Procedural Soundscape

Claire Goeckner-Wald & Amy Xiong

1 Introduction

A short overview of your project idea, why it is interesting and what you would like to learn from it.

1.1 Final Summary

We built a website with a procedural-generated soundscape inspired by 'coffeehouse jazz'. While we did not integrate the soundscape with live variables, we did integrate it with a synesthetic background image. It would not be terribly difficult to integrate the soundscape with live variables at this point, but we chose not to due to time constraints. (Amy: discuss musical 'palette' here.) We chose to use `tonejs-instruments` because it integrated open-source WAV files from real instruments with `Tone.js` [4]. We tested the final product in both Mozilla Firefox Quantum 63.0 and Google Chrome 70.0. Rather than using Google App Engine, or similar, we simply hosted the website for free on Claire's personal GitHub site, cgoecknerwald.github.io/procedural-soundscape. This greatly simplified the workflow, as we could easily push HTML/CS/JS to the GitHub repository, and it would then be immediately updated online with no extra work.

2 Detailed Description and Features

2.1 Description

Precise description of features

2.2 Technical requirements

Audio requirements (and probably also requirements necessary to run the files)

2.3 Technical challenges

2.4 Technological Review

Discuss relevant github repos and projects and articles

Wheelibin's `synaesthesia` (drum kit and synths). We based our chords.js and rhythms.js off of `synaesthesia`. Tambien's `Jazz.computer` but they had a very strange music set-up with interpolation and mediators between synths. We attempted to replicate by playing mulitple synths simulataneously but the resulting 'piano' was very tinny and sounded like Scottish bagpipes. We got mostly drums synths and pads from Yotamm.

2.5 Licensing

We chose to license with the MIT License.

3 Implementation

3.1 Technical Design

Technical design and reasons for choosing this design

We've decided to use tone.js instead of audiosynth.js by Keith William Horwood. We also chose tone.js over SuperCollider, Flocking.js, PureData, because of web integration ease. Flocking also had web integration but a smaller online community and seemed less robust and less abstracted. Audiosynth.js did not have looping technologies. We briefly considered integrating with audiosynth.js but it proved to be too difficult.

We looked at Karplus-Strong String Synthesis but determined it was only relevant if we used audiosynth.js.

3.1.1 Tone.js

> Tone.js is a Web Audio framework for creating interactive music in the browser. The architecture of Tone.js aims to be familiar to both musicians and audio programmers looking to create web-based audio applications. On the high-level, Tone offers common DAW (digital audio workstation) features like a global transport for scheduling events and prebuilt synths and effects. For signal-processing programmers (coming from languages like Max/MSP), Tone provides a wealth of high performance, low latency building blocks and DSP modules to build your own synthesizers, effects, and complex control signals. [11]

3.1.2 Flocking.js

> Flocking is a JavaScript audio synthesis framework designed for artists and musicians who are building creative and experimental Web-based sound projects. It runs in Firefox, Chrome, Safari, Edge, and Node.js on Mac OS X, Windows, Linux, iOS, and Android.
>
> Flocking is different. Its goal is to promote a uniquely community-minded approach to instrument design and composition. In Flocking, unit generators and synths are specified declaratively as JSON, making it easy to save, share, and manipulate your synthesis algorithms. Send your synths via Ajax, save them for later using HTML5 local data storage, or algorithmically produce new instruments on the fly.
>
> Because it's just JSON, every instrument you build using Flocking can be easily modified and extended by others without forcing them to fork or cut and paste your code. This declarative approach will also help make it easier to create new authoring, performance, metaprogramming, and social tools on top of Flocking.
>
> Flocking was inspired by the SuperCollider desktop synthesis environment. If you're familiar with SuperCollider, you'll feel at home with Flocking. [5]

3.1.3 Audiosynth.js

Dynamic waveform audio synthesizer, written in Javascript. Generate musical notes dynamically and play them in your browser using the HTML5 Audio Element. No static files required. (Besides the source, of course!) [6]

3.1.4 Supercollider

SuperCollider is a platform for audio synthesis and algorithmic composition, used by musicians, artists, and researchers working with sound. It is free and open source software available for Windows, macOS, and Linux. [8]

3.1.5 PureData

Pure Data is an open source visual programming environment that runs on anything from personal computers to embedded devices (ie Raspberry Pi) and smartphones (via libpd, DroidParty (Android), and PdParty (iOS). It is a major branch of the family of patcher programming languages known as Max (Max/FTS, ISPW Max, Max/MSP, etc), originally developed by Miller Puckette at IRCAM.

Pd enables musicians, visual artists, performers, researchers, and developers to create software graphically without writing lines of code. Pd can be used to process and generate sound, video, 2D/3D graphics, and interface sensors, input devices, and MIDI. Pd can easily work over local and remote networks to integrate wearable technology, motor systems, lighting rigs, and other equipment. It is suitable for learning basic multimedia processing and visual programming methods as well as for realizing complex systems for large-scale projects.

