Orbits: A data driven instrument for live performance

Monica Bolles

Resonant Interactions, LLC
Denver, CO USA
monica@resonantinteractions.com

ABSTRACT

Orbits is a data-driven generative instrument, built in Max MSP, that uses data relating to the rotational patterns of Venus and Earth around the Sun to generate a variety of tones and visualizations that can be composed or improvised into a real-time performance. The data sets the instrument uses are supplied by Hartmut Warm in his publication *Signature of the Celestial Spheres* and data from the High-Resolution Transmission Molecular Absorption (Hitran) database. The instrument is built to output to variable numbers of speakers and has been performed on systems that range from stereo to 140 channels. The instrument is controlled through an iPad and Mi.Mu gloves. This paper will explore the different methods of data sonification and sound spatialization and how the artistic exploration of data can be used as a means of entertainment as well as a tool to generate further curiosity into the exploration of data.

1. INTRODUCTION

Data visualization and sonification can be a method of making data more easily accessible for non-data scientists. By building instruments that musical performers can use as tools to explore and perform data sets we are creating the potential for people to engage with data in new and unusual ways. This paper will discuss the build of the data-driven instrument Orbits and the method of data sonification used to build an immersive and experiential tool for exploring data through sound and visual immersion.

2. RELATED WORK

The development and build of Orbits was based on conversations and exploration of work by Hartmut Warm in his publication and software application *Signature of the Celestial Spheres* [1] in the context of working alongside Kelly Snook and others in the development of a data sonification instrument called Concordia [2]. In his work, *Signature of the Celestial Spheres,* Hartmut Warm uses osculating data from Solex to generate intriguing geometric patterns based on the drawing of a line between two planets and mapping them to a visual output. The final visual representation of the data set concerning Venus and Earth as they rotate around the Sun can be seen in Figure 1.

These images beg to question patterns in nature and how data visualization and, in our case, sonification can be used to explore these patterns and create deeper human understanding and appreciation of the natural world around us.

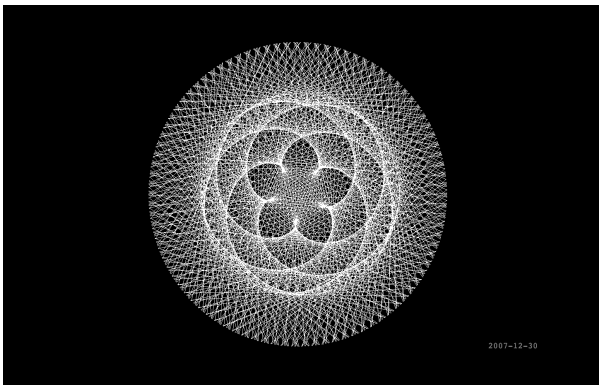

Figure 1: Visualization of geometric pattern realized through the Warm's Venus and Earth data set.

3. ORBITS

In this section of the paper we will discuss the Orbits system and all of the parts that contribute to it's playability.

3.1. Data

Orbits uses two data sets to generate the tones that the performer can use in the live application of the instrument. The initial data set used was published by Hartmut Warm in his development of *Signature of the Celestial Spheres.* This data set is based on osculating data from Solex and is discussed in depth in the related work section above. The particular data set used for Orbits calculates the position of Venus and Earth as they move around the Sun every four days for seven years.

The specific data values used will be further referenced to as:

- Distance - the calculated and scaled distance between Venus and Earth.
- Venus Length – the scaled value of the data point referred to as Venus length within Hartmut's data set.
- Earth Length - the scaled value of the data point referred to as Earth length within Hartmut's data set.
- Venus Latitude - the scaled value of the data point referred to as Venus latitude within Hartmut's data set.
- Earth Latitude - the scaled value of the data point referred to as Earth latitude within Hartmut's data set.

The second data set used was published online as part of the High-Resolution Transmission Molecular Absorption (HITRAN) database [3, 4]. HITRAN uses spectroscopic parameters to predict and simulate the transmission and emission of light in the atmosphere. Scaled frequency

spectrums for the molecules Nitrogen, Oxygen, Carbon Dioxide, Hydrogen, and Methane were used to generate tone samples that were further used in combination to create a final tone based on the molecular makeup of Earth's atmosphere and Venus's atmosphere. These tones will be further labeled Earth tone and Venus tone.

3.2. Sound Spatialization

The initial performance of Orbits was built for a 16.1 channel speaker array; however, it is easy to adjust for different sized arrays and has been performed on systems ranging from stereo to 140 channels. The instrument uses a combination of ambisonics and the individual addressing of speakers to be able to create a fully immersive sonic experience. To modulate the instrument for the current speaker array, the instrument needs a speaker map to decode the ambisonics elements and a few adjustments to .mc objects in Max MSP to stipulate the current number of speaker outputs. A fully spatialized experience is preferred; however, the system can accommodate a stereo version.

3.3. Transport Control

The entire system is controlled by an overall transport. Within the transport, there is the ability to assign a meter (which is used to control rhythmic values of certain tones) and a tempo (which dictates how quickly or slowly the system moves through data points in Warm's Venus and Earth data set). There is also a control for lowering the resolution of samples (ie.. skipping lines in the data set so that values are being distributed every 7 days instead of four). These parameters can be controlled and manipulated in a live performance to create interesting effects.

