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Voices of Earth: A Global Symphony

**A Musical Simulation of Acoustic Phenomena
Computer-controlled in Real Time from Sunset to Sunset**

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Acoustic Phenomena

There are four categories of acoustic phenomena that are generated within the various layers or spheres of earth. These sounds vibrate and propagate through the air (atmosphere), liquid (hydrosphere), solid (lithosphere), and organic substance (biosphere). Within each category of phenomena, there are a variety of sounds that vibrate within the range of human hearing. When these sounds enter the ear and brain, we experience the magnificence and wonder of speech and music.

Of course, we think of sound as something we hear or listen to. Yet, there are many sounds that occur on earth that exist outside the range of human hearing. Many acoustic phenomena, such as high and low atmospheric pressure systems, tidal motions, earthquakes, etc. may be perceived if the frequencies and amplitudes of a sound are transposed to within the range of human audibility.

Sounds on earth that are undetectable by human ears extend from tiny microacoustic waves produced by fluctuations of the trapped particles in a normal sound field in air, to macroacoustic wave disturbances, including seismic waves and global waves. These sounds may oscillate at frequencies ranging from millions of cycles per second to a single cycle within a period of days, months, or years. Sounds may travel at speeds ranging from several feet per second, to speeds approaching the speed of light.

Frequency

For the presentation of *Voices of Earth*, frequencies of about thirty different acoustic phenomena – excluding sampled sounds - were converted into audible hearing range. Sounds were scaled up, as needed, by the proportion of eleven octaves. Some adjustment was made for the few sounds that were outside the eleven-octave boundary.

Many phenomena vibrate within a *range* of frequencies, similar to a musical instrument that can produce a variety of tones from low to high. For each of these sounds, a fundamental frequency was established, as well as a low to high range. Finally, the fundamentals were converted into musical tones.

Amplitude

Amplitudes of the various phenomena were translated into dynamic intensities, expressed in degrees of loud and soft. The greater the amplitude of the phenomena, the louder the tone, the lesser the amplitude, the softer the tone. Overall, the dynamic range of the phenomena vary from softest for the smallest vibrations, such as stress waves in crystals or acoustic cavitation (bubbles), to loudest for the larger rhythms. Ocean and land tides are represented by a dynamic crescendo (flood- 6 hr.) and decrescendo (ebb - 6 hr.) applied to harmonics of the earth's rotation.

Duration

Voice of the Earth plays for a duration of 23.7 hours, extending from sunset to sunset. Since the earth has been rotating for 4.6 billion years, one period of rotation, or day, represents a tiny fraction, or sample, of the earth's lifespan. Similarly, this period represents an infinitesimal sample of the earth's acoustic phenomena as they occur in time.

Comparatively large-scale phenomena, such as the earth's rotation, tides, light-dark periods oscillate continuously throughout the life of the planet. These oscillations are represented by *continuous* sounds that persist in the music from beginning to end.

Other phenomena vibrate in repeated segments of similar or varied durations, separated by periods of inactivity. These oscillations – referred to as *pulses* – which include, but are not limited to, ocean waves, brain waves, circadian rhythms, are represented in the music as sustained sounds, separated by varied durations of silence. These 'pulses' tend to occur periodically, but are not necessarily regular, within the course of a day.

Finally, there are sounds dubbed *cycles* that occur for a finite duration, typically once only, on a particular region of the earth, within a 24 hr. period. These include phenomena such as high or low pressure fronts, atmospheric waves, seismic waves, cyclones, tidal waves.

Timbre

Each of the four categories of acoustic phenomena – air, liquid, solid, organic substance – has been assigned a unique quality of sound, or timbre. These four 'voices' serve the music much like different instrumental groups in a symphony orchestra. As a general rule, tones associated with air tend to sound light, transparent; liquid tones, buoyant, flowing; solid tones, dense, dark; organic tones, lively, animated.

Timbres for individual sounds within a category were selected and modified according to aesthetic qualities that, in our musical judgement, best suited both the unique sound, and the category to which it belonged.

Computer Program

After gathering and categorizing acoustic phenomena, converting the frequencies to musical tones, and assigning appropriate dynamics and timbre, a computer program was created to coordinate the musical events in time.

The goal of the computer program is to activate various algorithms, or self-contained mini programs, that simulate the flow of acoustic phenomena in nature. The computer is programmed to organize *continuous* tones, *pulses*, and *cycles* within a period of a single rotation of the earth, from sunset to sunset.

Some sounds are *continuous* over the course of a day, such as the Earth's spin, or a hurricane. In many cases, dynamic intensity of these sounds is varied, referencing changes in amplitude.

To find the start-stop times for *cycles*, the program calculates the probability of occurrence of a particular cycle. Then it plays that sound for its given duration. The program divides the period of the earth's rotation by the cycle duration to find the maximum number of times a cycle might occur within a day. For example, a cyclone has an average duration of about 8 hours, with an initial probability of occurring on a given day. As the time of day increases, if a cyclone hasn't occurred, the program increments the chance of occurrence every hour.

Pulses are programmed to repeatedly start and stop, with intermittent silences (periods of inactivity) separating the sounds. The program generates a phase offset number from 0% to 100% of the sound's duration, which gives the new start time for each pulse. The duration of the silence between each pulse is determined by generating an upper fraction (50% to 100%) of the total duration. A simulated Delta brain wave, for instance, lasting for an hour, will play again following an intermittent silence of 30 to 60 minutes.

In addition to controlling start and stop times for the various phenomena tones, the computer program automatically incorporates recorded sampled sounds into the music.

Sampled Sounds

There are a variety of sampled sounds that are integrated into the music. These range from environmental noises, such as rain, wind, and thunder, to human speech sounds representing more than 25 different languages. The sounds also include various animals, birds, and insects that are representative of diverse regions and environments throughout the world.

A computer program was used to control the selection of individual sounds, and their respective start times.

Images

A number of screen images of the various acoustic phenomena accompany the sounds. Many of the images are low-orbit satellite photographs mined from NASA's *Visible Earth* collection.

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