience patterning" [1].

Often times we are not alerted to our acoustical surroundings until something sounds out of place. The goal of this project is to bring to focus an unfamiliar acoustical space by recontextualizing it into something more familiar. As we began the process of creating the installation we became acutely aware that a natural body of water is a complex resonant space and could be reframed as an instrument in itself, just as the surface of a pond is like "a membrane enclosing something deep in thought" [2].

2. Implementation

The sounds heard during a performance of *The Argus Project* are the result of the complex interactions of two separate but mutually dependent acoustical mechanisms: those of sound production and sound modification.

2.1 Sound Production

The sound production mechanism consists of two hydrophones (microphones specifically designed for underwater use), an amplifier, and a quadraphonic sound amplification system. The hydrophones amplify sounds both from below the surface of the water and from above, including surface disturbances, escaping air pockets, water currents, fish, insects, and various other underwater organisms. The sound production aspect is highly specific to the location of the installation. Different underwater locations will have vastly different soundscapes. In addition, the same underwater location may sound completely different from month-to-month; a lake or pond might sound loud and chaotic at one time of the year yet nearly silent at another. This is caused primarily by the behavioral changes in the lifecycles of underwater organisms as well as the seasonal effects causing a varying level of vegetation, which affects the sonic transparency of the water. Because of this, each performance of *The Argus Project* is unique to both place and time.

2.2 Sound Modification

The sound modification mechanism consists of two 1 mW laser beams, two solar cells, a voltage-to-data converter, and a laptop. The two lasers are placed on opposite sides of the pond and directed across the surface of the water to the solar cells located at the central processing location. Unpredictable natural elements such as wind, water vapor, flying insects, and floating particles disrupt the laser beams as they travel toward the solar cells. These disruptions cause alterations in the intensity of the beams, which are translated by the solar cells into a stream of constantly changing voltage levels. The data gathered from the changing voltage levels is then converted by a *Teabox* sensor interface, which is then synced to a control patch created in the Max/MSP software environment.

3. Technical Description

3.1 Hydrophones

Two highly sensitive lab-grade hydrophones (designed primarily for research in marine biology) are used to retrieve the rich soundscape within the body of water. The hydrophones are connected to independent input channels of an audio interface connected to the laptop. In the most recent performance the hydrophones were hung over opposite sides of a bridge that crossed the mid-section of the pond. This allowed for the hydrophones to reach a depth of approximately 6 to 10 feet below the pond's surface. In preceding tests of the installation, the hydrophones were buoyed to rafts and canoed out to the center of the pond where they could reach depths of 12 to 20 feet. The placement of the hydrophones is one variable aspect of the installation and is typically determined after extensive testing to find the most acoustically active location of the pond. In certain cases during the testing process, we found that we were able to achieve the best sonic results in areas of the pond that combined low surface wind turbulence with a low density of vegetative growth.

3.2 Solar Cells and Laser Modulation

In addition to the acoustic behavior of the pond we felt it was important to incorporate other physical elements of its behavior as well. We made the decision to trace the activity immediately above the pond's surface, as this would allow for a dynamic and continually changing stream of data to map onto the parameters of the sound processing.

Two class II laboratory lasers (1mW 600-700nm) are mounted on tripods on opposite ends of the pond and the beams are directed just above the surface of the water to two solar cells (7 x 4.5" 9V). The minute fluctuations in the intensity and location of beams that result from natural disturbances in the air cause the voltage outputs of the solar cells to move slightly up and down. The photovoltaic signal is then converted into an audio signal and sent to the audio interface. Finally, an ADC translates the audio signals into two independently controllable data streams. The two streams can then be scaled in a mixture of ways to allow for extensive dynamic sound processing within the Max/MSP software. Because of the nature of working with photovoltaic cells in conjunction with lasers, we found it best to present the installation after dusk to avoid having to shield the solar cells from the sunlight. Another factor that was taken into consideration during the planning phase is the amount of laser light diffusion, which is proportional to the distance of the lasers from the solar cell. Too little diffusion diminishes the voltage output of the solar cell as well as the range of voltage fluctuation. Conversely, too much laser diffusion causes much of the light to escape into the atmosphere, which also decreases the voltage yield of the solar cells. The distance from the laser beams to the solar cells needs to be calibrated so that the diffusion of the laser beams is approximately equal to the size of the solar cells.

3.3 Speakers

The sound amplification for the sound installation consists of four compact powered speakers (4" woofer and 7/8" tweeter) located on the far corners of the pond. Sound spatialization is an extremely important aspect of *The Argus Project*. Because of this, custom audio speaker cables provide for maximum speaker separation (up to 150 feet from the central processing location). The speakers are pointed away from the water both to avoid speaker feedback and to increase the acoustical territory of the installation. This design allows for the participants within the space to walk around the pond's circumference thus encouraging a kinetic relationship with the resultant soundscape.

