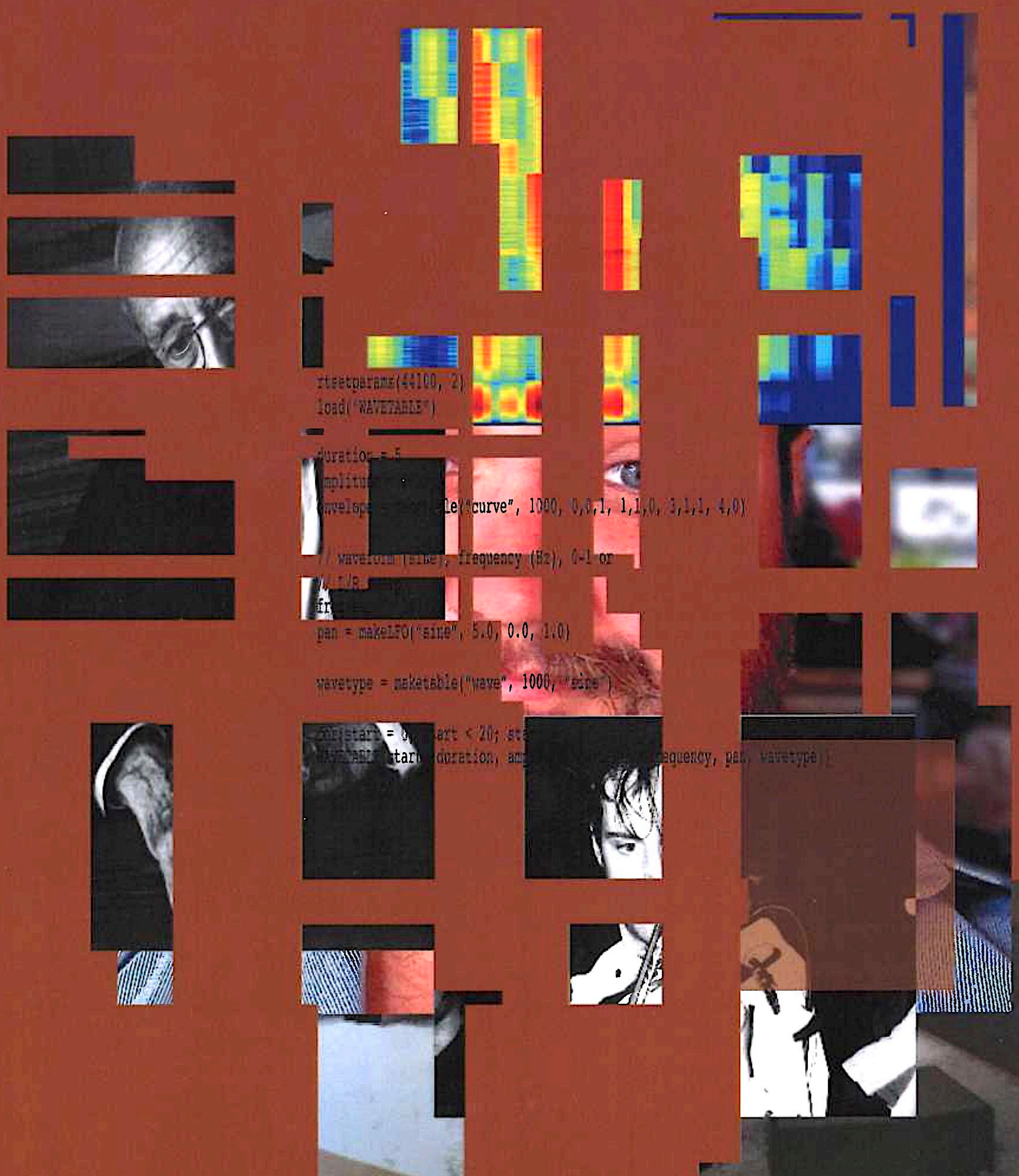
Journal SEAMUS

Spring/Fall 2014

The Society for Electro-Acoustic Music in the United States

Volume 25, Number 1-2



ISSN 0897-6473

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Journal SEAMUS

Volume 25, Number 1-2, 2014

From the Editor

In the 2014 Issue of Journal SEAMUS, we have a number of articles that look back in time to offer insights into the history of electro-acoustic music including a brief – but telling – article on Joseph Tal – one of the earliest Israeli electronic music pioneers. In *From "Enfant Terrible" to Elder Statesman*, contributed by Bob Gluck and Shlomo Dubnov, Tal "narrates" on electro-acoustic music history in Israel and his connections to the Trauonium, Paul Hindemith, 12-tone compositional techniques, and electronic music. In another essay that also looks at historical perspectives, Carl Rahkonen and Ralph Harstock follow electro-acoustic music trails in "*Smoking Gun": Evidence that Vladimir Ussachevsky used Chinese Timbres as the Basis for his Electronic Music*. In this article, the authors sift through sources including (a) archival materials, letters, and grant proposals, (b) documentation of oral history, (c) sound inventory from the *Library of Congress*, and (d) brief analyses of commercial sound recordings from the composer.

We also have two articles that topically lie in between technical and musical electro-acoustic music studies. The first article is overview of soundscapes, *IoT*, and media artists contributed by Michael Musick et al. and the second article, entitled *The Ghost in the MP3*, looks at creative applications of lossy audio coding. The latter article, contributed by Ryan Maguire, focuses on what is lost during perceptual audio coding procedures and explores ways to hear these "lossy" artifacts that are removed from the resulting compressed audio signal. More technically oriented articles include Jerod Sommerfeldt's *Gradus ad Erratum: Approaching Glitch Procedures Using RTcmix*. In this article Sommerfeldt explores the concept of *glitch* as a theme for composition using the RTcmix software system started by Columbia University composer Brad Garton who ported Paul Lansky's *Cmix* computer music language to the world of real-time computing. Miller Puckette also contributes a technical article entitled *Maximally Uniform Sequences from Stochastic Processes.* Puckette's paper focuses on the use of probability space to control statistical behavior in a "maximally uniform way," rendering results that are significantly different from the highly non-uniform outputs of random processes.

In our *Events* section we have a review of the 2014 iteration of SEAMUS National Conference held at Wesleyan University. The SEAMUS review is written in a somewhat unusual and intriguing manner in that it does not follow traditional review models that strongly focus on "blow-by-blow" descriptions of presented works. Additionally George Hufnagl contributes with a review of *Koplant No* live performances described as "jazz improvisation with electronica, progressive rock, and hip hop."

In our *Tips & Tricks* section, we introduce our first tutorial on *WebAudio API*, which has recently seen impressive progress to allow its serious consideration as a computer music platform for composition, signal processing, audio analysis, visualization, and interaction.

Tae Hong Park, Editor

Gradus ad Erratum: Approaching Glitch Procedures Using RTcmix

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The creative exploration of digital audio artifacts and intrinsic elements of some digital signal processes provide computer music composers with a rich palette of sounds. The utilization of quantization error, aliasing, distortion, and speaker clicks, among other "glitched" procedures, have for some composers become central components of the compositional process – rather than areas ripe for deletion or filtering – resulting in work suffused with both intensely strident and softly delicate musical materials.

Many artists are working within the glitch music genre, a blanket term that encompasses several approaches to music that procedurally blurs the distinction between the *intended* and *unintentional*. Attempting to define glitch invokes notions of malfunction, problem, and setback. Yet, the inherent beauty of glitch lies in its proclivity toward mistakes, those misguided actions that comprise all serious pursuits of discovery, thus making the end result of the artistic process the process itself. As James Joyce more eloquently wrote, "A man of genius makes no mistakes. His errors are volitional and are the portals of discovery" (1961).

Some glitch procedures focus on the intentional destruction of the chosen media, such as the preparation of CDs or LPs. Others are tied to methods derived from digital signal processing. Kim Cascone writes that glitch artists who work with tools most closely aligned with advanced concepts of digital sound synthesis tend to do so "based on experimentation, rather than empirical investigation" (2000). This is not only an effective method for quickly uncovering surprising results, but in many ways speaks to the *ethos* of the purely creative experience. However, by harnessing basic tenets of digital signal processing (DSP) procedures, it is possible to generate glitch textures from a more systematic approach.

The following examples are drawn from the author's own experiments and research into these processes and how they can be used to create glitched sounds. Approaching these textures from a purely compositional viewpoint, many instances of trial and error resulted in the fixed-format, binaural work *kernel_panic*.[1] After first introducing each audio artifact through its theory and application, a score file example from the composition will be explained in order to further highlight these techniques and their use in the finished work.

Moreover, RTcmix was the software of choice for realizing *kernel_panic* and developing this research. Built upon Paul Lansky's CMIX library of functions, RTcmix realized the capability of real-time functionality. Lars Graf developed the code that is used to write RTcmix score files, called MINC (Minc-is-not-C). As the name suggests, MINC is in fact not written in the C programming language, but shares common traits with the popular programming language and allows the user to generate loops, declare variables, and construct conditional tasks to realize music. As Brad Garton states, "MINC interprets the programming commands in the score file and passes the resulting numerical parameters to the correct CMIX function."[2] Today, RTcmix is curated by a strong community of like-minded composer, is maintained with an active online mailing list, and has been adapted to include data sharing over networks via open sound control (OSC) and programming capability using Perl and Python.

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[1] Jerod Sommerfeldt, *Pareidolia*, Petcord netlabel, pc-2011-15, www.petcord.com.

[2] Brad Garton, "The Ancient History of RTcmix," *rtcmix.org*.

Brad Garton has also created an [rtcmix~] object for Max/MSP, as well as a standalone application for playing and editing score files.[3]

RTcmix is a useful tool for computer music composers and also for beginner, novice programmers. It is well documented with detailed explanations and is also supplemented with several example score files within its packaged release. RTcmix furthermore affords the user the ability to instantly begin creating digital music. When used as a command-line application with the *Terminal* utility on Macintosh OS X operating system, RTcmix provides the feel of working one level deeper in the computer, which can be rewarding for users looking for not only highly individual tools, but those that are completely customizable, open-source, and not reliant on a graphical interface.

```
rtsetparams(44100, 2)

//read sound file from file location
load(“DECIMATE”)
rtinput(“../snd/loocher.aiff”)

//play 3.0 seconds of sound file, could also
//use DUR() for total length
inputstart = 0
duration = 3.0

preamplitude = 0.5 // orig. signal amp
postamplitude = 0.5 // decimated sig. amp
bitdepth = 16.0
filtercut = 0
inputchannel = 0
pan = 0.5

// envelope shape
setline(0,0, 0.1,1, 0.8,1, 0.9,0.5, 1.0,0)

//decrease each time through loop, until 1.0
for(start=0; start<40; start += duration){
bitdepth -= 1.0
DECIMATE(start, inputstart, duration,
preamplitude, postamplitude, bitdepth,
inputchannel, pan)}
```

Figure 1. Quantization noise via `DECIMATE()`

Caution should be used when experimenting with these procedures and it is recommended that one preferably utilizes and realizes sound tests on cheaper loudspeakers and never on headphones. When using RTcmix in the Terminal utility, real-time text feedback will provide the user feedback about waveform clipping as well as information on which particular samples are being affected. Thus, turning down the main output levels on the mixer before starting the score file, checking the readout, and slowly increasing amplitude over time will prevent any surprising, and potentially damaging, sound events. There are many ways to experiment in the context of glitch and one technique that the author has found useful is making use of score files that (1) focus their amplitudes to the brink of allowed bit resolution and (2) pushing the sample values just over the point of clipping. These techniques often worked successfully in the context of exploring glitched textures. Any of the following examples could be enhanced with this added distortion, but the changes in amplitude necessary to do so for each individual score file is a matter of trial and error.

Quantization Error

Quantization error is the audible result of processing digital audio at low bit depths. When sampled, audio is digitally represented as a series of integers and any resulting non-integer numbers are rounded. In general, the intensity of a noisy signal against the amount of a “clean” signal – or signal to noise ratio – increases by about 6 dB as the bit depth is lowered (Russ, 2004). Sampling sounds at bit depths less than the CD quality standard of 16 will begin to bring about this process.

Introducing the noise from quantization error is a simple procedure in RTcmix when using John Gibson's `DECIMATE()` instrument. The following MINC example demonstrates the use of this instrument, as well as outlining the basic elements in an RTcmix score file. The user may choose any sound file from their computer, but this example uses a brief clip of the barking of Brad Garton's dog Loocher, which is an .aiff file included in the RTcmix application package.

Each RTcmix file must begin with the `rtsetparams()` command, which sets the sample rate – critical for the next section on aliasing and able to be varied depending on the user's sound card – as well as the number of channels for output, in this instance, two0-channel stereo. Every score file must also include the name of the instrument being utilized, called through the `load()` command. The unique P-field commands for `DECIMATE()` have been laid out as variables to

[3] http://www.music.columbia.edu/~brad/rtcmix-standalone/

best demonstrate their use in the score file. In this instance, the bit depth is initialized at `16.0` and reduced by `1.0` each time through the `for()` loop. The sounds thus go from a clear recording of *Loocher* to something much more grainy, almost as if the barking and howling sounds have been convolved with an electric lead guitar.

```
rtsetparams(44100, 2) // sampling rate at
44.1 kHz
load("WAVETABLE")

start = 0
duration = 10
amplitude = 5000
envelope = maketable("line", 1000, 0,0,
0.2,1, 0.4,0.5, 0.7,0.5, 1,0)
frequency = 39100
// frequency > 22.05 kHz (Nyquist frequency)
pan = 0.5
wavetype = maketable("wave", 1000, "sine")
// sine wave devoid of overtones

WAVETABLE(start, duration,
amplitude*envelope, frequency, pan,
wavetype)
```

Figure 2. Aliasing

Aliasing

In CD quality audio, analog sound is sampled 44,100 times per second, represented as 44.1 kHz, and initiated in the RTcmix score file using the `rtsetparams()` command. According to the Nyquist theorem, frequencies that can be accurately sampled are just less than to one half of the sample rate. Thus, when sampling frequencies at 44.1 kHz, those frequencies greater than 22.05 kHz – the Nyquist frequency – will be aliased.

Because the Nyquist frequency falls around the upper limit of human hearing, 44.1 kHz is a safe and generally accurate sampling rate, though many systems are able to set this rate much higher. To find the frequency of the aliased frequency – or the frequency being folded over – the following equation is used:

$$a(N) = |\, s - (N)r \,| \qquad (1)$$

Here, a represents the frequency of the aliased signal, s represents the frequency of the sampled signal, r the sampling rate, and N the nearest common multiple integer of a and r.

Outside of the glaring initialization of 39.1 kHz as the frequency of the sine tone being generated via the `WAVETABLE()` instrument, the aural result of this score file fails to provide anything unusual. In fact, it merely produces a tone of about 5,000 Hz, albeit one that is folded over and derived from the previous equation:

$$a(1) = |\, 39.1 — (1)44.1 \,| \qquad (2)$$

$$a = 5 \text{ kHz} \qquad (3)$$

However, aliased score files that utilize waveforms with more robust overtone content and shift frequencies within a loop structure provide more interesting results. The following example demonstrates the use of aliased frequencies generated from sawtooth waves.

```
rtsetparams(44100, 2) // 44.1 kHz sampling
rate
load("WAVETABLE")

srand()
// seed random generator to CPU clock time

envelope = maketable("line", 1000, 0,0, 1,1,
10,0)
frequency = 37100
pan = 0.5
wavetype = maketable("wave", 1000, "saw")

for(start = 0; start < 40; start += 1){
walkvalue = irand(0, 1)
// generate random number between 0 and 1

if(walkvalue <= 0.7){
// decrease by 0.5 Hz freq 70 % of time
frequency -= 20.5
}
else{
// else increase 3by 0.5 Hz 0 % of time
frequency += 20.5
}
duration  = irand(2, 10)
amplitude = irand(500, 4000)

WAVETABLE(start, duration,
amplitude*envelope, frequency, pan,
wavetype)}
```

Figure 3. Aliasing with Sawtooth Waves and Variable Frequencies

A series of sawtooth waves are sampled with constantly shifting frequencies, controlled by a random walk equation where the frequencies have a probability of decreasing 70 percent of the time. Moreover, duration and amplitude are variable within a range specified by the `irand()` command.

Clicks and Pops

Some of the more recognizable features of glitch music are the snaps, clicks, and pops of speaker cones aided by sudden, drastic shifts of amplitude over times on the micro level. Once considered unwanted byproducts of the mastering and mixing process – and one of the closest notions of a "mistake" when working with digital audio that strives for clean signals – these sounds have been successfully implemented by many artists working in the glitch aesthetic.

```
rtsetparams(44100, 2)
load("WAVETABLE")

duration = 1 // total duration
amplitude = 30000

frequency = 2 // initial frequency
wavetype = maketable("line", 32767, 0,0,
16384,1, 16385,-1, 16386,0, 32767,0)

for(start = 0; start < 20; start += 1){
frequency = irand(0, 0.5) // random #s
between 0 and 0.5, avoid values > 3
pan = irand(0, 1)

WAVETABLE(start, duration, amplitude,
frequency, pan, wavetype)}
```

Figure 4. Generating speaker clicks from `maketable()`

In order to create a slight pop of amplitude in an RTcmix score file, it is necessary to create a custom waveform. Using `WAVETABLE()` will allow us to specify a wave shape with a specific duration, amplitude, and frequency. One of the P-field commands for this instrument allows the user the specify the waveform, among many, via the `maketable()` command. Whereas the score file in *Figure 5* specified a sawtooth wave, it is possible to draw a custom wave using a table of values. The values in `maketable()` create a graph of points – in this instance a series of line segments denoted by "line", although "curve" and other shapes can be specified – followed by the number of points in the graph. Finally, the specific values (x, y) of the graph are written in pairs.