3.4. Sound Synthesis

All together there are 8 different sounds that have various variables that you can control in live performance, as well as an FX's unit that can be applied to a live instrument or vocal feed. The approaches to the sonic development and sonification methods used will be discussed further in this section.

There will also be mention of what variables, if any, are available to be controlled with each tone. Those variables are defined as follows:

- Rhythmic Duration: Can control the rate at which the notes are being played. (ie every quarter note, eighth note, sixteenth note)
- Frequency Multiplier: Can multiply the frequency values coming in by an assigned valued to raise or lower the overall pitch of the tone.
- Mod Values: The ability to modulate the tone based on the control of another signal.
- Distance: Specifically relating to cluster tones in ambisonics field this variable represents the distance of orbiting sound objects around central sound object within the tone clusters.

3.4.1. Triangles Yay!

Triangles Yey! is a tone based on the layering of triangle wave oscillators. The frequency (pitch) of the oscillator is controlled by the Distance value. As we move through the data set the following data point is played in the consecutive speaker. The larger the speaker array the more data points are playing at one time. This creates a beating tone when the audience is centered in the middle of the speaker array. The sound becomes a tone that rises and falls when the audience moves around the space either counter clockwise or clockwise.

Variables: No Variables.

3.4.2. Distance Melody

Distance Melody combines the Earth Tone and Venus Tone and loads that tone into a wavetable that is then pitched by the Distance value. This sound is sequentially output to the consecutive speaker in the array.

Variables:

- Rhythmic Duration

3.4.3. Venus Melody

Venus melody uses the Venus Tone as the basis for a wavetable that is then pitched by the corresponding Venus Length value. This sound is sequentially output to the consecutive speaker in the array.

Variables:

- Rhythmic Duration
- Frequency Multiplier

3.4.4. Earth Melody

Earth melody uses the Earth Tone as the basis for a wavetable that is then pitched by the corresponding Venus Length value. This sound is sequentially output to the consecutive speaker in the array.

Variables:

- Rhythmic Duration
- Frequency Multiplier

3.4.5. Molecule Dance

Molecule Dance uses the combination of two 2-dimensional wavetables referencing the Earth Tone and Venus Tone being modulated by both the Venus and Earth Latitudes and Lengths to generate this tone. This sound is summed to either whatever speaker outputs are available or can be assigned to specific speakers in the array.

Variables: No Variables.

3.4.6. Triangles of Death!

Triangles of Death uses the Distance value to modulate the duty cycle of a series of triangle waves. This sound consists of a heavy amount of low frequency content and is best assigned to available subwoofers; however, can also be creatively assigned to specific speakers in an array.

Variables:

- Mod Values.

3.4.7. Ambi Earth

Ambi Earth uses ambisonics to virtually encode a cluster of 16 sound objects into a 3-dimensional space that orbit around the center of that space based on the positional data of Earth in its relationship to Warm's data set. The sound objects consist of sixteen triangle wave oscillators each with sixteen separate pitches controlled by the Earth Length values. When a new data point is added the oldest data point is subtracted.

Variables:

- Distance

3.4.8. Ambi Venus

Ambi Venus uses the same methodology for the creation of the sound as the Ambi Earth tone. It substitutes the Venus positional data and Venus Length values for the Earth values used in Ambi Earth.

Variables:

- Distance

3.4.9. FX Unit

The FX unit is a spatial delay effect that can be applied to any single live input. The unit creates a multichannel delay that is output to sixteen sources that are then applied to the sixteen sound objects in the Ambi Earth cluster and encoded into the ambisonics field.

Variables

- Mod Values
- Distance

3.5. Performance Controls

The system is currently built to be controlled by both an iPad and Mi.Mu Gloves. The iPad gives the performer control of turning on and off the audio engine, the activation of the transport, the volumes of the sounds in the system, and the rhythmic durations and frequency multipliers in the system. The Mi.Mu gloves are best used to control the tempo of the entire system, the data sample rate, mod values, and distance controls. All of this is customizable; however, and can be adjusted to the performers wishes.

4. FURTHER ADVANCEMENTS

The next steps in the build of Orbits are as follows:

- Incorporate more of the planetary data sets provided by Warm.
- Create more tones and sonifications for sonic choice and variety. Fully explore and research the gestural relationship between the control of the instrument and the body.
- Build out FXs units that are exploring the relationship between data and real time manipulation of a live input.
- Continue performing and gathering input on the effectiveness and inspirational nature of performances.

5. CONCLUSIONS

The tones created in Orbits through the exploration of data sonification create a base of sonic exploration that can be expanded and contracted as a means of providing an engaging performative experience. Creating data driven instruments for performers to use in live contexts allows for new and inspiring ways to connect audience members from a variety of backgrounds and interests to data in new and exciting ways. Through further human engagement and interaction with data we can only hope to find relationships and patterns that would otherwise be lost in an overwhelming string of numbers. Through this exploration of human relationship to data patterns in nature we can only hope to further connect humanity, nature, science, and art in a symbiotic relationship that could potentially lead to new discoveries and new connections.

6. ACKNOWLEDGMENT

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7. REFERENCES

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