Unreal Worlds a Study in 2d Wavetable Synthesis and Soundscape Ecology

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Abstract

In ***Unreal Worlds*** (2023) audio is processed by a 2d wavetable object in Max/MSP enabling radical manipulation of nature sounds recorded near my home at various times of day. Recorded sounds feature song sparrows (day), frogs (night), frogs and birds (day), and bird song (morning). Native species include sparrows, nuthatches, titmice, yellow chat, robins, cardinals, tree frogs; and sparrows figure significantly in the recordings.

Sound gestures in ***Unreal Worlds*** (2023) were composed to resemble the natural environment's densities and proportions, but the sound worlds themselves are fabricated. Effort was made during the compositional process to both emulate the natural world and, in some cases, leave in or enhance the artifacts of the audio processes used to transform the sound. Once known, these are easily distinguished; from pitch transposing birds and frogs, the sounds of "wind, "water," and the ambient drones of the second half of the work.

There are several versions of the work the first is approximately thirty minutes long, with six minutes of silence interspersed throughout. The silence to enables patrons to perceive how sound transforms an environment (habitus).

During this paper presentation, I will discuss the creation of transition matrices from environmental recordings and demonstrate other versions of the work including installations, and user-controlled patches.

Unreal Worlds 2d Wavetable Synthesis Installation

Unreal Worlds (2023) was composed for an exhibition entitled, ***Making Place***, September through October 2023 in the Carroll Gallery of the Marshall University's School of Art & Design. The work is a 30-minute loop capturing aspects of the local soundscape presented tongue-in-cheek to those who would listen critically. As a composer and nature lover, I am continually amazed by the beauty and diversity of ecosystems, and the richness of any sonic environment and though subsequent variations of ***Unreal Worlds*** will attempt to emulate nature more closely through the incorporation subtle biophonous proportions, and tonal variations; *the* subtext is that these imitations are no substitute for the beauty and variety of the world that surrounds us. They are a pallid imitation; representations using sounds we perceive with only limited understanding of their function, purpose, or intent. As David Dunn stated: [We must]…*hear beneath the surface of our most familiar projections to what might be a more intrinsic understanding*, what Bateson called [the] mind in the natural world. [1]

Soundscape?

Bioacoustics often focuses on individuals of the same species implying that communication is a locked system that ignores inter-species interactions. It often refers to the **emission-propagation-reception paradigm**. Though this approach is useful, more recent work focuses on revealing networks of communication, or the sum total of acoustic elements occurring in a network, ecosystem, or **soundscape.** These studies focus on species interactions, and how they compete, or cooperate for limited acoustic space in the environment, and they have yielded models of sound transmission that focus on biophysical characteristics, the physical environment, and feedback mechanisms that give rise to changes in songs and calls. Species interactions are classified as-**biophony**, sounds of the environment-**geophony**, and human sounds-**anthrophony.** [2] These are the primary components of a soundscape of which we are generally aware. My experiences while making field recordings for this project highlighted that species in close proximity (2-10 meters) often times interacted like a group of improvisers, giving each other space to 'sound off' in the biophonous chorus (Acoustic Niche Hypotheses-ANH). Continuous anthrophonous sounds (machines) had little effect on biophonic interactions, while sudden loud anthrophonous sounds, the presence of a predator, or my presence often silenced the group. After an interruption when the chorus resumed, if I remained, my presence was still 'felt'. These observations confirm what has been well known in the bioacoustics field, that human disturbance of environments reshapes geophony and alters animal activity, sounds, and interactions. [3]

Acoustic Indices

When addressing networks of communication, **Acoustic indices** may be used to account for acoustic diversity. Indices can be classified for a wide range of factors but many refer to amplitude, complexity of time/rhythm, frequency or amplitude, or take into account **biophony**, **geophony**, or **anthrophony**. [2] Figure 1 shows a sonic spectrum featuring three distinct species. During the analysis phase of the project, sounds were processed with broadband noise reduction to reveal individual species more clearly. The audio spectrum below demonstrates differences between three species in one of my recordings. The frog sounds had a quick rhythm at a lower frequency and amplitude than the Yellow Chat bird call that followed. This call was slightly slower, had a broader pitch range, and a higher amplitude intensity than the frogs or the American Robin whose call featured more pitch diversity, a lower amplitude, and short phrases separated by silence.