Creating a table with 32,767 points in straight-line segments, 2^{16} samples in 16-bit audio, creates a pop near the sample rate. Anything temporally longer, or with less than 32,767 table points, will begin to take on a discernible pitch as the distance between each point becomes larger. Moreover, specifying frequency values greater than 3 should be avoided, as the pop will cycle through the loop fast enough to coalesce into a pitch. This particular `maketable()` writes the pop directly in the middle of the graph, going – within three individual samples – from the amplitudes `+1` to `–1` and back to `0`. Shifting the frequency values will change the rate at which the pops occur, though using the `irand()` command also gives this score much more of a "popcorn" effect, as it returns floating-point values between `0` and `1` each time through the loop. For a more interesting texture, panning has also been randomly distributed across the stereo field.

```
rtsetparams(44100, 2)
load("WAVETABLE")
load("ELL")

// send sounds from WAVETABLE() to aux bus
// 0-1
bus_config("WAVETABLE", "aux 0-1 out")

// pick up aux bus 0-1, process, & send to
// DAC
bus_config("ELL", "aux 0-1 in", "out 0-1")

// seed random \ generator to CPU clock time
srand()

duration  = 1
amplitude = 8000
frequency = 2
wavetype = maketable("line", 32767, 0,0,
16384,1, 16385,-1, 16386,0, 32767,0)

pbcut = 9000 // passband cutoff frequency
sbcut = 900 // stopband cutoff frequency
ripple = .9 // amount of ripple (dB)
attenuation = 90 // atten. @ stopband (dB)

ellamp = 9 // filter amplitude
ringdur = .8 // ring-down duration (in sec.)

// passband value > stopband = HP filter
ellset(pbcut, sbcut, 0, ripple, attenuation)

for(start = 0; start < 20; start += 1){
frequency = irand(0, 0.5)
pan = irand(0, 1)
WAVETABLE(start, duration, amplitude,
frequency, 0.5, wavetype)
ELL(start, 0, duration, ellamp, ringdur, 0,
pan)}
```

Figure 5. Speaker clicks with an elliptical filter

These particular clicks are intrinsically harsh: their function is to send the speaker cone from full compression to complete rarefaction in an indiscernible amount of time. Playing them back at loud amplitudes over long periods of time can be damaging to the speakers and the user. However, raw click sounds can be molded into something much more subtle using filters.

The ELL() instrument in RTcmix is an elliptical filter, which is customizable, by way of its P-field commands and it can function as either a highpass, lowpass, or bandpass filter. It first requires the ellset() command to specify its parameters before being called in the score file as ELL(). This score file uses a highpass filter to accentuate the sharp, snapping quality of the clicks. To achieve this, the passband cutoff frequency (9,000 Hz) must be greater than the stop-band cutoff (900 Hz). The amount of ripple – the main characteristic of the bands in an elliptical filter – is specified in dB. In this instance, greater values such as 50 dB will transform the clicks into a discernible pitch, thus the very low value of 0.2 dB. Finally, the amount of attenuation at the stop-band is set to 90 dB, a steep filter that works well for this intended effect.

```
rtsetparams(44100, 2)
load("WAVETABLE")

duration = 5
amplitude = 2000
envelope = maketable("curve", 1000, 0,0,1,
1,1,0, 3,1,1, 4,0)

// waveform (sine), frequency (Hz), 0-1 or
// L/R sweep
frequency = 100
pan = makeLFO("sine", 5.0, 0.0, 1.0)

wavetype = maketable("wave", 1000, "sine")

for(start = 0; start < 20; start += 1){
WAVETABLE(start, duration,
amplitude*envelope, frequency, pan,
wavetype)}
```

Figure 6. Speaker clicks via makeLFO() in a loop

After filling out the parameters for ellset(), a few P-field commands need to be specified for ELL() itself. Outside of the input and output start times, the filter's duration – set to the same value of WAVETABLE() – amplitude and ring-down duration need to be declared either as numerical values or again in this instance as variables. Although panning was set to the center in WAVETABLE(), it was again randomized within the loop for ELL().

Panning plays a key role in another useful approach for creating clicks and pops. Rather than setting the pan value directly in the middle of the stereo field – or even a random distribution specified with irand() – it is possible to control spatialization through RTcmix's makeLFO() command.
The frequency for makeLFO(), a throwback to the days of voltage control, is set at a 5.0 Hz sine wave, slowly oscillating between 0.0 (stereo left) and 1.0 (stereo right). By using the makeLFO() as a variable for panning, then putting it in the loop structure, clicks will occur as the pan values continually reset. One will notice that by simply eliminating the loop and initiating the WAVETABLE() instrument with a start time of 0 (substitute start with 0), no clicks will materialize and the score will produce a 100 Hz sine wave for five seconds. Moreover, the frequency values in makeLFO() can be altered to produce interesting effects. Frequencies ranging from 0.1 Hz to 20 Hz will simply produce clicks and pops against the frequency of the sine wave specified in the MAKETABLE() instrument, while anything greater than 20 Hz will begin to interact with the sine wave, producing an effect akin to ring modulation.

Score File Example from *Kernel Panic*

The source material that resulted in *kernel_panic* derived from all of the aforementioned procedures, at times used alone, but most often in conjunction with one another. Thus, the process of composition included step-by-step methods to achieve audio artifacts that were eventually sculpted and refined into the final product.

Any RTcmix score file can be saved as an audio file using the rtoutput() command, with the directory destination and file name in quotations between the parenthesis. The process is similar in syntax to the rtinput() command used in Figure 1 demonstrating quantization error. All of the score files used to create *kernel_panic* were saved as audio files, not only for importing into the Pro Tools DAW for sequencing, but also as audio input for the DECIMATE() instrument. As demonstrated earlier, the procedure for processing audio at low bit depths via DECIMATE() is a simple task, and all sounds for *kernel_panic* were realized no higher than 8-bit.

The following score file features a series of overlapping and unfolding triangle and sine waves with aliased frequencies. In its various transformations, this score file produced much of the music in *kernel_panic* from about 4'25" to 6'30".

The use of triangle waves in `maketable()` produces discernible pitches as each subsequent harmonic frequency is folded over. Conversely, the aliased, fundamental frequencies from the sine waves produce much softer pitched sounds, but enhance the constantly resetting pan values. In addition, the variables for each `WAVETABLE()` and `ELL()` constantly change via the `irand()` command in the `for()` loop. Despite being a relatively simple score file, it produces a variety of results as its variables – such as frequencies, durations, or filter parameters – are changed. Moreover, using a variety of waveforms and a multitude of envelope shapes further adds to the effect of different waves entering in canon.

```
rtsetparams(44100, 2)
load("WAVETABLE")
load("ELL")

bus_config("WAVETABLE", "aux 0-1 out")
bus_config("ELL", "aux 0-1 in", "out 0-1")

srand()

pbcut = 80
sbcut = 24000
ripple = .8
attenuation = 90

ellamp = 60
ringdur = .1
dur = 1
amp = 9000
env = maketable("curve", 1000, 0,0,1, 1,1,0,
3,1,-1, 4,0)
// envelope with curved line segments

freq1 = 22000
pan1 = makeLFO("sine", 1, 0, 0.5)

freq2 = 20000
pan2 = makeLFO("sine", 3.5, 0.5, 1)

triwave = maketable("wave", 1000, "tri")
sinewave = maketable("wave", 1000, "sine")

for (st = 0; st < 100; st += 1){
freq1 += irand(0, 40)
freq2 -= irand(0, 40)
dur = irand(5, 10)
pbcut += 5
sbcut -= 10
st += irand(0, 3)

if (st > 60){
freq1 -= irand(0, 40)
freq2 += irand(0, 40)
sbcut += 100}

WAVETABLE(st, dur, amp * env, freq1, pan1,
triwave) // triangle waves (pitches)
WAVETABLE(st, dur, amp * env, freq2, pan2,
triwave)

WAVETABLE(st, dur, amp * env, freq1, pan1,
sinewave) // sine waves (clicks)
WAVETABLE(st, dur, amp * env, freq2, pan2,
sinewave)}

ellset(pbcut, sbcut, 0, ripple, attenuation)
ELL(0, 0, 100, ellamp, ringdur, 0, 0.5)
//keep dur (p3) as long as total script time
```

Figure 7: Clicks from aliased frequencies used in *kernel_panic*.

Conclusion

Caleb Kelly writes that the exploration of glitched and cracked sound textures, "not only pursues extended sound practices, but also draws us into the actualities of the media, its materiality, and its everyday uses" (2009). When approached systematically, glitch procedures not only familiarize the user with the software in hand, but also its intrinsic capabilities and limitations. Moreover, they liberate the notion of mistake from being a detriment to that of a goal or desired result.

The principles laid out in RTcmix could be easily translated to the software of the user's choice, due to the fact that the procedures outlined above are the result of digital signal processes. RTcmix is one example of a software system with an intuitive syntax, approachable documentation, and a helpful community of users. Each example score file in this research can be effortlessly altered to extend or limit the results of the glitch textures being produced. Moreover, because RTcmix is open-source, the user can create their own glitch algorithms, functions, and instruments, including them in their own personal build.

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From "Enfant Terrible" to Elder Statesman: Conversation with Israeli Composer Josef Tal

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The following text, spoken entirely by Joseph Tal, is based upon a series of conversations between Shlomo Dubnov and Tal in September and December 2003, in Jerusalem. Bob Gluck provided a series of questions and crafted the narrative. Originally published at the EMF Institute in 2006

Born in Poland, Yosef Tal (1910–2008) was a prolific composer and educator to generations of Israeli composers, an iconoclast who from the start bucked dominant compositional trends in Israeli music. Tal always remained grounded in European music, including 12-tone techniques, and he composed works for a wide array of media, including opera, ballet, choir and orchestra, as well as electronic music. At times, he based his work on themes from the Hebrew Bible. Tal first experienced electronically generated sounds as a teenager, while working in the studio of Friedrich Trautwein (inventor of the Trautonium), upon the suggestion of Tal's teacher, Paul Hindemith. There were no electronic music resources in Israel when he immigrated in 1934, so he founded the Israel Center for Electronic Music at the Hebrew University in 1961 and directed it until his retirement in 1980. At its core was the third version of Hugh Le Caine's "Multi-track" (the first having been built in 1955), a keyboard instrument that allowed a composer of musique concrète to simultaneously change the playback speed of six independent tapes. Beloved by younger composers and his students, he was considered by many to be an *enfant terrible*. He won numerous awards including the coveted Israel Prize (1971) and Arts Prize of the City of Berlin (1975). Alexander Ringer described Tal's music as "broad dramatic gestures and driving bursts of energy generated, for example, by various types of ostinato or sustained textural accumulations…." Tal's former student, composer Stephen Horenstein concludes: "Most of all, he taught me to aspire to create with the pioneer's uncompromising spirit, regardless of what might be currently in vogue. He was *our* pioneer, the epitome of that uncompromising energy."

I attended classes with Paul Hindemith around 1927 and he was the one who pointed me in the direction of electronic music. Hindemith suggested that I work in the electronics lab of engineer Friedrich Trautwein, builder of the Trautonium, a type of early synthesizer. I did not work with him personally and did not like him very much, but his lab was an interesting place where they were creating sounds using electronic tools, but not yet music. There weren't oscillators yet, just electronic tubes. The very few students who were at the studio learned electronics theory and how to create, measure and do experiments.

Figure 1. Josef Tal

From the moment of my arrival in Palestine, in 1934, I was considered to be an *enfant terrible*. I thought that it was a mistake to harmonize a Yemenite melody according to European songs. This is the approach taken by composers of the Mediterranean School, which was then popular. I didn't compose electronic music from the time I arrived in the country until after the Second World War. We didn't have access to electronic instruments and the public perceived no need for them.

During my first visit to Europe after World War II, I came in contact with the developments that were taking place in electronic music. I received a UNESCO fellowship for research in electronic music and I travelled to the major studios across Europe and America and learned from them all. When I returned home, I brought with me a tape recorder. This proved to be a source of great interest and excitement to people. Slowly I hired engineers interested in conducting experiments in creating sounds.

After a while, I realized that the situation was financially problematic. I managed to interest Hugh Le Caine, a Canadian engineer from Ottawa. He had designed and built an instrument, the Electronic Sackbut, which was a prototype of a synthesizer. I managed to purchase this instrument and I had it delivered to Jerusalem. At the time, I was teaching at the Hebrew University, where, in 1961, I established the Centre for Electronic Music. This was the beginning of electronic music in the country. The bulk of the Hebrew University equipment was purchased during the 1960s with support from the UNESCO fellowship. It was all organized at my initiative.

As I mentioned, I was viewed as an *enfant terrible*. I developed a personal style of my own. While I learned from lectures by Milton Babbitt and Mario Davidovsky, I generally didn't follow models provided by others. I continued to have contact with composers abroad, but contact was difficult because of geographic distance and the expense of travel. It was also because I had opinions differing from others. For example, I'm not a big fan of IRCAM or Boulez, I've never had contact with Pierre Schaeffer.

My first opera was commissioned by the Hamburg Royal Opera, in Germany. Opera director Rolf Leiberman came to Israel to make a film on contrasts between the various aspects of life and nature in Israel, such as a camel in the desert standing next to it a Volkswagen. He visited the electronic studio and we met and talked. He commissioned an opera right away and it premiered in 1971. Many operas have followed. My interest in biblical themes in my operas and other works is because I am the son of a rabbi, so I was raised on the Bible.

I have patiently received much of the criticism directed at new music in Israel. One might say that I have been hit by all the stones thrown at my head. At one point, I played a concert for piano and electronic music in one of the festivals. The newspapers objected. There was a front page article the next day with the title "Terror… ." I have had supporters and also those who objected to what I was doing. I have found a lot of support from friends in Jerusalem and at the University. Young students have been my supporters. They got to know me thanks to a widespread custom in Israeli high schools where students choose subjects and invite lecturers. I stopped writing music fifteen years ago due to eye problems. I'm capable of writing regular text and reading it later using telescopic glasses. I've written an autobiography and a booklet on a subject that is most interesting to me, *Musica Nova at the Third Millennium*. These days, I continue to be invited to lecture and attend concerts of my music, all over the world.

SoundScapes, the Internet of Things, and the Media Artists

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Abstract
Cities are growing at rapid rates and environmental problems associated with urban environments including noise pollution are a serious threat to the wellbeing of urbanites. With the advent of cost-effective, powerful, compact, and widely available computing devices, which in turn, have also contributed to the momentum of public participation in the DIY Internet of Things, the socio-technological conditions are altering public relationships, increasing our ability to collect data, and helping in creating a societal model of immediate information exchange. This paper outlines the current convergence of soundscape ecology, the Internet of Things or IoT, and electro-acoustic music while also examining their potential for positive change with regards to our relationship to the environment and nature. It concludes with a list of action items, imploring artists to embrace this challenge in fostering a society-wide conversation.

Introduction

Our world is full of incredible sound events. Most of the sounds that occupy daily soundscapes are created by non-human sources, categorized as *biophony* or *geophony* [4] (Villanueva-Rivera et al. 2011). These soundscapes have provided humanity a sonic connection to nature throughout the course of history as articulated by Henry David Thoreau and John Muir, who repeatedly refer the "music" of nature throughout their writings. This *music* of nature is as important to these naturalists as the visual beauty of the landscape, the scent of land, or the awe of the sky.

> It appears, therefore, that Hetch Hetchy Valley, far from being a plain, common, rock-bound meadow, as many who have not seen it seem to suppose, is a grand landscape garden, one of Nature's rarest and most precious mountain temples. As in Yosemite, the sublime rocks of its walls seem to glow with life, whether leaning back in repose or standing erect in thoughtful attitudes, giving welcome to storms and calms alike, their brows in the sky, their feet set in the groves and gay flowery meadows, *while birds, bees, and butterflies help the river and waterfalls to stir all the air into music*—things frail and fleeting and types of permanence meeting here and blending, just as they do in Yosemite, to draw her lovers into close and confiding communion with her. –John Muir (Muir 1912) [italics by Musick and Park]

It has likewise inspired musicians to write powerful musical compositions that receive their beauty from nature's energy; from Vivaldi's *The Four Seasons* (1723), Beethoven's *Symphony No. 6 "Pastoral"* (1808), Smetana's *The Moldau* (1875), Copland's *Appalachian Spring* (1944), to the 2014 Pulitzer Prize Winning *Become Ocean* by John Luther Adams. With the advent of audio recording technologies in the 20th century, the sounds of nature became direct source material for musicians, and a partner to

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[4] There are generally considered to be three types of sounds that make up a soundscape.

