OCEAN BUOY SPECTRAL DATA SONIFICATION: RESEARCH UPDATE

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ABSTRACT

Since first presenting this work at the 2002 International Conference on Auditory Display the author has professionally produced a multimedia CD that explores the sonification of ocean wave data. "Music from the Ocean" is a multimedia CD that explores the sonification of ocean wave data for oceanography, science pedagogy, and music and sound synthesis. Turning this data into sound provides new ways of experiencing and comprehending the phenomena involved; the processes come alive and are more comprehensible, memorable and exciting than graphs of the data. This CD contains over 55 minutes of sound examples as well as an interactive Flash presentation and research paper explaining the methods in more detail. The accompanying 16-page booklet features graphics and information about the data, phenomena, and music. The CD appeals to a wide variety of consumers, from oceanographers, science teachers, experimental computer music enthusiasts, and music therapists.

1. INTRODUCTION

A previous paper details the author's methods used to sonify ocean buoy data [1]. The data used is collected by the Coastal Data Information Program (CDIP), at Scripps Institution of Oceanography (SIO), at the University of California, San Diego (UCSD). For 25 years this program has measured, disseminated, and archived coastal environment data for use by coastal engineers, planners, and managers as well as scientists, mariners, the military, and surfers. CDIP operates approximately twenty buoys which record ocean conditions including wave height, period, and direction, air and sea temperature, wind velocity and direction, and barometric pressure [2]. Such multidimensionality and the data's cyclic wave nature is inviting for sonification and computer music composition.

The basic sonification mapping is quite direct. The spectrum of the original wave data is shifted and transformed into an audible signal. Thus frequencies in the sound domain are proportional to frequencies of the ocean waves. Amplitudes are determined by energies present in the corresponding frequencies. Each component can be spatialized according to the direction from which it is originating.

Low frequencies are long period swells which create large breakers that come in long regular intervals. High frequencies are short period waves, which create choppy water. Several times in the sonifications there are clear frequency sweeps from low to high. These signify passing energy that originated in a faraway storm. At other times there are quick downward frequency sweeps. These events were mysterious, even to oceanographers, until they were correlated to local afternoon winds.

Figure 1: "Music from the Ocean" CD cover

The author has professionally produced a CD demonstrating the sonification method, and composing with the ocean [3]. There are thirty-four tracks of sound and music that demonstrate the mapping, phenomena, and composing with the ocean. The CD also contains an interactive Flash application that combines the sonifications with graphs of the data, as well as the publication [1]. The accompanying 16-page booklet contains more text, graphs, and explanations of the data and sonifications.

2. THE SONIFICATION

The acoustic conversion of the data is simple and direct. The spectral composition of the sound is the shifted spectrum of the wave-driven motions measured by the buoy. The energies within the spectral components are the amplitudes of the spectral components in the sonification. The spatialization of a spectral com-

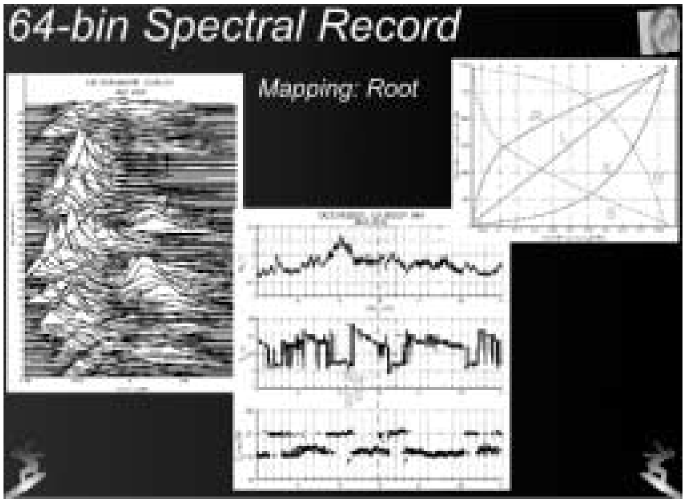

Figure 2: A screengrab of part of the Flash application. Users can play the sound using different spectral mappings, and follow along as a red bar sweeps across the graphs.

ponent is determined by the direction from which that component is observed originating. In its most basic presentation, the ocean waves are being scaled to audibility.

The most important parameters for the sonification are adequate spectral shifts, and the time compression of the data. Certain portions of the spectra can be emphasized more than others, which can make swell more or less perceptible than sea. Compression of the time-series data can turn a year's worth of data into a sonification lasting seconds to hours.

3. MAKING THE CD

The sonifications on the CD were created using MATLAB 6.0 on a Sun Blade 1000 running Solaris 7. Ten gigabytes of sound were computed and from this just over 600 MB were chosen. The CD tracks are arranged in three sections: sonification parameters, ocean phenomena, and composition.

The first section demonstrates several sonifications of the same dataset, showing how different spectral mappings and time compressions change the perceived information of the sonification. In the time compression examples an entire year of data is compressed into 10, 3, and 1 minute durations.

The phenomena section gives aural examples of swell, sea, wave-trains, and sea surface temperature change. A general characteristic of the sonifications are long upward sweeps and short regular downward sweeps. Those latter effects were mysterious until they were correlated with the normal afternoon winds near the sonified buoy. After mixing into a sonification aural clicks at each midnight, the downward sweeps are heard to occur most often in the afternoon. These effects are not apparent in visual representations of the data, and only came to be "discovered" after making the sonifications.

The third section of the CD demonstrates the use of the sonifications for compositional purposes. One track on the CD overlays sonifications of 14 buoys during the same period; the enormous sound is like a busy train station near a church during an earthquake.

The CD also includes an interactive Flash application of the methods and data to allow for a more complete understanding of the technique. The user is able to hear the data and watch a graphs of the data as the sound plays. *Figure 2* shows one such display where the user chooses a sonification mapping and watches a red progress bar sweep over graphs of the data as the sonification plays.

4. RESPONSE

"Music from the Ocean" is appealing to more than one market. It has applicability in oceanography, demonstrating a new technique for data analysis. It has value for pedagogy as well, providing interesting lessons for physical oceanography that are entertaining and memorable. The CD is also musically interesting for computer music, science and art topics, and as relaxation music. One employee at CDIP suggested that if he knew the data sounded like that his job would be more interesting and dramatic. Other auditors have remarked how calming it is. A second grade teacher has used it in lessons about the ocean. Many people either relax or sleep to the CD. To appreciate and be intrigued by the music one doesn't need to follow the science.

For a review of the CD, sonification expert Stephen Barrass has said that it's "like holding a digitally enhanced seashell to your ear to hear waves of data crashing on the shore." He and others working professionally in sonification research have commended it "for making sonification more generally available and accessible to a broader community of listeners, raising the potential for new genres of 'sonification inspired music' and 'musically inspired sonification"' [4].

5. CONCLUSION

It is rare to find a CD that is not out of place with books on physical oceanography, Diana Deutsch's aural illusions and paradoxes, experimental computer music, and new age music. "Music from the Ocean" is an attempt at creating a CD that successfully crosses all these disciplines and remains an interesting application of sonification.

The ocean buoy spectral data of CDIP lends itself well to sonification by its being not only cyclic and dynamic, but a measurement of waves. Since the CDIP database is very large it provides a rich collection of data for auditory display experimenting and algorithmic composition. Further work should be done to enable real-time interaction with this data, image, and sound. This CD is an excellent first-step for directing future research and development.

6. REFERENCES

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