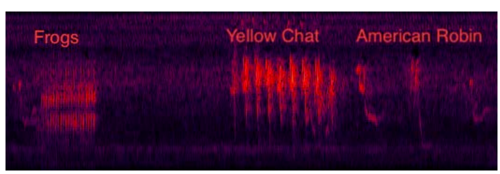

Figure 1: Audio Spectrum of Biophonous sounds recorded June 8, 2023. [1]

Day, Time, Season

Unreal Worlds employs sounds from different portions of the day; morning, midday, and evening. My observations of activity in field recordings mirrored research findings where there are distinct differences in the dawn and dusk chorus, midday and evening biophony. Field recordings were made at my home, a .33-acre lot containing wooded and grassy areas, and ample food and water for our local animal residents. Further, these recordings were made in summer, which has the greatest animal activity. [4] More recordings are being collected and analysed to map changes of season.

Unreal Worlds #1: fixed version, 2d Wavetable Synthesis

In the first version of the work, I collected sounds from field recordings and modified them using the mc.2d.wave Wavetable Synthesis object in Max/MSP. In this object the audio file is divided into rows (e.g., 1 = the entire file), the length of the segment to be played, starting point for playback and range are specified. Inputs may also be modulated using continuous waveforms (e.g., phasor) or multichannel waveforms. Both are shown below, though only one can be used at any given time.

Figure 2: Max/MSP mc.2d.wave patch

Combinations of input variables enable changes to playback, speed, pitch, duration, forwards/backwards playback, radical modulations, and/or granularization of the sound file. [2] Modified sound materials were then assembled and mixed in a DAW for the final version using roughly the same time proportions as the original source files. This version of the work plays off the notion that environmental sound recordings are representations of the original environment; a flattening of acoustic complexity which has been edited to be repeated and consumed. [4] My version takes this one step further using processed sounds to represent geophony (e.g., wind, rain, burbling streams), and altered biophony creating 'new' species of birds, frogs, and insects from the original sound recording, as well as other ambient sounds similar in style to the work of Hildegard Westerkamp. [3] In this first version of the work, timing between iterations of single species were generally preserved, but the interactions between species were composed to create an imaginary soundscape, with imaginary creatures. To further the project and develop a more nuanced understanding of soundscape interactions, I built analysis patches to capture timing, amplitude, and frequency events from the original recordings. These became the basis for probability matrices and the beginnings of a second version. This process confirmed the cyclic nature of sound events, the relative consistency of frequency and amplitude for each species, and a clearer understanding of event variability in the realms of pitch and rhythm.