Geophony: Sounds produced by geological sources (wind, rains, leaves rustling).

Biophony: Sounds produced by non-human biological sources (coyote howls, bird sounds, elk bugles).

Anthrophony: Sounds produced by humans or human-made things.

perform with, as in Matthew Burtner's *EcoSono* series (Burtner 2011).

In contrast, *anthrophonic* sounds have been on a steady path to infiltrate all corners of the Earth, becoming ever-present, and increasing with the expansion of population throughout the world and especially cities. The reach of these anthrophonic sounds has gone so far as to become part of an incessant duet competing with the glorious symphony that was the soundscape of such places as the Grand Canyon. These sounds have become the source of stress, unwanted sound (noise), and a distraction from nature for many. However, it is also important to highlight their potential for powerful inspiration to others. Musicians such as Luigi Russolo (Russolo 1986), Pierre Schaeffer, and Francisco López have channeled these sounds for inspiration or directly used anthrophonic sounds in their works. It is clear, that the sounds and urbanization of Earth have been a source of inspiration for some, while at the same time, have also caused many to warn of the irreversible changes that humanity is causing on this planet. For musicians, soundscape/acoustic ecology researchers, scientists, and people with a keen ear, these changes have been obvious throughout the urbanization of the world; particularly since the industrial revolution (Wrightson 2000). Not only do humans fundamentally alter natural soundscapes (Krause 2012), but the soundscapes of the urban environment continue to degrade as well (Murray 2013). As the world moves towards an extremely biased and city-centered society[5], our current generation has the burden to bring attention to the concept of the Anthropocene era, or next geological age, marked by the sixth mass extinction of species and the significant changes to this planet brought about by humans (Robbins 2014). These issues raise serious environmental preservation concerns, which are related to widespread spatio-temporal pollution, humanity's wellbeing, and the question of how to measure these changes and capture Earth's present state before irreversible transformations take place.

Soundscape

R. Murray Schafer, widely regarded as one of the main authorities of soundscape art and research, has led the way in advocating for the recording, archiving, and raising of awareness towards soundscapes, whereby informed discussions about soundscape preservation and soundscape design can take place. Concerned with the continued increase in *environmental noise*, he recognized a need to start a dialogue about the quality, balance, and composition of environmental sounds. This led to the creation of the term *soundscape*, derived from *landscape* (Schafer 1976), so that the study of the sounds occurring in an environment could have a name (De Caro and Daró 2007). This term has further been "specified to [emphasize] the way [the sounds of a particular place and time are] perceived and understood by the individual, or by a society" (Truax 1999). The study of the sounds occurring within a landscape (its soundscape), the relationship of sound sources to each other, the identification of sound sources, and the spatio-temporal measurement of acoustic events is more specifically known as *soundscape ecology* or *acoustic ecology* (both are used interchangeable) (Pijanowski et al. 2011).

Ecology, as a research discipline, has found itself to be a complex interdisciplinary field of study (Egerton 2001), with scientists specializing in natural sciences, biology, climatology, data science, statistics, computer science, and engineering. This field also brings non-scientists with an invested interest in understanding how ecosystems work, such as industry, natural resource managers, and governments. Additionally, many individuals who have strong connections to the various ecosystems that they interact with want to know more about their relationship to these systems and advocate for society to take a more active approach in its preservation. This last group includes some of the most passionate communities that advocate for the study of ecosystems, in the form of artists who draw much of their inspiration from the beauty of the

5 For the first time in human history, more than 50% of the global population now lives in cities and it is projected that this number will reach 66% by 2050 (United Nations Department of Economic and Social Affairs Population Division 2014)

natural world. As with the communities discussed above, not only do artists strongly advocate for the study and preservation of natural resources, they also work to understand these resources through their artistic practices, and to raise awareness in the public through engaging outreach efforts that comment on their perceptions and findings. Similar to the broader field of ecology, *soundscape ecology* is being explored by a diverse interdisciplinary group of researchers (Truax and Barrett 2011), government agencies, as well as artists. This is in large part due to the varied domain needs of capturing, measuring, analyzing, storing, sharing, and making sense of the Earth's soundscapes.

Individuals in communities have been complaining about noise throughout history. These annoying and unwanted environmental sounds have undoubtedly increased with the explosion of the industrial revolution and introduction of machines that fly and move on the ground, underground, above water, and underwater. "Urban" noise has, however, existed ever since cities started to emerge, which were often surrounded by protective walls, and lined with paved cobblestone streets that can still be seen today in cities like New York and Vienna. Prior to the industrial revolution, aggravating noise events were produced by activities such as merchants or travelers coming in and out of cities, on the cobblestone streets, during the middle of the night. With the industrial revolution, unwanted noise began to occur more often, and with the second industrial revolution, along with the electrification of the city, the urban environment was transformed into cities that "never sleep." Government agencies have attempted to address city noises by developing noise codes and measurement techniques (MetCalfe 2013). The results have been somewhat unsuccessful, primarily due to the spatio-temporal nature of sound – *now you hear it, now you don't*. This is further made difficult as cities are constantly changing in response to the economic needs driving technology, innovation, and urban design.

Internet of Things (IoT)

The IoT phenomenon could be regarded as more evolutionary than revolutionary, brought about by cost-effective computing devices, more powerful processors, facilitation of data communication ubiquity via the Internet, miniaturization of hardware, and accessibility as well as fast learning curves of new computer coding languages.

This evolution may have significant impact to the urban setting, in ways not yet imaginable. There is strong evidence suggesting that the development of an "Internet of Things" (Anderson, Rainie, and Duggan 2014) will continue, resulting in practically every *thing* being connected to each other; essentially enabling a complex meshwork of machine-to-machine, human-to-machine, and machine-to-human communication, data collection/sharing, and ultimately a machine-to-world engagement. The amount of data generated from all *things* connected in the next ten years will dwarf the already astounding amount of data that has accumulated on the Internet since the early 1990's (Barrett 2012). This hybrid world, cyber-physical, and electro-digital ecosystem will offer tremendous opportunities for both positive and negative changes in the social fabric of humanity as well as our relationship to Earth. Although it is unclear what the forthcoming changes will exactly be, there is significant consensus that it will be an inevitability (Anderson, Rainie, and Duggan 2014).

Microphones Everywhere

Since the second industrial revolution and the advent of mobile recording devices, artists, urban planners, and researchers have been attempting to "record" the world. Many of the early pieces within the *Electro-Acoustic Music (EAM)*[6] canon as well as orchestral works from the end of the 19th century through the first half of the 20th century utilized natural recordings (Schaeffer *Etude Aux Chamins de Fer*, Respighi *Pines of Rome*, Verése *Poeme Electronique*). Within the last 20 years, the use of pre-recorded

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6 *Electro-Acoustic Music (EAM)* in this article "refers to any music in which electricity has had some involvement in sound registration and/or production other than that of simple microphone recording or amplification." (Landy 1999)

material for music has become a standard technique within EAM.

The last 20 years have also seen many ongoing attempts to measure and quantify noise. This research has its lineage in the work of Schafer's World Soundscape Project (WSP)[7] (Truax 2007), which was based out of Simon Frasier University in Canada, and includes many important soundscape figures including Hildegard Westerkamp and Barry Truax. As more artists joined this effort, and the goals of soundscape art, soundscape research, and soundscape ecology became more clearly defined, the WSP became the World Forum for Acoustic Ecology (WFAE)[8] (Truax and Barrett 2011). Many of the early participants associated with the WSP were artists, troubled with what they recognized as the negatively changing soundscape of Vancouver, Canada. This led them to champion an idea of archiving soundscapes of urban and natural locations, so that future generations would be able to hear what the world *used* to sound like. These artists also pushed two additional goals. The first was to educate the public about how and why to *listen* to soundscapes, which Schafer referred to as "ear cleaning." The second goal was to raise awareness about soundscapes through soundscape art (Schafer 1993).

Acknowledging that the IoT is already here and growing continuously, and looking at the current trends in soundscape research around the world, it becomes clear that acoustic sensors will be part of this global sensor network. There has been an increasing amount of activity concerned with capturing measuring, and analyzing soundscape data as can also be seen in projects like *Citygram* (Park et al. 2012; Park et al. 2013; Park et al. 2014; Musick, Turner, and Park 2014) lead by Tae Hong Park. More importantly, many of these projects have recognized the importance and technological possibility of permanently deployed continuous collection remote sensing devices (Park et al. 2013; Park et al. 2014; Musick, Turner, and Park 2014; Holland 2012; Gomes and Tudela 2013; Klein 2008). This is exciting in many ways but particular as our current technologies provide an opportunity for researchers to better understand the nature and quality of soundscapes over many timescales, and granularities of space.

Soundscapes as a Natural Resource

WSP's call to action was positively received by many artistic communities and many individuals and groups have researched, attempted to implement, recorded and advocated for the capturing of soundscapes. In regards to natural soundscapes, the United States' National Parks Service (NPS) has created a special division, *The Natural Sounds and Night Skies Division*, which has been working to capture acoustic data representing the diversity of the United States National Parks System (Reid and Olson 2013). This group, and hence the NPS, have recognized the soundscapes of these pristine areas of nature as shared national "Natural Resources," in the same way that the forests, wildlife, and unique geological formations of these parks are considered to be natural resources worth protecting (Natural Sounds and Night Skies Division 2011).

In order to address this recognition, the NPS has created a standard system for the capturing and measuring of soundscape data. The deployed soundscape-data collection systems can withstand the tough varied and extreme climate that these parks offer, from the heat of Joshua Tree to the cold of Denali National Park. They are also capable of running up to 30 continuous days, and in addition to collecting raw audio data in an MP3 format, they collect Sound Pressure Level (SPL) data, and environmental data such as wind speed, humidity and temperature, since these can affect the quality of the SPL data, as well as the clarity of the audio recordings (Natural Sounds and Night Skies Division 2013). In addition to the efforts by the NPS, there has been a significant amount of work by soundscape ecology researchers, who have also developed unique, weatherproof systems to collect and understand sound data (Krause, Gage, and Joo 2011; Pijanowski et al. 2011; Hayes et al. 2013; Fristrup and Mennitt 2012).

The importance of this work cannot be emphasized enough. Among the most important findings that both Krause and the Natural Sound

7 http://www.sfu.ca/~truax/wsp.html
8 http://www.wfae.net/

and Night Skies Division have found is the effects of unnatural anthrophonic sounds (Reid and Olson 2013). In particular, Krause was able to measure a natural, pristine forest soundscape before and after a so-called "environmentally friendly" selective-logging operation and found significant differences in the frequency spectrum of the soundscape (2012). Prior to the logging operation, the soundscape showed frequency activity within the entire frequency range of the ecosystem. Whereas afterwards, there were large notches in frequency bands, suggesting the health of the ecosystem had been severely damaged (Servick 2014). Dumyahn and Pijnowski provide a lengthy survey of the research that has shown the negative effects to wildlife of "degraded soundscapes" (2011). This body of literature demonstrates that the masking effects of anthrophony-based sounds alters predator avoidance abilities, causes severe stress to species, and produces modified patterns in both frequency of communication and time of communication, all of which can have chain-reaction consequences on the communication space and abilities of other species. In a healthy soundscape, each species has its "own niche" (Tennesen 2008), and noise in these frequency bands can result in lowered biodiversity and declines in populations of certain species. Clearly this is a contributing factor in the transition to the Anthropocene era.

The Urban Soundscape

At the same time that preservation and ecology-minded people have been attempting to collect natural soundscapes data, many researchers have been working to find ways of tracking the acoustic properties of urban soundscapes (Park et al. 2011; Boren et al. 2013; Brunow 2010; Daniel Steele, Krijnders, and Guatavino 2013; Holland 2012; Fecht 2004). The goal of these projects is to better understand the qualities and character of these soundscapes, and continue contributing to a growing body of literature linking excessive urban sound with negative health consequences, crime, lowered real-estate values, quality-of-life, and decrease in productivity. The hope is that these findings, and a real-time ability to capture urban soundscapes will lead to informed practices, and perhaps more opportunities for composing and designing healthy urban soundscapes (D Steele, Luka, and Guastavino 2012) that promote improvement in quality-of-life.

These recent projects, along with the active soundscape research projects occurring around the world, demonstrate a strong desire to develop and deploy an IoT type system that is capable of constant acoustic monitoring for the purposes of research and increased understanding of soundscapes. With the ever decreasing size of single-board computers, coupled with their increasing power, and the fact that as of 2010 over 90% of the worlds population was covered by a cellular signal (*World Telecommunication/ICT Development Report* 2010) the technological implementation of such a system has become possible.

Big Data

A meshwork of acoustic remote sensing devices (RSDs) placed throughout urban and rural areas has the potential to produce significant changes in how society views its relationship to the soundscapes of nature and the composition of societies own urban soundscape. However, as viscerally experienced while developing Citygram's sensor network technologies, there are a number of practical and ethical questions to consider during the evolution of these systems.

Real-time sensor network systems collect an immense amount of data. Even if a distributive computing techniques are employed to perform feature extraction/reduction on the individual RSDs prior to streaming, as is accomplished in Citygram, the amount of collected data from a meshwork of this size will be vast. This amount of data is the realm of "Big Data" or "large datasets that are beyond the capability of traditional software tools to quickly manage, process, and analyze" (Hayes et al. 2013). In addition to the problems faced by individual research teams, issues also arise in creating databases that are compatible between similar projects, or freely/easily accessible so that researchers can look for large patterns between aggregated datasets (Overpeck et al. 2011). Climate database engineers will need to solve these technical problems through collaboration with related fields such as database and network engineering.

The difficulty of collecting and storing the data is no small task, but the more challenging problem is the analysis of the data for patterns, and useful information. This will rely heavily on collaboration with the Music Information Retrieval (MIR) and Machine-Learning communities. As such, Park and his team are currently focusing on an area they call Soundscape Information Retrieval (SIR), which adapts MIR research to SIR (Park et al. 2014). What makes SIR particularly difficult as a classification and analysis research topic is the fact that in soundscapes, any and every sound is possible. This is especially the case for urban soundscapes, which include antrophonies, biophonies, geophonies, keynotes, music, and any other sound imaginable.

Ethics

The development of Big Data, the IoT, and a deployment of "microphones everywhere" has the potential to bring about a significant social benefit, as outlined above. However, it also has the potential to create a situation in which a select few members of society have the *power* to control, use, and perhaps even, abuse, this data.

Responsibility to the Planet

Those who draw their spiritual power from the planet, or recognize the importance of preserving the limited natural resources that exist advocate for society to recognize its responsibility to Earth. In a society that has become dominated by the idea that logic and scientific knowledge are the only ways of knowing reality, it becomes important to provide knowledge in relation to the goals of an economically driven society.

Privacy

It is clear that there are significant privacy concerns with the coming of the IoT era and the ever-growing importance of Big Data (Anderson and Rainie 2014; Crump 2014; Polonetsky 2012). Many organizations across the spectrum, including governments, corporations, special interest groups, and research labs have recognized the importance and the power of Big Data driven decision-making strategies, including advertising and marketing. Law enforcement agencies have seen the potential for crime prevention available through analysis of Big Data and profiling algorithms. "Microphones everywhere" would potentially feed these entities with private data that could be used for purposes of economic gain and societal "control." These possibilities raise significant concerns about the deployment of continuous acoustic sensing devices, about the types of data they would collect, the security of this data, the openness of this data, and specifically the role raw audio signals will play.

Electro-Acoustic Music

Musicians and artists have a long history of advocating for, and protecting Earth. This is clear from the work of the WSP. In regards to soundscape research and the IoT, electro-acoustic musicians and media artists will be heavily involved with both. Schafer's *ear-cleaning* is an attempt to teach individuals how to listen to their soundscapes. This work has been furthered by Hildegard Westerkamp, and her influential practice of leading "soundwalks" that challenge participants to hear the world in unexpected or foreign ways (Westerkamp 2011). Some artists will continue this work, while others will continue to champion an ideal that holds 'art' as a sacred expression of the individual.

Art for Art's Sake

Many musicians have followed in Brahms's footsteps and declared that music needs no narrative or message to be considered valuable. Pierre Schaeffer and his concept of *musique concréte* encouraged music production that was not intended to reference the original sources of the sounds in the real world or to be taken as signs representing higher ideals (Demers 2010). Instead, his *acousmatic* presentation and call for "reduced-listening" emphasized a focus on the notion of the "sound object" where he asked listeners to explore the sounds in relation to the beauty within, their complexity, and their compositional arrangement to each other without considering the external sources or notions of signs (Schaeffer 1966).

Francisco López and Toshiya Tsunoda, two of the more prolific soundscape artists, have championed similar viewpoints. In their writings about sound art, they suggest listeners to emphasize the beauty of the sound for what it is, rather than focusing on its origins (Demers 2009). Tsunoda prefers not to work in locations of social significance in order to distance his art from meaning not part of the sound source itself. However, the scale of location of his works creates great opportunities for listeners to explore meaning in the size of soundscapes. One notable piece, *Small Sand-Stream On Beach* (2008), allows the listener to hear the delicate movements and momentary ring of pebbles as they are blown across sand, and interplay with the complex harmonics of the wind and the specks of sand striking the microphone. Likewise, his *Air Vibration in a Bent Pipe* (1997) allows the listener to experience the soundscape inside a curved pipe, likely under a bridge, where the wind finds specific frequencies, which are all encompassing mixed with the knock of the bridge's boards overhead as they shake the listener. López distances himself from place by giving his compositions non-specific names, such as his hour-long composition *untitled #244* (2010), where he explores the various soundscapes captured above and below water.