The spatialization design of the installation reflects a strong concern for integration: of the listener with the artwork (interactivity), the listener with the environment (natural observation), and of the installation with the environment. This last aspect, that of integration of the installation with the environment, is one of the most

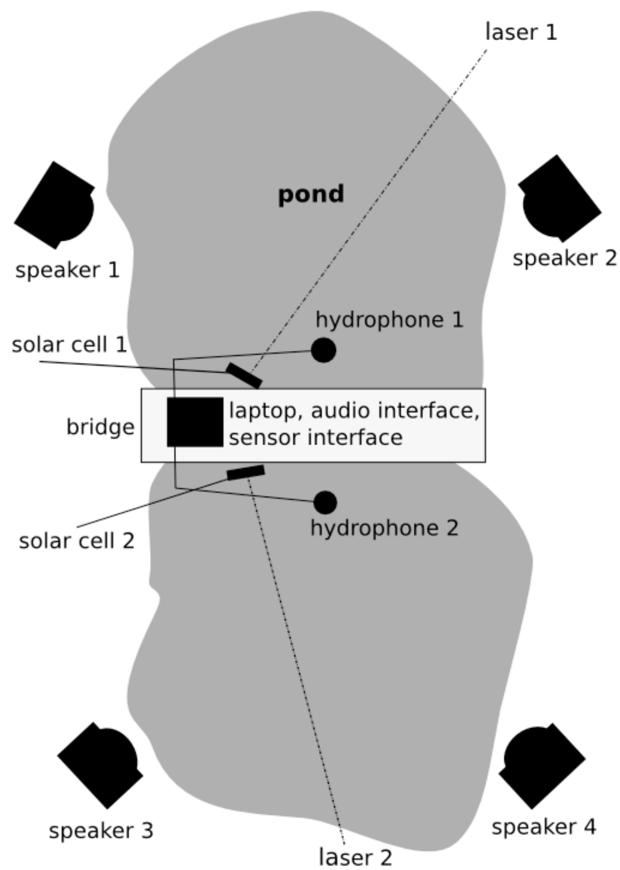

Figure 1. The design layout of *The Argus Project*.

striking and mysterious features of the project. Not only does both the sonic material and sound processing originate from the natural environment itself, but, additionally, the sounds emanating from the speakers become integrated with (and very likely influence) sounds outside the installation. In previous presentations of *The Argus Project* familiar night sounds, both natural (birds, cicadas, crickets) and man-made (distant traffic, airplanes, distant laughter, the footsteps of the listeners) were often difficult to distinguish from the processed sounds coming from below the water. This created an exciting, if at times slightly disturbing conflict between the sounds and our ability to discern their source. We see this as a partial realization of Pierre Schaeffer's concept of acousmatic hearing as applied to everyday experience, where multiple sonic ecosystems are fused in a disoriented immersive experience [3].

3.4 Sound Processing

The real-time sound processing is all implemented in Max/MSP and uses a randomized alternation of combined processes. A total of six processing techniques are used with anywhere from one to four processes happening at one time. The processing techniques used are spatial reverberation, spatialized granular synthesis, narrow band pitch shifting, comb filtering, and two varieties of spectral filtering. The most present of these techniques within the sound output is granular synthesis, which was chosen primarily for the ability to allow for imitative and ecologically-minded sound events and a more complex rhythmic schema reflective in the pond itself [4]. Manipulated parameters include the length of the grain, the spacing and overlapping of grains, the pitch shifting of grains, and the overall randomization of each of these parameters. As the data stream remains relatively static, the granular synthesis parameters will be less randomized, resulting in an even grain length and spacing between the grains. As the data stream becomes more active, as a result of more interference with the laser beam, the parameters become more randomized. This processing adds a dynamic element to the overall sound in ways that reflect a pond's behavior. As another example, data collected from the variation in water vapor patterns can be applied to the pitch parameter of the pond's harmonic spectra, resulting either in a reinforcement of the familiar rising glissando that occurs in the real world or in less expected ways (inverting the pitch arc, slowing down the granular motion, etc.). Techniques such as this offer the sound artists some subjective input into the installation, creating a multi-faceted counterpoint that is guided but not controlled by human interaction. The overall result is both an acceptance of indeterminacy from the generative source of the installation and a compositional interpretation of the source soundscape by the composers.

4. Concluding Thoughts

In this project we aim to momentarily reframe an absolutely unique biospectrum. One of the most important facets of the work is that it is installed outdoors where the listener's response to every environmental change becomes heightened. It is also our hope that by entering and walking through the space, attentive listening achieves a renewed environmental awareness. A crucial element of this project is that it relies on a rigorous observational routine, where both the generative sound sources and the electronic transformation creates unpredictable results wholly dependent on the chosen location, weather, and time of day, time of year. We strive to create a spatialized speaker arrangement that is coterminous with the underwater space that is being observed. We also strive to create a sound work that provides allusions to natural feedback systems through the use of natural environmental changes to modulate sound sources from a natural ecosystem.

5. Acknowledgments

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