Analyses Patches

I analysed field recordings using the bonk~, sigmund~, and timer objects in Max/MSP. This generated tables of amplitudes, frequencies, and timings for each of the files analysed. [5] Amplitude of octaves in recorded samples returned predictable results with most biophonous sounds existing in the sixth and seventh octaves of the spectrum analysed approximately 1.5 to 6 khz. [2] These amplitudes were then incorporated into the demo version of **Unreal Worlds #2**.

```
AmplitudeDaytime
0.24., 0.18. 0.32. 0.66. 2.15. 4.64. 3.36. 1.49. 0.84. 0.240.;
0.20., 0.43. 0.38. 0.83. 1.80. 6.74. 8.39. 2.41. 1.12. 0.200.;
0.15., 0.20. 0.27. 0.59. 2.15. 4.22. 3.47. 1.41. 0.81. 0.150.;
0.16., 0.26. 0.24. 0.54. 1.11. 4.26. 5.40. 1.73. 0.74. 0.160.;
0.31., 0.26. 0.49. 0.73. 1.43. 5.84. 9.15. 2.14. 1.25. 0.310.;
0.30., 0.23. 0.30. 0.68. 2.47. 5.05. 3.99. 1.45. 0.93. 0.300.;
0.11., 0.18. 0.25. 0.43. 1.07. 3.37. 5.44. 1.67. 0.96. 0.110.;
0.21., 0.28. 0.36. 0.77. 2.26. 4.81. 3.45. 1.52. 0.80. 0.210.;
0.33., 0.36. 0.33. 0.64. 1.19. 5.00. 8.97. 1.92. 1.39. 0.330.;
0.14., 0.26. 0.38. 0.75. 2.11. 4.87. 3.32. 1.63. 0.75. 0.140.;
0.27., 0.24. 0.30. 0.58. 1.08. 4.27. 6.94. 1.64. 0.96. 0.270.;
0.23., 0.24. 0.39. 0.64. 2.00. 5.20. 3.18. 1.49. 0.92. 0.230.;
0.34., 0.30. 0.38. 0.63. 1.33. 2.51. 9.29. 1.67. 1.63. 0.340.;
0.19., 0.26. 0.34. 0.58. 2.13. 4.59. 3.18. 1.38. 0.88. 0.190.;
0.17., 0.28. 0.30. 0.58. 1.03. 3.78. 5.86. 1.58. 1.12. 0.170.;
0.22., 0.24. 0.36. 0.69. 2.17. 4.80. 3.54. 1.39. 0.86. 0.220.;
0.18., 0.26. 0.36. 0.62. 1.56. 4.79. 4.02. 1.50. 0.80. 0.180.;
0.25., 0.22. 0.33. 0.62. 2.08. 5.09. 2.99. 1.35. 0.88. 0.250.;
0.10., 0.21. 0.37. 0.82. 1.64. 4.87. 3.80. 1.75. 0.76. 0.100.;
0.12., 0.15. 0.25. 0.85. 1.25. 4.87. 3.81. 1.45. 0.75. 0.120.;
0.32., 0.19. 0.33. 0.56. 1.20. 5.12. 7.06. 1.92. 1.19. 0.320.;
0.26., 0.18. 0.26. 0.61. 1.09. 5.06. 3.51. 1.64. 0.75. 0.260.;
0.46., 0.56. 0.48. 1.23. 1.44. 7.01. 16.79. 2.46. 2.65. 0.460.;
0.37., 0.64. 0.51. 1.21. 2.57. 10.55. 14.2. 3.90. 1.55. 0.370.;
0.39., 0.30. 0.53. 0.95. 1.99. 8.21. 9.32. 2.89. 1.20. 0.390.;
0.29., 0.27. 0.38. 0.76. 2.05. 5.37. 4.69. 1.58. 0.93. 0.290.;
0.28., 0.26. 0.33. 0.62. 2.07. 5.25. 3.21. 1.52. 0.86. 0.280.;
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Figure 3: Frequency Spectra Amplitude Collection Output from Bonk~.

Timer output of attacks filtered through Bonk~ captured event timing. In these cases, audio that had been processed with broadband noise reduction produced the best results for analysing discrete rhythms and frequencies. The table below shows the timing of chirps from the Yellow Chat in Figure 1 with short pauses followed by 5-7 repeated chirps in rapid succession. The timing of events (short, or long) are variable, but the overall perception of long silences followed by short sound events are perceived as a regular and predictable pattern.

1536	4045	3996
103	92	103
95	157	106
103	122	122
129	141	130
109	78	109
111		
141		

Figure 4: Timer Analysis of Rhythms of the Yellow Chat bird.

Visual Analysis of Recordings

In addition to using Max to analyse recordings, I also analysed audio spectra visually to parse species activity and general proportions. All of this data informed the creation of sketches for ***Unreal Worlds #2***.