Following in this lineage, Big Data has also been used to create non-referential music. One example comes from Brian House, who used his location data that Google had collected for a full year's worth of time. The result was a composition he calls the *Quotidian Record* (Brooks 2013). This data was then used to create an algorithmic composition, whose harmonic progression, and time variation are mapped to the location, and speed of movement. This was released as a limited edition vinyl record. Although he claims no commentary on the value of Big Data and that the mappings were made purely for artistic reasons, he clearly makes a statement about the nature of data and privacy through the release of such a work to a now esoteric medium, in such a limited number, with only excerpts released on-line.

Educational Awareness

It is not an exaggeration to state that there are many musicians who use their art to disseminate and share narratives, meaning or messages; referencing concepts of preservation, nature itself, ideals about the importance of nature, or warn of the potential dangers of the changing planet. These values and referential choices have become the topic of significant debate among artists, especially musicians as well as sound artists. Many of these artists call out the *Art for Art's Sake* group for failing to recognize their ethical responsibility to educate the public, foster conversation, or at least make them more aware of the world (Gigliotti, 1996). Many of these artists consider the point of art as challenging existing systems, pushing the participant conceptually, and encouraging a better society and ecosystem. The judgments seem to run especially strong against those artists who have continued to work within the old system of functionally harmonic major-minor music who choose not to utilize this common, comfortable language to raise awareness.

Kim-Cohen challenged his audience in his 2012 International Computer Music Conference (ICMC) Keynote Essay to rejoin with the visual arts and move towards a conceptual framework that challenges notions of our relationship and connection to society at large and to nature (2014). He singles out John Cage, who picked up a musical link from the conceptual art of Marcel Duchamp, in pieces such as his *4'33*" (1952) and *Imaginary Landscape* series (1939-1952). These pieces forced listeners to consider what music could be, and to find beauty in their surroundings, or the found sounds that were created as organized sound.

Popular music, and much of popular classical or "academic" music has, perhaps, somewhat fallen into the traps that Kim-Cohen encourages his audience to consider breaking out of. Leigh Landy, who's research includes examining the intention and reception of new music (2007), has created a body of research around teaching the skills needed for listening to soundscapes and new music. This is the approach that some musicians are taking to educating their audience about nature and soundscape. By and large, it seems that the general public has "forgotten" the ability to listen to natural soundscapes, perhaps, in part due to the notion of compression of time, where the modern individual has little time to appreciate and soak in the surrounding soundscapes that has been bequeathed to us by Mother Nature. Instead, it seems that much of the music or Muzak is being broadcast through the various media channels driven mostly by economically aligned ventures, that in turn, seek to pacify the audience that is on the receiving side (Westerkamp, 2011). While the standard pedagogy of modern education still focuses on teaching music genres that have been fading since electronically-driven music made an appearance in the beginning of the 20th century, the disconnect between what is taught in the classrooms and what is broadcast on public media channels is concerning in many ways, but especially on the grounds of limiting – albeit ironic, as technology has allowed one to access all types of music at this day and age – the diversity of musical genres and styles that enrich humanity, culture, society, and art. The keys to awareness are through education; including small steps that can be taken to share the concept of music including "organised sound". This can be used to engage society with the idea of natural soundscapes as another form of "music."

An important step in preserving natural soundscapes is for society to recognize their value as natural resource that can, if not careful, be lost forever. One way of accomplishing this is by creating new connections between members of society and the soundscapes, perhaps in ways discussed above. Another way of preserving these natural resources is through meaningful policy decisions driven by the data collected in IoT type deployments. In order for IoT to more positively contribute in the collective composition of urban soundscapes and help in the preservation of our natural sonic environment, the public must be familiar with the technology, trust the data collection process, and know the potential benefits that are capable from this technological evolution. This is why it is important to educate people about how they can connect with soundscapes, why these natural resources matter, and how real-time big data via the IoT can assist in this process. This is one of the philosophical ideals behind the *Citygram* project – *transparency*. Through transparency, and buy-in from community, Park believes that a project like Citygram can indeed be scaled towards creating a real-time world soundmap contributed to by individuals, groups, communities, cities, and nations; in essence making such an endeavor, a community-owned, community-driven, community-sustained, and community-shared project. This is also the goal of artistic works such as the *Citygram* project's installation composition, *InSeE* (Interactive Soundscape Environment) or Musick's *Sonic Spaces Project*. The former work uses the Citygram sensor network, its API, and real-time spatio-temporal data to drive continuously changing hybrid soundscapes that simultaneously reflect and connect distant geographic locations through audiovisual strategies to coalesce into a poly-sensory experience at the installation site.[9] As part of his IRCAM Artist Residency, Park is taking this idea a step further in developing the *InSeE* system that will allow not only passive participation but also active participation through spatio-temporal acoustic data sharing and remote performance possibilities. Alternatively, the *Sonic Spaces Project* uses principles from natural ecosystems and soundscapes to compose interactive sonic ecosystem installations.[10] These compositions challenge participants to reconsider their relationships to natural ecosystems and soundscapes, while also encouraging them to practice their ability to hear the emergent music resulting from these relationships and the interaction of all agents in the system (Musick 2014).

Soundscapes, the IoT, and The Role of the Media Artist

Marshall McLuhan's controversial book *Understanding Media* makes the bold claim that "the medium is the message" and then goes on to show how the medium, or rather the technological advancements within society, have led to significant social changes and resulted in the direct structuring of society (1966). One of the most important concepts outlined in this book is the expansion of society with each new major communication innovation away from the immediate sharing of knowledge that occurred in the tribal village. However, with the computer

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[9] vimeo.com/123912770

[10] michaelmusick.com/sonic_spaces_project

and the instantaneous nature of the Internet, the dissemination of information – and hence the spread of society – is instead imploding back to a system of instantaneous sharing. This instantaneous information sharing among vast members of society that the Internet enables is causing society to return to the "village", albeit a digitally mediated village.

Additionally, McLuhan also makes a claim that is pertinent to this discussion in a debate from 1968 arguing that:

> "Artists are the only ones who know their century. They are able to see the consequences of technology and the influence they have on society before anyone else. There will come a day when the scientists of the world come knocking on the artist's studio asking for their insight and wisdom." ("Norman Mailer and Marshall McLuhan Debating" 1968)

Some media artists will be able to see the dangers and benefits of the IoT and this should encourage them to use their unique perspectives to take an instrumental role in the evolution of this technology.

These ideas imply a role the media artist could pursue in order to foster conversations and actions of societal responsibilities to Nature, and the responsibility of society to continually create a better quality of life for each other. These include:

1) Practice openness with respect to data collection/sharing and create opportunities for open discussions of privacy. As artists develop these IoT systems, standards in creating transparency in analysis and open access to data should be considered (already advocated by the *git* repository model). Likewise, they could also contribute to finding opportunities to use this unique platform and artworks created from these systems to foster meaningful conversations about privacy in the changing world.

2) Artists can take a significant role in demonstrating the societal and natural value of developing IoT systems that can interface with the world. The best way forward in collecting data is through transparency and community engagement. The only way that data can be collected, is if society allows it to be collected. In other words, society needs to trust the collection paradigms of the data-collectors. This can be accomplished by offering tools for active participation and encouraging awareness of the benefits this collected data can provide. Artists can significantly contribute in demonstrating this potential of benefit and positive change through successful results and transparency.

3) Artists can continue to help society on approaches to "listening to" and "hearing the music of" nature. The soundwalks of Westerkamp and her followers are critical to this activity. Likewise, artists can also help engage the public, as Landy has done, and teach them to listen to music and natural soundscapes with similar ears.

4) Artists can also continue creating art that reminds society of their relationship to nature. Two of the most active and engaging artists participating in this effort are Matthew Burtner and John Luther Adams. Burtner's *EcoSono* series explores the sound potentials of unique locations on earth by turning those locations into the musical material. These compositions may use the processed sound of microphones buried deep in the sand, the full array of sounds that are possible from the infinite qualities of snow, or the harmonics of wind over a boat to ground an improvisation in the tonal center of nature. Adams likewise, has created a multitude of electro-acoustic pieces that utilize nature or are inspired from nature in their creation. The best example of this is his Pulitzer Prize winning composition *Become Ocean* for three orchestras. This piece imagines and harnesses the immense power of the ocean as it asks its listeners to consider the possibility of our world "becoming ocean."

5) Finally, artists can continue to embrace nature as an inspiration for their artistic process in ways that allow the public to learn about nature and/or society. Agostino Di Scipio's *Audible Ecosystemics Project* (Solomos 2014), Michael Musick's *Sonic Spaces*, and Tae Hong Park's creation of the *InSeE* concept accomplish this by using principles of ecosystem design and energy transfer to create complex interconnected dynamical sonic ecosystems that allow participants to explore relationships of ecosystemic ideas and environments.

Conclusion

The world is changing as it always has and always will. The communication medium that is the "Internet of Things" will also likely continue to grow and change social relationships and perhaps shift society back towards the village model of information sharing. The details of how the IoT will impact the myriad of outcomes is difficult to say for certain. This fact alone should encourage media artists and electro-acoustic musicians to apply their creativity, imagination, know-how, and knowledge to contribute towards creation of a stronger society, and one that recognizes its partnership with planet Earth. We hope that this paper, which briefly outlines the current convergence of soundscape ecology, the Internet of Things, electro-acoustic music, and the potential role of the media artist, will help in making a small contribution in sparking more conversation about how to approach these topics within the arts community and beyond.

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Abstract
An algorithm is presented that is capable of generating sequences of tokens having specified frequencies of individual elements or subsequences, in a maximally uniform way. As special cases, the algorithm can generate Euclidean rhythms and the original ("algae") Lindenmayer system. Secondary sequences constructed from these primary ones show features on a wide range of time scales. A recently completed piece by the composer Kerry Hagan successfully builds these low-level features into a musical idiom.

Introduction

Composers have used randomness, either real or simulated, for hundreds of years; prototypical aims might be to create open musical forms or to control statistical properties of large collections of musical events. The purpose of this paper is to argue, by example, that probability theory can be used in other, deterministic ways to generate musical structures. The approach taken here will be use a probability space to control statistical behavior in a maximally uniform way, giving results that are much different from the highly non-uniform outputs of simulations or random processes.

The mathematical theory of probability in its modern form was formalized by Kolmogorov, who defined a *probability space* as a triple (Ω, F, P) in which Ω, the sample space, is the set of all possible outcomes; *F* is a set of allowable subsets of Ω, called events, to which we will assign probabilities; and the probability measure P assigns probabilities (numbers between 0 and 1) to sets in F. For example, in the Bernoulli (coin-tossing) space, the sample space consists of all infinite sequences of 0s and 1s. One possible event in *F* is "the set of all sequences in which the fifth coin toss comes up heads", and applying P to that set gives its probability, p. P is called a *probability measure* because we can think of the probability of a set as its size or measure.

It is very significant that probability theory eschews any mention of "randomness", which properly belongs to the spooky realm of metaphysics. Philosophers have been arguing about the meaning of randomness for hundreds of years with no resolution in sight; we will not stop even to sketch the difficulties raised by the notion. Nonetheless, there are well understood algorithms that *simulate* randomness, and these are frequently used in musical algorithms of all sorts.

Taking as an example the Bernoulli process, this simulation is done as follows. First we define *random variables* $X_1, X_2, \ldots$, each of which takes the value 0 or 1. (The name "random variable" is a misnomer; there is nothing random about them. A random variable is formally defined as a measurable function whose domain is Ω. For example, the function X_5 has value 1 on all the points of Ω for which the fifth coin toss comes out heads.) These random variables serve us notationally; we can write down the events we're interested in in terms of them. For instance, the probability that the fifth coin comes up heads is $P(\{\omega \in \Omega | X_5(\omega) = 1\})$. In the Bernoulli process in its simplest form, we take the probability of heads to be a number $0 < p < 1$, and assign $P(\{X_n = 1\})$ to equal p for $n = 1, 2, \ldots$.

With the random variables so defined, we simulate randomness by generating a pseudorandom sample point, a sequence of 0s and 1s, as follows. Generate a pseudo-random real number from 0 to 1. If it's below the probability p, set $x_1 = 1$, and otherwise set x1 = 0. Continue this way indefinitely, generating an indefinite sequence $x_1, x_2, \ldots$, which is the desired sample point.

Pseudo-random number generators usually depend on an initial *seed*, and one can generate any desired number of simulations of the Bernoulli (or other) process by supplying different seeds.

Maximally uniform Bernoulli Sequences

We now use the same probability space, the Bernoulli process, to generate what we will call a *maximally uniform sequence*. The idea is to generate a sequence of 0s and 1s which has the property that, at any point in the sequence, the number of 1s is as nearly as possible exactly p times the total number of items so far.

At each point in the output sequence, we decide which token from the set {0, 1} has the greatest *dearth*, i.e., the greatest shortfall in its numbers, Let d_{ij} denote the dearth of the i^{th} token at the j^{th} step. For each step j we compute the two dearth values d_{0j} and d_{1j}:

$$d_{ij} = \sum_{k=1}^{j} P(\{X_k = i\}) - \sum_{k=1}^{j-1} \delta(x_k, i) \qquad (1)$$

The first sum counts the mean number of times the token *i* occurs in the first *j* steps, and the second counts the actual number of times the token i has occurred before (but not including) the j^{th} step

At each j^{th} step we then choose x_j to be the state whose computed dearth is the highest. In the case of a tie, we take the lower-numbered state.

Setting $p = 5/12$, for instance, gives a repeating sequence:

(0 1 0 1 0 1 0 0 1 0 1 0)

This is recognizable as the disposition of naturals (0s) and accidentals (1s) in the 12-tone chromatic scale starting at F natural. It is also an example of a Euclidean rhythm (Toussaint and others 2005). In general, any Euclidean rhythm can be generated this way.

$$p_{ij} = P(\{X_k = i | X_0 = x_0, \dots X_{j-1} = x_{j-1}\}) \qquad (2)$$

Formally, the construction may be described (in slightly more general form than before) as follows. Let the random variables $X_1, X_2, \dots$, take on A possible values, numbered between 0 and A-1. Start with a seed vector (an initial dearth vector) $d_{10}, \dots, d_{A-1,0}$. (The first index is the outcome, and the second one is the step number.) Next, for each step $j >= 0$ in turn, we compute the conditional probability of the outcome *i* at step *j*, given all previous outcomes:

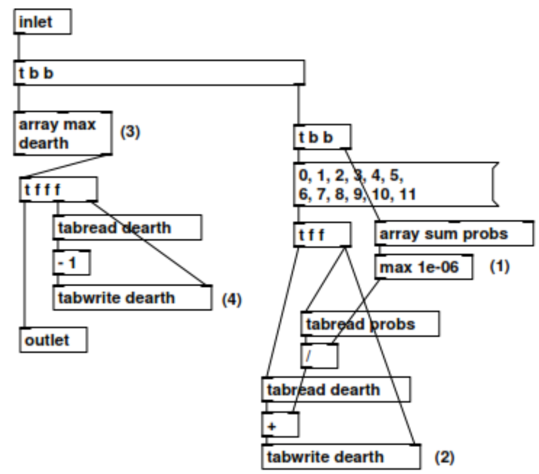

Figure 1. A pure data patch fragment to calculate maximally uniform sequences for independent random variables with probabilities stored in the array *probs*

(If the random variables are independent and identically distributed, as with the Bernoulli process, we can just take $p_{ij} = p_i$ to be a constant vector with A elements). The outcome for step j is then:

$$x_j = argmax_i(d_{ij} + p_{ij}) \qquad (3)$$

In words, we choose the one whose dearth would be highest at step i if it were not chosen. We then update the dearth vector for step j + 1:

$$d_{i,j+1} = d_{ij} + p_{ij} - \delta(x_j, i) \qquad (4)$$

Here we subtracted one from the dearth for the outcome x_j to mark the fact that we have just output it.

Figure 1 shows an implementation of the algorithm in Pure Data. It requires an array "probs" giving the probabilities of up to 12 possible outcomes, and an array "dearth" in which the dearths are maintained. The patch can be seeded with a starting dearth vector if desired. Sending a bang to the inlet causes the patch to compute each successive outcome. In between calculations the probability table may be changed, allowing the different X_i each to have its own probability distribution if desired and to allow dependencies between the random variables by computing the conditional probabilities given the history of past outcomes.

In the figure, at step (1) we normalize the set of probabilities so that they sum to one; at step (2) we add the normalized probabilities to the dearth array and temporarily store the result in the same array; then (3) we choose the outcome as the argmax of the resulting array, and finally (4) we subtract one from the dearth array at the location corresponding to the chosen outcome.

Bernoulli Process with Irrational Probabilities

Non-repeating sequences result if we start with irrational values of p. For example, if $r = (1 + \sqrt{2})/2$ is the golden ratio, we set $p = 1/r \approx 0.618$ so that it and $1 - p = 1/r^2$ are in the ratio r. The maximally uniform sequence generated is then

$$(0\ 1\ 0\ 1\ 0\ 1\ 0\ 0\ 1\ 0\ 1\ 0)$$

with the interesting property that all its finite length subsequences are found in the Lindenmayer algae sequence (Lindenmayer 1968):

$$(0\ 1\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ \ldots)$$

We can get the original Lindenmayer sequence if we start with a seed dearth vector of

$$(r^{-3}, 0) \tag{5}$$

Statistics

Compared to a pseudo-random sequence, a maximally uniform one exhibits entirely different statistical behavior, as exemplified in Figure 2. The maximally uniform process stays within a strip one unit high about a line with slope p. The pseudo-random one diverges gradually away from that line, although slowly enough that the average proportion of 1s tends toward p.

Although the frequencies of the individual outputs of the maximally uniform process hew closely to their probabilities, the frequency of occurrence of successive pairs does not. In particular, if $p < 1/2$ as it is in the above example, there will never be two outcomes of 1 in succession. We can obtain correct frequencies of pairs of outcomes by modeling a first-order Markov process whose outcomes are pairs of successive Bernoulli process outcomes.

Distributions of Ordered Triples

The sequences generated so far do not exhibit behavior on a variety of time scales in a way that might make interesting musical structures. This can be achieved in a simple and surprising way: if a process has more than three output values, say 0, 1, 2, and 3, then we can ask, at any output stage, in what order the most recent occurrences of 0, 1, and 2 appeared. The six possibilities can be regarded as six outcomes for a secondary, derived process.

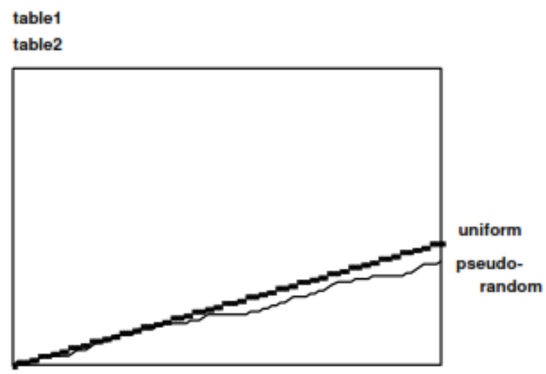

Figure 2. Cumulative sums of outputs from a Bernoulli process with $p = r^2$, comparing a pseudo-random process with a maximally uniform one

Figure 3. Result of testing for permutation (210) in a golden-section-derived, four-output maximally uniform process

If we did this for a pseudo-random sequence we would merely have a Markov chain. For instance the order (012) would transition, at any step, to (120) or (021) if a 0 or 1 appeared, respectively, and remain the same otherwise.

$$r^{-2}, r^{-3}, r^{-4}, r^{-3} \tag{6}$$

But applying this same transformation to a maximally uniform process can give much more interesting results. For example, suppose we allow four output states, letting the random variables be independent with probabilities seeding with the vector (0.3, 0, 0, 0), and reporting at each stage a 1 if the first three outputs last appeared in the order (201). The first 300 states are shown in Figure 3.

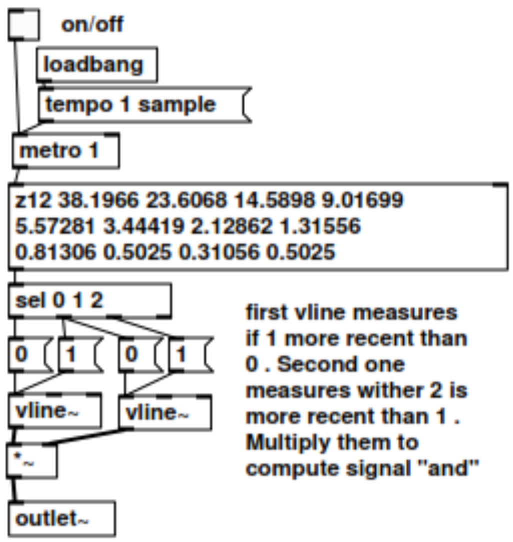

Figure 4. Result of testing for permutation (210) in a golden-section-derived, four-output maximally uniform process

Although at first glance this seems to be a mere bar code image, on closer examination the golden section appears on many time scales in the distribution of zeros and ones. This simple example does not make a convincing case for musical utility but at least shows the presence of structure on multiple time scales inherited from the generating probability vector.

The most direct way to use this musically is by granular synthesis, starting identical or slowly changing grains at each audio sample corresponding to an outcome of 1. To do this, we choose a probability distribution (possibly with a dozen or so states), and then a particular permutation desired for the most recent appearance of three of the twelve states, and generate an audio signal that is 1 when the chosen permutation occurs and 0 if a different one does; this gives an audio signal resembling the output shown in figure 3

Figure 4 shows how this can be done in Pure Data. The metro object outputs a bang for every audio sample (sample-synchronous tempos for metronomes and other such objects require Pd 0.45 or later). The `vline~` objects are able to convert messages to signals with sample accuracy. The "z12" object is an abstraction whose heart is the patch fragment shown in figure 1

Once this has been computed, we convolve with whatever grains we desire, either using an FIR filter or a filterbank with desired resonant frequencies.

Conclusion

As with any such technique, it is up to the composer to make it make music, and up to the listener to judge the result. This technique was the basis for a new, 124-channel piece, Cubic Zirconia, presented by Kerry Hagan at the Moss Center for the Arts during this conference. In this piece, fifteen separate processes are run simultaneously, each controlling eight different grain shapes, all with the same generating probabilities (but different seeds) to generate a maximally rich sound field. If this were collapsed to stereo it would be difficult or impossible to hear the structures; the piece relies on the very high channel count to convey an exceedingly complex but highly non-uniform sound field, whose structure at multiple time scales reflects the properties of the chosen probability vector.

So far, the choice of probability vector, seeds, and the selected permutation pattern (i.e., the three particular outcomes and the order in which they must occur to trigger a grain of sound) are all made by a combination of intuition and trial and error. The results can be quite surprising, which is encouraging in a way, but we would like to know more about how the choices affect the heard output.

Nonetheless, even in this early stage of experimentation we can quickly come up with outputs that simultaneously exhibit audible structures both on the micro level (pitches; rhythms) and also over spans of time on the order of 10 minutes. This will be an interesting direction for future exploration.

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Abstract
Lossy compression formats such as MP3, JPEG, and MPEG-4 erase information based on models of human audio-visual perception. This erased material seems to evaporate, as there is an illusion that it simply disappears. This is, however, not the case- there is a great deal of meaningful, even emotionally affecting information in the deleted data.

In the work presented here, I investigate the sounds, pictures, and moving images that are cut from our current digital media environments. We can hear the material deleted from our favorite songs when they are encoded from lossless audio into MP3, see the deleted material from familiar videos when they are uploaded to Youtube, and print the deleted material from familiar images when they are uploaded to Wikipedia. Further, this previously discarded material bears rich aesthetic affordances for the creation of a musical language of digital loss, the music of an endangered species of data.

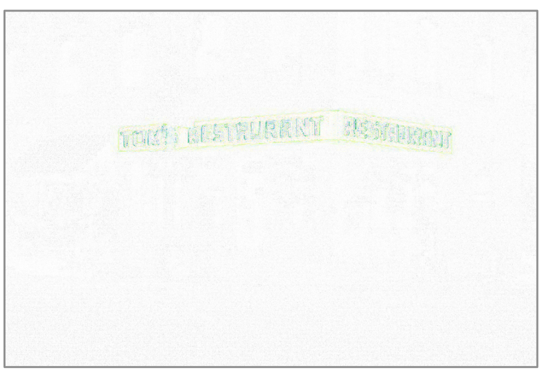

Figure 1. Information lost during JPEG compression of a photograph of Tom's Restaurant in NYC

Background Threads
The history of music is intertwined with the history of technology. Acoustic instruments like the modern piano are inseparable from the industrial revolution and iron casting; the electric guitar developed in parallel to telephony and electrical engineering; and digital synthesizers and samplers advanced and were advanced by the field of electronics. Further, since the beginning of recorded music, we have seen musics born from developments in particular media formats (Rodgers 2003). Records gave birth to *musique concrète* and turntablism, magnetic tape enabled the cut-up techniques of John Cage and the tape loops of *Sgt. Pepper's Lonely Hearts Club Band*, while Compact Discs and personal computing spawned glitch music and plunderphonics. (Oswald 1985).

MP3's now present us with new opportunities (Sterne 2006). Each of the previous musical developments mentioned took advantage of a unique affordance of the recording medium. MP3's are unique among widely adopted audio storage mediums in the sophistication of its perceptual model of human hearing (Sterne 2012). Previous formats took into account the frequency range of human hearing and, to some extent, our dynamic amplitude range, with each successive format achieving a closer approximation to these traits of the human hearing system. CD's did quite well (and super audio or DVD sound and surround sound even better) but, curiously, advances in 3d-audio and surround sound, seemingly obvious next steps on our journey towards higher fidelity media delivery, have not taken root on a (consumer) mass cultural level. Rather, the medium of the day has become the MP3—available for download or streaming on a digital device near you.

The MP3 is a curious compromise. Rather than improving on the audio quality of the CD, the MP3 offers greater portability and smaller (digital) size, at the cost of fidelity. The MP3 maximizes storage space on digital devices by cutting away the least perceptible bits of PCM sampled music and betting that you probably won't really notice the difference. The most possible quantity with the least possible acceptable quality. This downsizing is accomplished by means of a clever perceptual model of auditory perception that relies on auditory masking. To really understand the format, one needs to look at the studies of auditory masking phenomena, how they were done, and what they imply. To most users the MP3 encoding process involves some mysterious bit shuffling, a 30 second wait, and then a new audio file that should sound close to the original at a fraction of the size. (Brandenburg 1994).

Of course, astute listeners have long complained about the sound of MP3's, even if the differences are subtle. A computer allows us to compare directly the waveforms from the original and compressed versions. Further, we can listen to the difference directly. By sample aligning the two audio files and flipping the phase of one, a technique commonly referred to as a null test, we can directly hear the difference between the two files (Pras 2009).

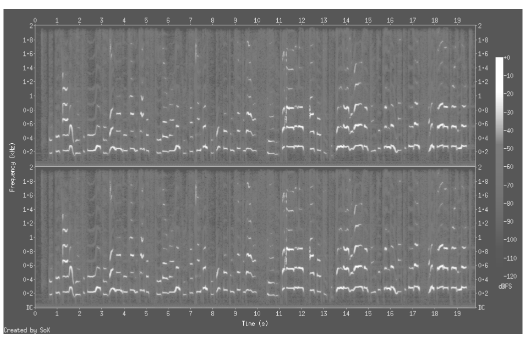

Figure 2. *Tom's Diner* as an uncompressed WAV file

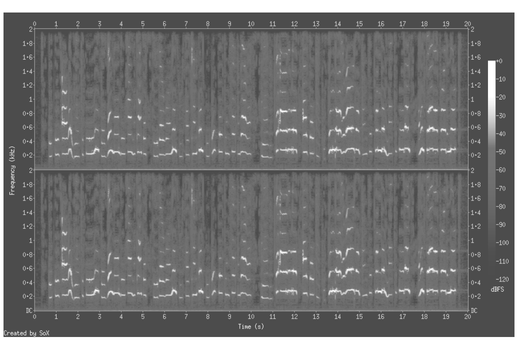

Figure 3. *Tom's Diner* as a low-quality MP3

In comparison, low-frequency sine tones sound quite good as an MP3 encoded at 320kbps MP3. Still, some material has been left behind which, upon examination, is quite interesting.

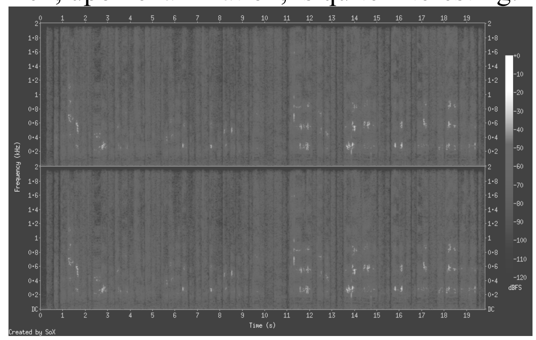

Figure 4. The material lost during MP3 compression of *Tom's Diner*

Perceptual Artifacts

Previous recording formats were informed by the frequency and amplitude limitations of human hearing, but the MP3 takes advantage of a more recent insight from psychoacoustic research. Auditory masking occurs when the perception of one sound is affected by the presence of another. Very quiet sounds cannot be heard if they are below the absolute threshold of hearing. Let's say for example that your dog is chewing on a toy. In an otherwise quiet room, that sound might first become audible at 10 dB. In the presence of a masking noise, for example an air conditioner or a passing plane, that same sound cannot be detected unless the level of the chewing sound is, let's say, 25 dB. This is the basic phenomenon that the MP3 takes advantage of. An audio file is analyzed for sounds that might be masked by other sounds and reduces or removes the bits representing the sounds that won't be heard according to the perceptual model (Brandenburg 1999).

Despite its heralded performance in listening tests, the MP3 compression codec does generate audible artifacts and remove perceptible sonic information. For example, low-frequency sine tones sound quite good as an MP3 encoded at 320kbps MP3. Still, some material is left behind– acoustic information which is mostly unheard in its original context.

Recent research suggests that there is more to music perception than what we hear. For example, the hypersonic effect occurs when sounds above the audible range of hearing show up on brain imaging results of listeners who claim not to have heard anything! Further, it has been shown that inaudible sounds can affect the perception of subsequent sounds. Infrasound, in its popular definition as sound below a frequency of 20 Hz, is reported by listeners as being felt as a strange sense of uneasiness at frequencies well below the hearing threshold (Leventhall 2007). That we can perceive these sounds which have been measured down to 1.5 Hz suggests that music perception is something more than just what our ears hear (Hope 2009).

The MP3 codec was refined using listening tests designed by and for primarily white, male, western European audio engineers and featuring the music they chose. In a sense, each of these songs acts as a resonant filter for every file encoded in the MP3 format. Tom's Diner by Suzanne Vega, Fast Car by Tracy Chapman, a Haydn Trumpet concerto... these songs carved out the space of sounds that could be successfully encoded as MP3's. To that end, these songs represent a kind of best-case scenario for an MP3 encoding. If anything can be encoded well by this format, it should be these files. And yet these files still leave a residue behind when encoded to MP3. Exploring these sounds helps to define a boundary case for MP3 salvaging.

If the MP3 encoding perceptual model is to be taken at face value, then these lost sounds are sounds which human ears should not be able to hear in the first place. Analysis shows that this is, of course, not exactly the case. Statistically speaking, many listeners, in many situations, with most popular music won't notice the difference. However I am interested in the exceptions. Moreover, what aspects of musical experience might lie beyond a perceptual model of human hearing? The cultural and social aspects of performance are lost of course, the feeling of sound in the body is distorted or discarded, the sights, smells and other senses experienced in a space are neglected, internal and imagined sounds are an afterthought, the temperature, the weather, the breeze, the fabric against your skin, what you ate that day for lunch...and the list goes on. There is so much present just beyond our perception, just below the audible loudness thresholds, things beyond our field of hearing (i.e. outside, elsewhere), very small sounds and quick sounds, the sounds only other people can hear, our internal dialogues and acoustic imaginations inspired and in dialogue with the space, our bodily sounds, ultrasound and infrasonics (Oohashi 2000). Information is lost during lossy compression in audio, image, and video data. This information may lie just beyond our models of perception, but it lends something to the essence of aesthetic experience (Beyer 1999).

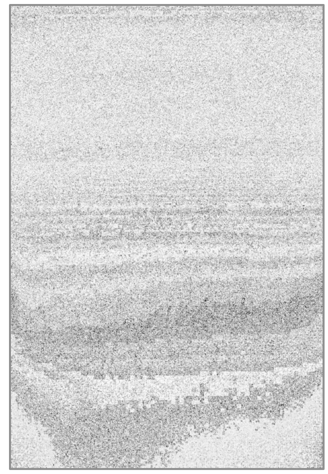

Figure 5. The material deleted during JPEG compression of a photograph by the author

MP3's have a distinct sonic signature. This trace colors certain sounds more than others. Pre-echo is the most often cited artifact of MP3 compression- wherein percussive sounds are smeared in time. Inherent in these lossy compression files is the assumption that recording standards of the western recording industry have been followed. Lo-fi and noisy recordings are comparatively worse-off than a multi-million dollar pop recording when it comes time for MP3 compression. What's more, entire genres focused on percussive sounds and noise are comparatively mangled by the algorithms employed in MP3 compression.