Unreal Worlds #2: Probability Matrices

Sketches for *the work* use timing garnered from analysis patches and visual analysis of recorded spectra. The patch below triggers avian, and anuran sounds from the recording pictured in Figure 1 (e.g., Frogs, Robins, and Yellow Chat).

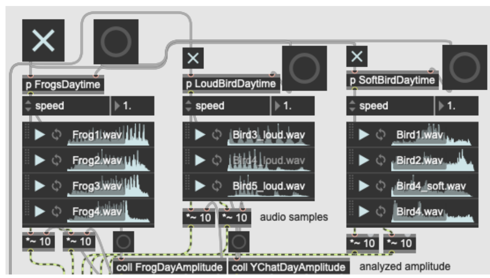

Figure 5: Max/MSP patch to trigger natural sounds.

Probability matrices created for each of the individual animal sounds incorporate timings between sound events into a transition matrix (middle of the figure).

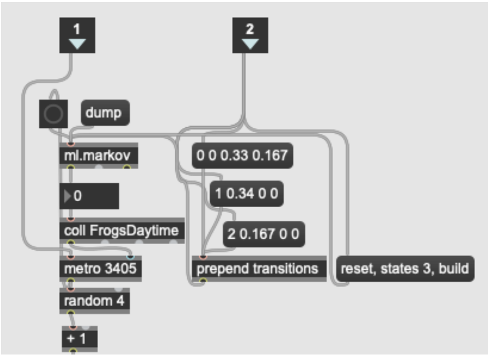

Figure 6: Probability Matrix

The sample analysed to generate the transition matrix was between two to three minutes in length, and though the sample length was short; the variation between entries of sounds from each species only generated between three to five states for each transition matrix attesting to the cyclic regularity of each species sounding in the chorus.

Conclusions

The ***Unreal Worlds*** project has been a fascinating journey of observation, aural perceptions, composing, audio analysis, and research in Bio Acoustics and Soundscape Ecology. ***Unreal Worlds 1, 2*** have revealed to me the potential for creating soundscape installations using samples triggered using probability matrices and the idea that a soundscape might be generated by assembling samples of its constituent parts. How many environmental recordings have been produced where the engineer waited to capture sounds absent the intrusions of ubiquitous anthrophony? I propose sampling individual elements and reconstructing them as an experiment to yield information about environments with or without each of the constituents (e.g., biophony, geophony, anthrophony). Further, I intend to continue gathering recordings in the Appalachian region to gain a fuller understanding of the biodiversity of the region and/or experiment with soundscape recordings collected by others such as those in the Bernie Krause archive, or on Xeno-Canto. [4]

Notes

1. Bird call identification, **BirdNET** Sound ID. K. Lisa Yang Center for Conservation Bioacoustics, https://birdnet.cornell.edu/ (accessed November 6, 2023).

2. ***Unreal Worlds #1*** https://drive.google.com/file/d/1V9VklovzSC_hhM4gFNyhkJJ-dYU_o1I4/view?usp=sharing

3. Westerkamp examples: Beneath the Forest Floor https://www.youtube.com/watch?v=n-U8iTyqKRA' Transformations: https://www.youtube.com/watch?v=J5Aa-JskUY0

4. Xeno-Canto wildlife sounds from around the world. https://xeno-canto.org/

References

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2. J. Sueur, A. Farina, A. Gasc, N. Pieretti and S. Pavoine, *Acoustic Indices for Biodiversity Assessment and Landscape Investigation*, ACTA Acustica United, Vol 100 (20, pp. 772-781, 2014.

3. B. Pijanowski, L. Villanueva-Rivera, S. Dumyahn, A Farina, B. Krause, B. Napoletano, S. Gage, N. Pieretti, *Soundscape Ecology: The Science*

of Sound in the Landscape, BioScience Vol. 61: 203-216, University of California Press, 2011.

4. van Peer, R. (1999), *'David Dunn – Music, Language and Environment'*, interview, *Leonardo Music Journal*, 9, pp. 63–68.
5. M. Puckette, T. Apel, D. Zicarelli, *Real-time Audio Analysis Tools for PD and MSP*, ICMC Proceedings, 1998.