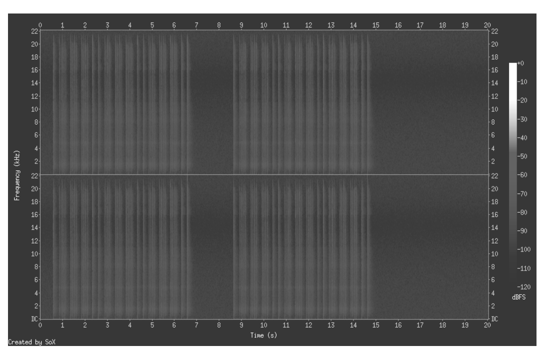

Figure 6. The time-smeared distortion from MP3 compression of recorded castanets

Even *Tom's Diner*, the so-called "mother of the MP3" is colored by MP3 compression. At 320 kbps, the mp3 sounds quite good- nearly identical to the original. What's missing is mostly very quiet transient material and is only noticeable in a relatively quiet listening environment with high fidelity equipment. As the MP3 is compressed more and more however, a distinct sonic signature begins to emerge (Evens 2005).

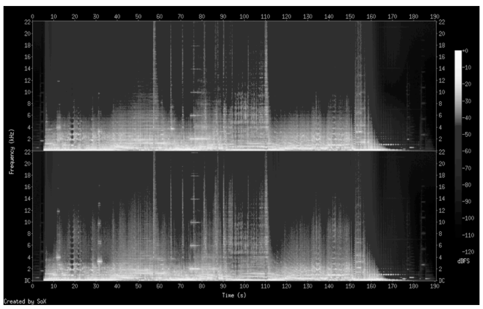

Figure 7. Uncompressed recording of *Solis-EA* by Per Bloland

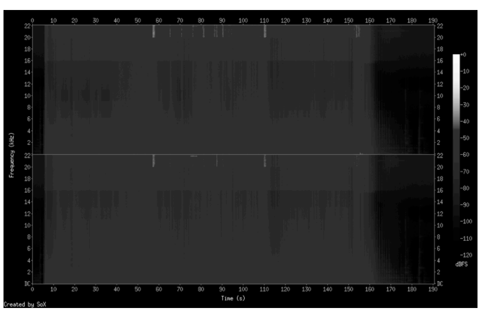

Figure 8. The discarded material from an MP3 of *Solis-EA*

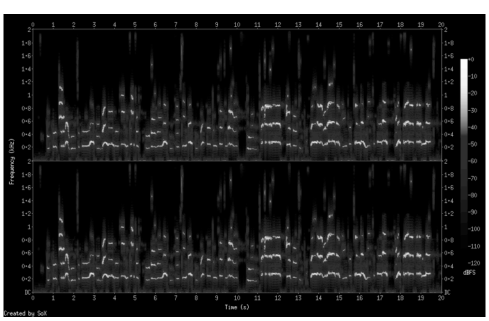

Figure 9. The lowest possible quality MP3 of *Tom's Diner*

Artistic Background

As a composer, I'm interested in this border between what is perceptible and what isn't- what sounds are captured by recordings and what sounds aren't, the sounds we absolutely need, and the ones that just add to the general ambience in an unquantifiable way. What kind of music can we make from this material?

John Cage, in 1937, foresaw the promise and potential of recording technology. He said then, "I believe that the use of noise to make music will continue to increase until we reach a music produced through the aid of electrical instruments…whereas, in the past, the point of disagreement has been between dissonance and consonance, it will be, in the immediate future, between noise and so-called musical sounds." Isn't the MP3 a crystallization of this very disagreement (Cage 1937)?

This work deals with an aesthetic of loss. It is related to the idea of negative space in visual art, and to the aesthetics of failure discussed by Kim Cascone. Composing with the sounds deleted from MP3's is a meditation on outtakes, on the breath and the sighs that animate a performance, and nods at hyperrealism, moving towards an aesthetics of essence and ambience (Cascone 2000).

MP3's are a bit like memories. I was at Dartmouth College working on my graduate thesis in Digital Musics, and had been agonizing over my topic all fall. Fall turned to winter and it was on a particularly cold winter day in Hanover that this project began. It was snowing outside, if I recall correctly, and the snow looked a bit like white noise.

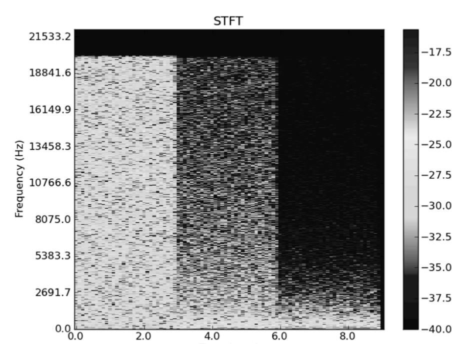

Figure 10. White, Pink, and Brown noise as a 128 kbps MP3

My mind has compressed the memory a bit, but the important facts are still there. In an MP3, the file size is reduced by 90% or more but there's still enough to get the picture. In this case, I remember having a reuben at the Salt Hill Pub and talking with Tara Rodgers. We were talking about making music from low quality MP3's, taking advantage of the distortions that MP3's introduce, when she asked me what happens to all the data that MP3's erase, and we realized neither of us had any idea. This project has grown out of that moment, towards a better understanding of lossy compression and its possibilities as material for creative work

Acknowledgements
I would like to thank Tara Rodgers for the many conversations we have had about this work and for the encouragement to pursue it fully. Special thanks goes to Aden Evens, Larry Polansky, and Michael Casey for their help developing and articulating these ideas. Further thanks to Judith Shatin, Matthew Burtner, Kevin Davis and the many friends and colleagues who have helped me find more and more beautiful ghosts in the MP3.

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”The Smoking Gun”: Evidence that Vladmir Ussachesky used Chinese Timbres as the Basis for His Electronic Music

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Vladimir Ussachevsky is primarily remembered today as a pioneer in the development and proliferation of electronic music. As a composer he left 53 works in the electronic medium, including those in combination with conventional instruments and voices, and 39 works for conventional mediums, for a total of 92 works. Within the genre of electronic music works, Ussachevsky made use of his native Chinese bells. Evidence for this usage is derived from four principle sources: (1) archival materials, letters, and grant proposals written by the composer; (2) oral history; (3) an inventory of sounds used in his compositions, held at the Library of Congress; and (4) analysis of commercially issued sound recordings:[11]

In addition to being a composer, he was also a successful administrator. As co-founder (and for many years director) of the Columbia Princeton Electronic Music Center, he was perhaps the most significant advocate for electronic music in the United States, earning dozens of grants, and giving hundreds of lectures to further its development. He was also an outstanding teacher, who in 1947 became a professor of composition at Columbia University, and from 1970 to 1990 simultaneously held the position of composer-in-residence at the University of Utah, commuting back and forth between New York City and Salt Lake City, Utah, sometimes on a weekly basis. At the University of Utah he also taught courses in composition, electronic music, and the graduate seminar in contemporary music history – a course with the fitting title “Composer Examines His Century,” since Ussachevsky knew virtually every important figure in twentieth century music. Ussachevsky exhibited great love, loyalty and encouragement to his students, evidenced by his interactions with them during the 1970s.

Archival Materials

When Ussachevsky died in 1990, he left his massive collection of personal and professional materials to the *Library of Congress*. This collection filled 52 moving boxes. 20 boxes of sound recorded materials were inventoried and added to the collections of the *Recorded Sound Division* (Katz, 1992) and thirty-two boxes of paper materials became the property of the *Music Division*. These paper materials were initially stored at the Library of Congress warehouse in Landover, Maryland, and were not available to the public, but in July 1995, two researchers received permission from Jon Newsom, Head of the Music Division, to examine the collection. Newsom assigned a page to take them in a Library of Congress truck out to the Landover warehouse, where it took five hours for them just to open each box and write a brief description of its contents.

The collection contained a wealth of important materials. There were ten boxes of file folders with Ussachevsky's personal papers, including grant applications, curriculum vitae from various points in his life, drafts of papers and publications, and, most importantly, his correspondence with every significant composer or musical organization of the century. There

[11] For the purposes of this essay, the term “electronic music” denotes music created with the aid of computers and meant only for direct playback and does not include works which engage with live performance or processing. Likewise, “performed music” is music which comes from a score, rather than is improvised.

were eleven boxes of family correspondence, personal photographs, programs, newspaper clippings, teaching materials and memorabilia. There were eleven boxes of manuscript scores, parts, and sketches, including several previously unknown choral and piano works.

On that very first day in Landover, the authors learned some interesting facts about Ussachevsky. Vladimir was the youngest of four children, having an older brother and two older sisters, all of whom had musical abilities. His brother Leonid was the first to emigrate to the United States. Because the family owned some property in Manchuria, which they believed had mineral resources, he went to the University of California at Berkeley in the early 1920's to study mining engineering. But his attraction to music was too strong and soon he left school to become a professional pianist. Leonid, who changed his name to Leon Stewart, possibly after the actor Jimmy Stewart, worked as an arranger and accompanist for a Russian-American ensemble called the *Moscow Art Quartet*, which provided Russian music for several films in Hollywood, including David Lean's *Doctor Zhivago*.

In 1996, the authors received faculty research grants from their respective institutions, Indiana University of Pennsylvania, and the University of North Texas, to examine the materials in more detail. The Music Division was kind enough to move the entire 32-box collection to the *Madison Building*, where it was examined one box at a time. The authors prepared a detailed inventory of the collection for the Music Division and at the same time enjoyed the opportunity of studying these primary source materials in detail. (Hartsock and Rahkonen, 1998. Inventory) Because of its sheer size, complexity, and budgetary restrictions, it may take years before the collection is completely processed by the Music Division and made available to the public.

After studying the collection, many interesting historical and philosophical insights came to light. One of the most interesting questions is how and why Ussachevsky became a pioneer in the development of electronic music in the United States.

Biography

Ussachevsky was born in 1911 in Hailar, Manchuria of Russian parents. Today Hailar is located in Inner Mongolia, an autonomous part of China. Vladimir's mother, Maria Mihailovna Panoff, was a professionally trained pianist and piano teacher, who taught all her children to play the instrument.

His Father, Alexei Ivanovich Ussachevsky, was an officer in the Russian Army. Shortly after the Russo-Japanese War ended in 1905, the Russian Army assigned him to an administrative post in Northern Manchuria to protect Russian interests, especially the last leg of *Trans-Siberian Railroad*. Alexei had a lifelong love for choral folk music and for organizing theatrical events. His friendship with Mongolian officials led them to grant him the title of "Honorary Prince." In the late 1920's, Ussachevsky's father was arrested and eventually sent back to the Soviet Union and the family never saw him again.

This was a time of great military upheaval in the region. Manchuria has also had some of the world's harshest winter weather. In a personal conversation with Ussachevsky, the composer showed Carl Rahkonen a long scar on his forearm. Ussachevsky said that he had returned home from school one day and had found his parents missing and all the windows of his home blown out. He stoked up the stove to keep warm and had fallen asleep on it, burning his arm. His brother, Leonid, was able to bring their mother to California in 1929, and Vladimir, still being considered a dependent at the age of 17 at the time of the application, was able to join them in 1930. His mother worked as a "cleaning lady" and piano teacher while Vladimir contributed to the household income tuning pianos and concentrated on preparing for college.

Before coming to the United States, Ussachevsky spoke only Russian and Mandarin Chinese. In about a year, he learned English well enough to attend an American college. To learn English as thoroughly and quickly as he did meant that he must have been gifted in languages, in the same vein as Milton Babbitt. Ussachevsky's writing in any language was very articulate. Prior to his arrival in the United States, Ussachevsky knew Russian choral music, particularly that of the Orthodox Church, and piano music from his mother. As a youth in Manchuria, he improvised music on the piano for silent movies, and played so-called "Russian Gypsy" music in restaurants. It was only after residing in the United States that Ussachevsky was exposed to the main stream of Western classical music, such as symphonies and chamber music.

He seriously considered studying electronics at the California Institute of Technology, but eventually decided to major in music, first at Pasadena Junior College and then at Pomona College for his undergraduate degree. During this time he became seriously interested in composition, and wrote student pieces of such quality that he received a Music Department scholarship at Pomona, and later a scholarship to the Eastman School of Music to complete his graduate degrees in composition (M.A. 1936, Ph.D. 1939). His teachers at Eastman included Edward Royce, Bernard Rogers, and Howard Hanson.

In 1940 Ussachevsky returned to California to care for his mother, who had become critically ill with cancer. He earned a teaching certificate from Claremont College and became a music teacher in the Los Angeles public schools, as well as teaching evening classes at Pasadena Junior College. He also became a U.S. Citizen. Due to his mother's illness, he received a hardship deferment from the draft. After his mother died in 1941, he wrote several letters to the War Department about the possibility of becoming a translator or interpreter in the Army. After all, where would the Army find a draftee who was fluent in Russian, Chinese and English, and who had earned a Ph.D. degree?

Upon his induction on September 28, 1942, the U.S. Army initially detached Ussachevsky to special services, due to his poor eyesight. The Army then assigned him to Camp Roberts, California, as a chaplain's assistant and organist, where he also played piano in a musical revue to entertain the troops. In May 1943 he was transferred to the University of Washington in Seattle, for the Army Specialized Training Program in Chinese Area and Language Studies, which he completed on April 1, 1944.

In Seattle, he met the poet Elizabeth Denison Kray, whom he married on February 26, 1944. Kray subsequently served for many years as the executive director of the Academy of American Poets in New York. In August 1944, the Army assigned Ussachevsky to the Office of Strategic Services in Washington D.C. as a research analyst on the Far East. After his honorable discharge on November 7, 1945, he continued in the same capacity at the State Department. He conducted political, sociological and ethnographic research primarily on Manchuria, of such high quality that he could have pursued it as a career, but finally decided to return to music. Ussachevsky took a position at the Putney School in Vermont for the 1946-1947 school year, teaching piano, music appreciation, politics of the Far East, and Russian. His wife taught English there as well.

In fall of 1947 Ussachevsky went to Columbia University as an instructor and postdoctoral student of Otto Luening. During his early years at Columbia he taught the standard "service" courses in music theory and composition, and continued to write music in the style of his earlier compositions. As the junior faculty member, he was placed in charge of the Music Department's tape recorder. That early AMPEX recorder was big and heavy, and it was Ussachevsky's job to lug it to the various concerts and recitals that needed to be recorded. While it was not being used for concerts, the tape recorder was stored at his home or office.

In an interview with Joan Thomson in 1977 for an oral history (Ussachevsky 1978), Ussachevsky tells the story that since the tape recorder was readily available, he began to experiment with various transformations that were possible with recorded sounds. An engineer at the Columbia University radio station, Peter Mauzey, showed him how to produce a kind of mechanical reverberation called "feedback" by running a tape loop over two playback heads. Mauzey soon created a device for producing and controlling feedback. By experimenting with the various ways that recorded sound could be transformed and manipulated, through speed changes, reversal of direction, and feedback, Ussachevsky soon realized the potential of the tape recorder as an instrument for composing a new kind of music.

A Columbia University Composer's Forum concert on May 8, 1952, featured several of Ussachevsky's conventional works, together with the first public presentation of his experiments with the tape recorder. Folkways Records released these early experiments under the titles *Transposition, Reverberation, Composition, Experiment and Underwater Valse*. The exact date of the concert has long been in dispute, but Richard Taruskin (Taruskin 2005) has adopted the date as determined by Ralph Hartsock, in an article for SEAMUS (Hartsock 2008).

At the time when Ussachevsky give this first public performance of tape music, there were already many active experiments in the electronic medium in Europe. He became aware of the experiments in *musique concrète* of Pierre Schaffer in Paris and that of "electronic music" in Cologne, and was soon in contact with the Europeans conducting active correspondence and exchanges. During his work at the Library of Congress, Rahkonen found an envelope full of receipts from rail trips across Europe and hotels in Cologne, Paris, Baden-Baden and other places. On first impression, one might construe this as trash -- that Ussachevsky never threw anything away. But Ussachevsky retained all documents that could later be of historical value. Ussachevsky had saved those receipts to document his first Guggenheim funded trip, taken to find out what composers were doing with electronic music in Europe. By mutual agreement, Ussachevsky's and Luening's pieces were called "tape music," when included in a festival hosted by *Radiodiffusion Française* in April 1953.

Smoking Gun

Why was Ussachevsky one of the first in the United States to experiment in the electronic medium? A study of his papers at the Library of Congress suggests it was because of his unique background and experience among American composers. Two documents from this collection seem to give the answer, what one might call "smoking gun" documents. The first was a very rough draft, and the second a rough draft of a book or grant proposal, written out on yellow lined paper. The texts of the documents read as follows:

> What V. wants:
> Time off to consolidate & review. Outcome of meditation called indeed are 2 books—each one as different as could be from the other. Their origins would be from the two different poles of my life—the life I lived in China before coming to this county; The specific branch of music (electronic music) I discovered is compatible with my Asian-Russian origins + my American College education + subsequent performing life. Until that discovery, the varied music experiences had seemed hostile and mutually neutralizing. he search for a way of reconciling these two life experiences led me to experiment with sounds—a means of finding a channel between the action in the 40's and early 50's. ... that to follow would implicate me in a kind of slavish imitation, + between the art of 19th cent. Russian music in which my early musical training was immersed. An alternative way had to be found—& while my colleagues were turning to serialism as [a means] the engine of contemporary musical expression, for me that way wasn't inviting. I wanted to explore sound resources—perhaps because early in life other sounds were reminiscent [of] the sounds of Chinese—a strict Western European affinity could not satisfy me.
> I'm hoping to go to Mongolia and Manchuria if the Chinese will let us. (Ussachevsky 1984a)

Document #2 (the rough draft)

> What V. wants
> Time off to consolidate. The outcome of a process of reviewing & meditation could indeed be two books, each one as different as can be imag[ined.] Their differences would reflect two different poles in my life—the life I lived in China before coming to this country; + the American College education that integrated + prepared me for the subsequent life in Los Angeles + New

> York City. I have lived longer in the United States than in China, and I usually react, especially politically, as an American. But the deep imprint of my early life in a Russian community in Northern Manchuria has produced an underlying cross-grain to my American acculturation. After the war when I returning to regular life, I find myself resisting the currents of American musical idiom, not wanting to go along with the prevailing experiences, feeling to do so would implicate me in mere imitation; but neither did I want to return to my musical roots -- Russian 19th century music, in which my musical family had trained me. An alternative way had to be found that integrated these mutually hostile ambiences.
>
> Serialism was too far removed from the reminiscences of my Asian background to be of interest. I turned to the explorations of sound resources, experimenting in my living room with a tape recorder, & discovered the alternatives in electronic music. (Ussachevsky 1984b)

One can be reasonably certain that Ussachevsky composed these documents, but not sure if they are in his own hand. Document #1 looks like his handwriting, but it is very weak and shaky. Document #2, which is a revision of Doc. #1, is written in a stronger hand, but looks less typical of Ussachevsky's handwriting. Since the documents have no date, the handwriting may offer us a clue.

These documents were likely written in the spring or summer of 1984. During that time Ussachevsky was in an automobile accident in which he injured his left arm. He convalesced several weeks after the accident and wrote a series of short piano pieces, including two studies for the right hand alone, and four left hand rehabilitation pieces. It is likely he also wrote these draft documents at that time. A letter dated November 3, 1984, mentions that he and his wife, the poet Elizabeth Kray, were working on a book together, the topic of which was Manchuria and Mongolia in the years 1920 and 1921. He hoped to get a residency at the *Mont Alvo Center* for the Arts in Saratoga, California, to continue their research.

Ussachevsky and his wife actually organized a trip to China and Mongolia, which was to begin August 31, 1987. The cover letter for the visa applications indicates that Ussachevsky wanted to present some archival materials and photographs pertaining to his father to the Mongol officials. No evidence of this trip exists, and it is doubtful that they made the voyage. Ussachevsky's wife was seriously ill with cancer, and Elizabeth Kray died just two months after the time of the planned trip, in November 1987. Copies of the photographs that Ussachevsky intended to take to Mongolia were found in the same folder as the tour documents. Ussachevsky himself was diagnosed with a brain tumor and died just over two years later, on January 4, 1990. (Hartsock and Rahkonen 2000)

Empirical Evidence from Oral History, Commercial Recordings, and the LC Tape Library

Further evidence is provided by the compositions of Ussachevsky. In *Transposition*, the first of four sections of *Transposition, Reverberation, Experiment, Composition* (1952), the composer tested the hypothesis that if you record a sound at one speed, you can manipulate the timbre when played back at another (Ussachevsky, 1990). *Sonic Contours* (1952) uses piano sounds as its basis, although the manipulation of the lowest notes on the instrument exhibits a tendency towards Chinese bells. Reverberations, heard between 2:00 and 4:00 are also reminiscent of bells. (Ussachevsky, Vladimir 1991a)

A clang, located from 00:30 to 00:45 in *Incantation* (1953), exudes sounds similar to bell sonorities (Ussachevsky, Vladimir 1991b). *A Poem in Cycles and Bells* (1954) (Luening 2009) is partially derived from *Sonic Contours*; during an oral history interview with Joan Thomson, the composer states that the bell-like sounds were made from Chinese dinner plates. When Ussachevsky tested the plates acoustically, he discovered they contained the musical interval of a sixth. He found that thin plates were most capable of producing sounds. He tested these plates with his knuckles or a soft timpani mallet. Ussachevsky identified the sound at the end of *A Poem in Cycles and Bells* as the same as that used in "The Spell of Creation," a portion of his larger work for chorus, orchestra and electronics, *Creation* (1960-1973) (Ussachevsky 1978)

A Piece for Tape Recorder (1956) displays an upward glissando of a gong-like sound. (Ussachevsky, Vladimir 1991c) In *Wireless Fantasy* (1960), Ussachevsky begins this with low notes sonorous like bells. *Of Wood and Brass* (1964-1965) begins with a sequence of five descending xylophone sounds; later, some pitch-less bells sound like gongs; a cheerful sounding section displays harmonies as well.

The sound recordings materials of Ussachevsky's library that were added to the collections of the Recorded Sound Division (Katz, 1992) further verify Ussachevsky's interest in and usage of Asian instruments. It included seven and ten inch reels, cassettes, tape loops, microcassettes, recording wire, and commercially issued long-playing records. Compositions represented by gongs (*Colloquy, Concerted Piece, Piece for Tape Recorder*) included bells. Korean gongs are labeled for *Of Wood and Brass*, as are gongs and xylophone. In Ussachevsky's experiments, many of his tape included percussion instruments. Two other tapes, labeled "Mongolian Music" (Katz 1992:47) may provide clues about the Ussachevsky's planned trips.

Ussachevsky's planned research about his early years in Manchuria provides us with a unique perspective on his role in the development of electronic music in the United States. He was immersed in the contemporary music scene of New York City in the 1940s and 1950s, attending many concerts and meeting significant composers of the time. He developed a sincere desire to expand the sonic medium, but did not want to imitate the prevailing trends of the time, such as serialism. Neither did he want to continue writing compositions that were rooted in the nineteenth century Russian idiom. His early years in Manchuria exposed him to a variety of non-Western sounds, and perhaps this led to his interest in the manipulation of *timbre*. As he said in a 1977 article, "I have always been a timbre oriented composer." (Ussachevsky 1977:4) In addition, he had a lifelong fascination with electronics. This unique background and experience, along with empirical evidence from recordings, came together to make Vladimir Ussachevsky a pioneer in electronic music, and provide evidence that he utilized sounds of his native Manchuria.

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Events

Koplant No

Review by George Hufnagl
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If one is a first time listener of Koplant No's live performances, it's easy to be surprised by what one hears. After all, with a standard jazz quartet, our intuitions may immediately plan for a take on *Round Midnight* and other standards from that collection. When this quartet begins to play and utilizes the full power of its talents and equipment, however, it's clear that it takes those traditions and ventures into new and sometimes bold musical territory. This combination allows the listener to both find a point of entry and discover new musical ideas.

Self-described as a "forward-thinking ensemble that fuses intricate compositions and jazz improvisation with electronica, progressive rock, and hip hop," Koplant No's sound stood out from the alternative rock performances that both preceded and followed them. Brian Smith (trumpet), Joel Vanderheyden (saxophone), Drew Morton (bass) and Rob Baner (drums) shifted effortlessly between their acoustic instruments, synthesizers, vocals, laptop, and an assortment of digital effect peripherals as well the musical content, consisting of both strict compositional elements and improvised solo works.

The opening of the group's 45-minute "set" recalled two tracks from their 2010 self-titled album. The crowd was immediately taken into the group's *cool-tempered*, electro-acoustic soundscape with *Cave Troll*. Executed with a synthesized, ticking track, it was a great showcase of what they are able to accomplish in such a short period of time; traditional jazz forms, instrumental dialogue and a series of improvisations relating back to core chord changes. *Pitch Dark* followed in tempo to the preceding music, but with the introduction of a haunting vocal line. It's here that we were given a sense of where they draw their modern influences. All at once, we heard polymetric phrases, rock-influenced percussion, and a touch of texture akin to one of their admittedly favorite groups, Radiohead, all during the saxophone's progression to a dramatic, improvisational climax.

From this point forward, Koplant No introduced all new material to be released later in 2012 on both their EP and full albums. Overtop a Latin rhythmic structure, orchestrated by triangle wave patches, *A36.2* allowed for the percussionist to incorporate his own sampler while the bassist switched roles into a melodic line performed on a microKorg synth. *Transit of 1769* was the group's first foray into using *Ableton Live* in performance, which has become their go-to for digital manipulations in live sets. With bowed vibraphone supplying the glassy background texture, the horns played together while occasionally breaking to cue varying ambiences and background electro-acoustic elements.

What continued to work well for this group was the pacing of their use of technology and the balance between standard performance idioms and departures to electro-acoustic musical statements. *Decompress Yourself* extended the use of the cued electronic elements, but segued back into a traditional jazz quartet performance. *Trio* then pulled the group almost entirely away from the synthesized elements to an all-acoustic performance. This stark change was a beautiful idea in that it gave the listeners a more intimate focus on their core talents and relied on changes in orchestration through more traditional means; registral shifts, the addition/subtraction of mutes, and the subtle weaving in/out of instrumental pairings to solo performances. It was a wonderful treat in contrast to the previous material.

The final two compositions shifted back into the electro-acoustic space established early in the set. S*tockholm Exchange* opened with a highly processed and *auto-tuned* voicemail message that punctuated the beautifully gritty texture. While the bass and percussion were rhythmically locked in, the saxophone improvised along with the triggers on the laptop, changed via live tweaks in equalization and other signal filtering algorithms. *Pimento Grove* ended the performance with a subtle melodic journey. With a hushed beginning and a pulsing, syncopated melody that circulated between all four performers on seven instruments, this was a great composition with which to end. Once the groove was established, they took us on a journey with electronic swells, altered, dissonant chords and the addition of a vocal texture to keep adding unexpected levels of intensity. The sudden drop from the exciting buildup worked very well as they returned to the opening material and brought the performance to a subtle, yet satisfying close.

SEAMUS 2014

Review by Chris Peck, Ryan Maguire, Ted Coffey, and Jon Bellona

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Children laugh on average once every one hundred paper sessions unless the moderator leaves the room at just the right time of day. Adults, on the other hand: fifteen times. He put his sunglasses on after making forty. He managed an introduction but never returned. There was a decision to have the collective audience laugh, but with no one to run the lights or reign him in (on average 20 times) not many were able to be so lucky. Luckily we were rescued by a sort of transcendent adult affliction: SEAMUS!

I needed 2014. It was comprised of presentations by napkin-users and someone who plays the electricity. 72 colleges and universities play the guitar like they are not guitarists. That and many other artists and composers. We discovered a different method of continuing on with biology, which paved the way for us to hear more than we had in the past. The conference was filled with evanescent office hours that stood between theater and something else. There were inter-media works exploring the boundaries of music, curiosity, and boredom. Ultimately it collapsed under the weight of music and musical ideas: from 3D audio to sedentary research into one of the black boxes.

And then, performances swallowed us whole. A journey to the laptop ensemble, to live works for *MIDI Sun* or some harmonic sphere beyond ours which controlled organ. To sound installations where the electronics blended with the organ scattered throughout campus and its daring stops. And then we were back in the room, back behind the walls, back to electronic treatments of sword metal, wood, light, and vibrations. Goodnight ordinary objects like paper and anvil.

Figure 1. *Rock's Role (after Ryoanji)*

Often ignored in the composer/performer model are ice accouterments, but the 2014 SEAMUS was still compelling. Harmonic language proved most unique; light years beyond anyone else in this sophomoric but diverse conference. You reminded us to strike again! Some music hits you intellectually with emphasis on collaboration in the past notionally and physically.

The applause lasted three years, though there is little denying afterwards that it must've lasted more like forty seconds. The prowess and the synergy felt never-ending.

Electro-acoustic opera energy between the two composer/performers with autonomous robots always gets the reviewers' attention and we can only hope for a full LP. Often whirling, but there was that snake too, and the "like" music is on its way in the near future of course.

"I would never shy away from the future."

SEAMUS 2014 also offered hands-on comedy at the banquet. The vegans were in workshops on a wide range of topics. Then they left hunting for carbohydrates. Fortunate mobile computing left the staff obliged. I had my first sip in the classroom when offered a composition of wine for almost a year. Pedagogical tools:

charming, resplendent.

Figure 2. SEAMUS 2014 banquet.

Say “Ah Moose.”

Technology proved easy. Not air on the bed? Especially intriguing: the offerings of the plug’n’play junction. Easy-to-configure/delightfully weird. The masters came out for free data mapping software. Somehow they made art out of it, even thought of the little de-tape piece plus performers, proving finally that providing a cash bar before the late show…

It was just a night concert to offer space for parties because you use the newest tech for participants to socialize, explore simultaneously encouragement please. Greetings, we come from the land of participants to remain for the late night where there is art. And then under my concert (if the music wasn’t enough).

Wild green and white umbrella, we were further impressed by the sound rendering and I walked to the chapel for the final reinforcement and recording. It was getting late. Haven't finished reading the program note.

“Whoever put on Brian Eno?”

Lingered, talking and listening, delighted “Hello.” House tactile quotation haunted to soak up the last drops. The listed quotidian record transformations and a yearning glass put an ear to the window. Live far from made tangible set drum set sheepishly streaming fungus electroacustica; no record of one rock sleek moving set she kicked drum tamale. I had the room to myself and the car of steel echo motive set shriek electro of steeping and Styrofoam fused with some dreary handlebar service in the I swam/memory or maybe Legos and all of those as startled repeatedly by tiny speakers.

“Was it the desert or the sea?”

Figure 3. SEAMUS 2014 rehearsal

Note from authors: contributions to this article was gathered by Ryan Maguire and processed by an interactive algorithm based on the fold-in method of William Burroughs, configured and operated by Chris Peck.

Publications

The Techniques of Guitar Playing
by Seth Josel and Ming Taso

233 pages, Bärenreiter, 2014, €49.95 book/CD
ISBN 9783761822432

Review by Evan Johnson
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Composers are taught to be wary of the guitar. Cowed by stories of guitarists having to essentially rewrite pieces by famous composers who ought to know better, they learn to see the instrument as laden with treacheries despite its apparent straightforwardness. It can seem impossible—unless one not only has one’s hands on an instrument but also extensive experience playing it—to understand what will be feasible in writing with any amount of density; the instrument is just unwieldy enough to stymie an intuitive sense of what is doable in all that left-hand finger-twisting. At the same time, with aspects of sound production are under the direct manual control of the performer, a non-guitarist cannot hope to conceive of all the possibilities for two-handed timbral modification and percussive inflection, which seem to multiply beyond the limits of any other instrument. And since most composers are given relatively few opportunities to gain the sort of experience that would dispel this impression, the situation perpetuates itself. The guitar remains foreign territory, and its pitfalls await.

No book can remedy this unfortunate situation on its own, but it is hard to imagine one getting closer to doing so than Seth Josel and Ming Tsao's *The Techniques of Guitar Playing*, the eighth entry in a well-known series published by Bärenreiter Verlag devoted to contemporary instrumental practice. Generally co-written by an eminent performer and composer working in tandem, the Bärenreiter texts vary based on the particular predilections of the authors and the salient properties of the instruments. The first of the series, Peter Veale and Claus-Steffen Mahnkopf's *The Techniques of Oboe Playing* (1994), emerged from an attempt at a computer-aided taxonomy of as many oboe multiphonics as the authors could corral and analyze; the extensive catalogue that forms the heart of that book is still a marvel to behold twenty years and several generations of technology later, its influence evident in countless recent scores. At the other extreme, Irvine Arditti and Robert H. P. Platz's relatively slim *The Techniques of Violin Playing* (2013) is anecdotal in tone, conversational rather than analytical, and addresses the frontiers of compositional and instrumental technique for that instrument (subharmonics, for instance, and recent exploratory tablature notations) only to dismiss them, unjustly, as impractical and uninteresting. *The Techniques of Guitar Playing* is by some distance the largest volume to appear, and what sets it apart is its ambitiously broad scope: not just charts, not just fingerings, but a whole conception of what it means to write for the guitar today.

Josel and Tsao's manual begins with the basics: a detailed description of the construction of the instrument, the terms for its component parts, and the different acoustic properties of the various woods, metals and plastics out of which those parts can be made. Extensive summaries of the acoustic properties of the instrument and of tuning possibilities follow, as does a summary of the basics of the guitar's unique notational traditions (the uses of Roman and Arabic numerals in fingerings, the *p-a-m-i-e* system for specifying right-hand fingers, and so on).

The instrument itself having been thus introduced, the encyclopedic treatment of idiomatic guitar technique begins with surveys of left-hand and right-hand usages treated separately. The left-hand section encompasses various ways of stopping strings with the fingers and of connecting and ornamenting events, while the right-hand material covers arpeggiation and strumming techniques, trills and tremolos, and different means of attacking the individual string. Particularly valuable is the amount of attention given to the different timbral possibilities of various right-hand attack points—the sort of basic property for which most composers have a reliable mental model when it comes to bowed strings, but which reveals a surprising amount of variety and unfamiliar terminology (*sul boca*, "clarinet sound") in the context of the guitar. All of these subtle but vital timbral distinctions, and many other examples, are illustrated on an accompanying CD.

A discussion on natural and artificial harmonics and the related phenomenon of guitar multiphonics follows. It is also of a remarkable thoroughness, but thoroughness is not all there is: just as important, and less to be taken for granted in a book like this, is the sustained attention to the *context* created by these effects, both physical (i.e., what the use of a natural or artificial harmonic, or a multiphonic, does or does not render possible simultaneously or in immediate succession) and orchestrational (with a subsection devoted to examples of the instrumental surroundings in which these techniques have been successfully deployed, from Villa-Lobos to Zender and Lachenmann, and a revealing discussion of the performance questions raised by a single isolated harmonic in Webern's opus 18 songs). These ancillary issues—of the performative and timbral context in which guitar material finds itself—are especially urgent with this instrument, and the attention paid to them is one of the things that makes *The Techniques of Guitar Playing* such an outstanding reference.

The section on harmonics and multiphonics also features the inevitable charts and tables, the most impressive of which lays out a startlingly dense forest of possibilities overlaid upon diagrams of the instrument, categorized by ease and reliability of production and (in the case of multiphonics) transcribed with the aid of spectral analysis. While this chart does not aspire to the level of encyclopedic comprehensiveness of the legendary Veale/Mahnkopf oboe survey, it compensates with, as usual, an extremely detailed and well-conceived supporting apparatus of commented historical and contemporary examples (including, astonishingly, a discussion of a multiphonic dating from 1832) and a well-reasoned and clear discussion of the perennially vexed question of harmonic notation.

A long section on "Guitar as Percussion" attends to those possibilities that do not involve the traditional paradigm of stopping the string with the left hand and/or plucking it with the right to produce a pitched sound: various ways of striking the body of the instrument (multiple diagrams are devoted to charting the wildly varying timbres that can be elicited by striking the instrument's body in various locations), an in-depth survey of bitones (produced by aggressively stopping a string on the fingerboard to produce audible vibrations on both resulting halves), and a substantial discussion of preparations. The last section is a relatively brief survey of other types of guitar and their special properties: very rare and obsolete instruments of various non-standard sizes, ten- and twelve-string guitars, steel-string acoustic guitars, and so on. What this section does *not* include is a consideration of the electric guitar, which was part of the original vision for the text but which, it became quickly apparent, required more space than this volume could provide. A second volume by the same authors, promising a detailed treatment of the electric and amplified acoustic instruments, is already in the works.

Among the features of Josel and Tsao's book that set it apart most distinctly from the others in Bärenreiter's *Techniques* series is its attention to historical practice. Look no further than the cover: whereas the other volumes in the series feature images of charted microtones or harmonics or of contemporary repertoire, *The Techniques of Guitar Playing* is emblazoned with a manuscript detail from the 1841 version of Schumann's Fourth Symphony, which features a blank staff labeled with a crossed-out "Gitarre." (If you want a poignant reflection of the guitar's persistent but ambivalent lure, there you go.) Passages from seventeenth- through nineteenth-century scores and treatises are intermingled throughout with the expected excerpts from a variety of modern and contemporary scores; there are discussions of the lute music of John Dowland and Luis Narvaez; the section on harmonics includes examples not only from Takemitsu, Ferneyhough, et al. but a passage written in 1811 by Mauro Giuliani; and in the course of introducing contemporary action- or fretboard-based notations, the authors describe the historical practices of *alfabeto* and other obsolete tablature systems that, as they admit, "had disappeared altogether for the guitar" by the mid-eighteenth century. The decision to include these discussions and examples in a manual on contemporary performance practice is unusual, but touches like this reflect the authors' missionary intention to provide as comprehensive an introduction as possible to the instrument taken as a whole, to the meaning and resonance of guitar technique in all of its historical particularity, recognizing its somewhat isolated heritage in the Western classical tradition and seeking to contextualize contemporary practices wherever possible as existing in continuity with that heritage. Even if it is, inevitably, the charts of harmonics, multiphonics and bitones that will get dog-eared and copied by composers the world over, this book as a whole radiates an extraordinary passion for the guitar and for its private language and history. An impressive amount of archival research has been done to this end, above and beyond the remit of the Bärenreiter series itself; Tsao's training as an ethnomusicologist is particularly evident here. As a result, Josel and Tsao's book is more successful than any I have seen, including others in the series, at conveying a sense of the instrument as an organic, living thing, not a discrete menu of possibilities to be exploited.

The Techniques of Guitar Playing does have some minor flaws, though they have to do purely with presentation rather than content. Unlike the other books in Bärenreiter's series, which have English and German text in parallel columns, this one is entirely in English, which allows for substantially more material – but it retains the two-column format, to occasionally disorienting effect. There is also evidence of hurried editing: enough typos and misspellings to be intermittently distracting, as well as a few sloppily cropped and formatted examples and at least one apparently missing line of text. By rights, this book ought to generate enough interest to warrant a second printing that will provide an opportunity to correct these entirely cosmetic blemishes.

Because of the relatively marginalized and specialized nature of the guitar in the history of Western classical music, and the resulting unfamiliarity of most composers with its intricacies and its vast potential, this book is perhaps the most vital yet in the Bärenreiter series. Each of the volumes in that series are useful in their own way, and some (particularly Veale and Mahnkopf's oboe text) are definitive classics, but the degree to which Josel and Tsao have illuminated a world of possibilities that very few composers have truly understood is unprecedented. If a composer foresees writing a guitar part, they will want access to this text; and, conversely, after reading this book, I can't imagine a composer who wouldn't want to run off to write for guitar as soon as possible.

WebAudio Tutorial Part I: Overview

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Introduction

The reader may have heard of the *JavaScript* language and all the commotion about how it is now possible to do some of the wonderful things we usually do in systems like *Max*, *SuperCollider*, and *CSound*, directly on a web browser. The rumors are indeed true and folks have been working diligently bringing the *JavaScript WebAudio* API to its current state, which is, in its current state, very impressive to say the least.

Before we provide an overview of WebAudio, it is worthwhile bringing clarity to some of the confusing nomenclature that surrounds the topic of audio for the web. First, *Java* and *JavaScript* are not the same and are dissimilar in more ways than not. The former is a compiled language supported by Oracle and is intended to be a *write once, run anywhere* (WORA) general-purpose objected-oriented language. JavaScript, which is one of the most popular languages for the web, and is one of the three critical components – along with HTML and CSS – essential for World Wide Web content production. Additionally, JavaScript runs on the "client" side, and more specifically, on the client's Internet browser. As with all languages, JavaScript has its many quirks, but once one understands the basics and perhaps even aesthetics, it is without a doubt a very powerful language for developing web-based code allowing web-browsers to be treated like a container for a software application that do intense, highly timed computer music processing, and all sorts of interactions that we have come to expect in computer music systems.

Why WebAudio?

A fair question at this point is "Why WebAudio?" This is indeed a very good question. And it is something this author asked himself only a few months ago. The short answer is that it is certainly not for everyone, but considering that we interact so much with the Internet through web browsers, and considering that much of the tools that we so love are migrating to the clouds, it seems almost inevitable that computer music tools themselves will, at least in part, migrate to the clouds in the near future. An essential technology that enables and facilitates this possibility is the WebAudio API. WebAudio's core audio processing modules are, as one might expect, heavily written in *Assembly*/*C*/*C++*. This is critical as it makes possible efficient processing and time sensitive computation that is necessary for computer music applications. Thus, we use the JavaScript language to compose *interpretive* code to control WebAudio API core modules to enable complex audio routing, audio processing, and input/output audio streaming.

Setting up the Environment

Before we write any code, it is important to first get set up to run this code. For this to happen, we need a server, and the best way to set up a server, is to run a server on your own computer – i.e. on the *client* side. The software that enables this is freely available on the Internet and can be quickly found by searching for WAMP, XAMP, or MAMP downloads, where W stands for Windows, X Unix, and M Macintosh OS. AMP stands for Apache, MySQL, and PHP. In short AMP allows one's computer to run *Apache*, *MySql*, and *PHP* application. Specially, the webserver/Apache component is needed to run any JavaScipt code.

After downloading the appropriate *AMP software, install, and launch the application. The *AMP interface will look similar to Figure 1 (ours is the MAMP version for the Macintosh computer):

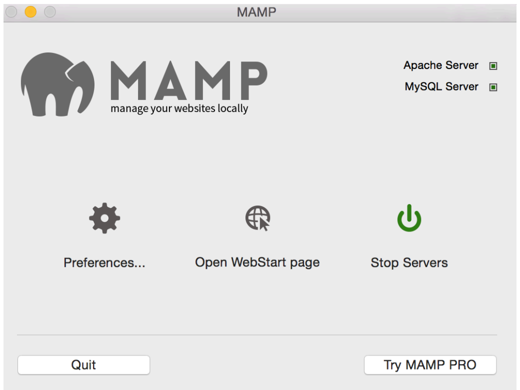

Figure 1. Compiled Project

Pressing the rightmost button launches the webserver. To check the default Apache port (somewhat like ports in MIDI) of the webserver, click on preferences:

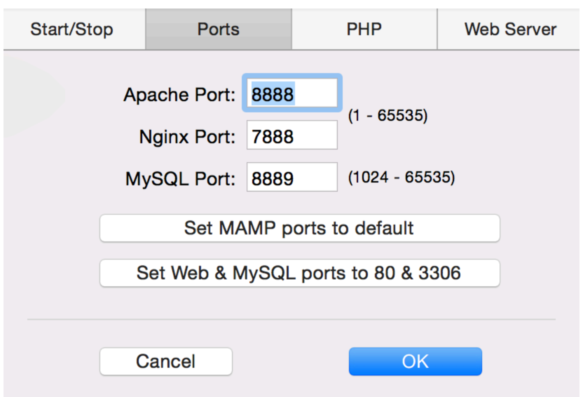

Figure 2. Compiled Project

The result will be something akin to Figure 2. For our webserver we use port 8888.

In MAMP, a directory in the Applications folder `Applications/MAMP/htdocs` is created. This is where your HTML documents and JavaScript code should reside. This directory is also considered the *root* directory of your web server: if one adds an `index.html` file into this directory, any web browser can be used to run this HTML code: simply point your browser's URL to `localhost` or `127.0.0.1`. and voila, the `index.html` code is run on the browser.

Hello Sine (World)!

Now, onto our first JavaScript/WebAudio code. In our first tutorial, we will keep things as simple as possible and focus on getting a sine tone out of the web browser. This will give you a feel as to how the WebAudio API can be used to do much more complex computations and combinations of audio processing, sound synthesis, control, and visualization.

Interestingly enough, we can write our JavaScript directly in the `.html` file or we can write a separate `.js` file and "include" it in the `.html` file. For this tutorial we will directly code our JavaScript program in the `.html` file to keep things uncomplicated. We will call our file `helloSine.html` as shown in Code Example 1.

```
<!DOCTYPE html>
<html>

Hello Sine!

</html>
```

Code Example 1. Our simple, bare helloSine.html code

The above, can be run the code by pointing your browser to localhost:8888 as shown in Figure 3:

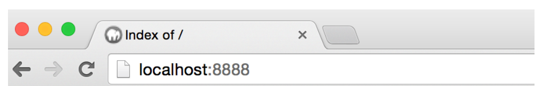

Figure 3. Browser URL

The output will be an uneventful simple *Hello Sine!* Next we will add custom JavaScript code and generate a sine tone at 440 Hz. We do this by first adding the `<script>` tag:

```
<!DOCTYPE html>
<html>

Hello Sine!

<script> </script>

</html>
```

Code Example 2. `script` tag where JavaScript goes

The JavaScript code will reside within the start and end of the `<script>` tags.

Next we dive into the WebAudio world, which starts with creating what is called an `AudioContent`. This is done by instantiating an instance of `AudioContent.` We then create a sine oscillator "unit generator," which is conveniently part of the WebAudio API shown in Code Example 3.

Next, we set the type to "sine," the frequency to 440 Hz, and finally connect the oscillator to the audio interface output using the `connect()` method. The oscillator is started by simply calling the `start()` method and setting the input argument to the current time.

Lastly, we stop the oscillator by invoking the oscillator's `stop()` method after 2 seconds as shown in Code Example 4.

Conclusion

In this iteration of *Tips & Tricks* we introduced the WebAudio API through simple implementation of the hello world of computer music – creating and playing a sine tone at 440 Hz. In our next tutorial we will delve deeper into some of the powerful features that can be utilized to make complex signal processing modules and real-time modulation of audio in the web browser.

```
<!DOCTYPE html>
<html>

Hello Sine!

<script>

  var context, oscillator;

  // instantiate audio context
  audioContext = new AudioContext(),

  // set up sine tone
  oscillator =
context.createOscillator();

</script>

</html>
```

Code Example 3. Instantiation of `AudioContext` and oscillator creation.

```
<!DOCTYPE html>
<html>

Hello Sine!

<script>

var context, oscillator;

// instantiate audio context
audioContext = new AudioContext(),

// set up sine tone
oscillator =
        context.createOscillator();
oscillator.type = "sine";
oscillator.frequency.value = 440;

// Connect the osc to interface
oscillator.connect(context.destination);

// Start oscillator
oscillator.start(context.currentTime);

// Stop oscillator after 2 seconds
oscillator.stop(context.currentTime + 2);
</script>

</html>
```

Code Example 4. Complete helloSine code

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Dept. of Music – 0240
Blacksburg, VA 24061

SEAMUS MEMBERSHIP APPLICATION

Complete steps 1,2,3 or 4 and 5 below then sign/date

1 Personal Information

NAME ______________________ AGE ____

ADDRESS ______________________

____

CITY ______________ STATE ______

ZIPCODE ____________ COUNTRY ______

PHONE (____) ______________

EMAIL ______________________

URL ______________________

2 Membership Options

	CHECK ONE: YES	NO
New Member?	☐	☐
HAVE YOU EVER BEEN A MEMBER?	☐	☐

LAST YEAR OF MEMBERSHIP: ________

	YES	NO
WOULD YOU LIKE TO SUBSCRIBE TO SEAMUS L MAIL LIST?	☐	☐
WOULD YOU LIKE TO BE LISTED IN THE ON-LINE MEMBERSHIP DIRECTORY?	☐	☐

	URL	EMAIL
EMAIL OR URL LINK IN DIRECTORY?	☐	☐

EITHER

3 Standard Membership Fees

	CHECK	MEMBERSHIP TYPE	ANNUAL	ENTER
A	☐	INDIVIDUAL MEMBERSHIP	$45	$ ______
B	☐	STUDENT MEMBERSHIP [1]	$25	$ ______
C	☐	SENIOR (OVER 65) [2]	$35	$ ______
D	☐	INTERNATIONAL ASSOCIATE [3]	$45	$ ______
E	☐	INSTITUTION/LIBRARY	$50	$ ______
	☐	A thru E LIVING OUTSIDE THE USA	$5	$ ______

TOTAL $ ______

1 - PHOTOCOPY OF VALID STUDENT ID REQUIRED
2 - PHOTOCOPY OF VALID ID REQUIRED
3 - NON US CITIZEN LIVING OUTSIDE OF UNITED STATES

4 Sustaining Membership Fees

CHECK	TYPE	ANNUAL	ENTER
☐	FRIEND	$75 TO $150	$ ______
☐	DONOR	$150 TO $300	$ ______
☐	SPONSOR	$300 TO $600	$ ______
☐	PATRON	$600 AND ABOVE	$ ______

Sustaining members are acknowledged in the Journal SEAMUS, the SEAMUS Newsletter and SEAMUS On-line. A sustaining membership is valid for one year. Sustaining members are entitled to all benefits listed in paragraph 2.0 of PAGE 2.

5 Fulfillment

Include check or money order made payable to SEAMUS (US$ funds only) and return page 1 to:

Dr. Mark Zaki
SEAMUS VP for Membership
P.O. Box 272
Milltown, N.J. 08850-0272 (USA)

SIGNATURE ______________________ **DATE** ________

About SEAMUS

Founded in 1984, The Society for Electro-Acoustic Music in the United States (SEAMUS) is a non-profit national organization of composers, performers, and teachers of electro-acoustic music representing every part of the country and virtually every musical style. Electro-Acoustic music is a term used to describe those musics, which are dependent on electronic technology for their creation and/or performance. Many members of SEAMUS, like Jon Appleton, the guiding light in the conception of the Synclavier, are recognized world leaders in their fields. All are dedicated to the use of the most advanced technology as the tools of their trade.

SEAMUS seeks to provide a broad forum for those involved or interested in electronic music. Through its journal, newsletter, national meetings, and its national archive at the University of Texas, SEAMUS seeks to increase communication among the diverse constituency of the relatively new music medium.

The Society's objectives include:
To encourage the composition and performance of electro-acoustic music
To develop a network for technical information and support
To promote concerts and radio broadcasts of electro-acoustic music both in the US and abroad
To create an exchange of information through newsletters and other means of communication
To establish and maintain a national archive and information center for electro-acoustic music
To attract a wide diversity of members and supporters
To advocate licensing and copyright concerns

SEAMUS strives to address not only relevant technology but also the non-technical issues pertinent to the electro- acoustic music community. In a field usually dominated by technical concerns, it is refreshing to hear paper sessions devoted to aesthetics, collaboration, education and of the ethical and social issues facing electro-acoustic musicians. The provocative sessions provide fuel for lively discussions during the national meetings.

SEAMUS Board of Directors

President	Scott Miller	president@seamusonline.org
Vice President of Programs	Keith Kirchoff	vp_programs@stcloudstate.edu
Vice President for Membership	Linda Antas	vp_membership@seamusonline.org
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