Algorithmic functions are represented in Pd by visual boxes called objects placed within a patching window called a canvas. Data flow between objects are achieved through visual connections called patch cords. Each object performs a specific task, which can vary in complexity from very low-level mathematical operations to complicated audio or video functions such as reverberation, FFT transformations, or video decoding. Objects include core Pd vanilla objects, external objects or externals (Pd objects compiled from C or C++), and abstractions (Pd patches loaded as objects). [9]

3.2 User Interface

We wanted to make our user interface fun without being confusing, or being so difficult to implement that it distracts from the work of sound design. We settled on a semi-transparent paneling design that would allow us to compartmentalize the different functions while showing off a collection of highly-textured backgrounds.

3.2.1 Actions

There are two actions a user make take: toggle play-pause button or toggle refresh button. Toggling the play-pause button functions exactly as expected - if the music is playing, it stops the music. If the music is not playing, it restarts the music exactly where it left off

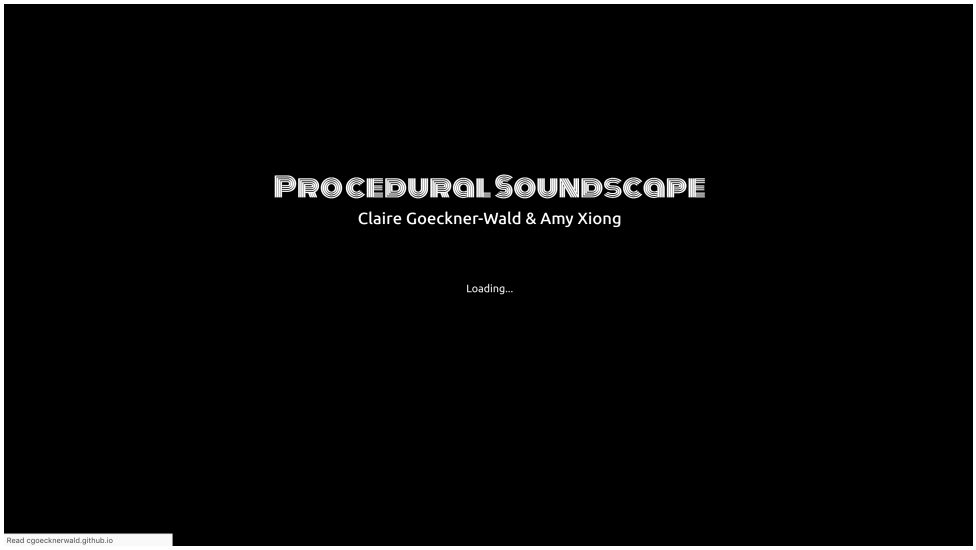


Figure 1: The loading screen as seen on Firefox Quantum 63.0. During this screen, fonts and WAV files are loading.

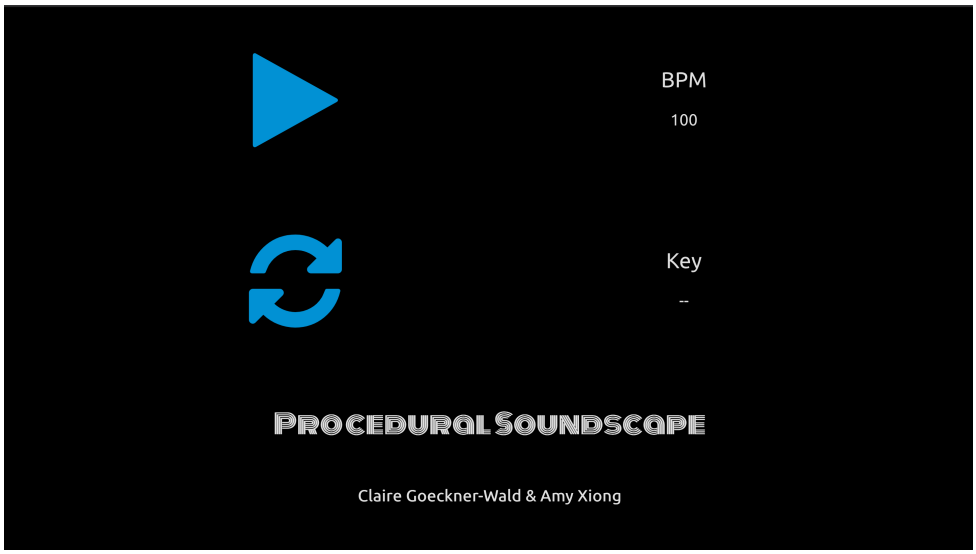


Figure 2: The pre-interaction screen as seen on Firefox Quantum 63.0. This screen occurs after loading is finished, but before the user has interacted with the interface. To begin, users can interact with the play/pause button and the reload/refresh button.

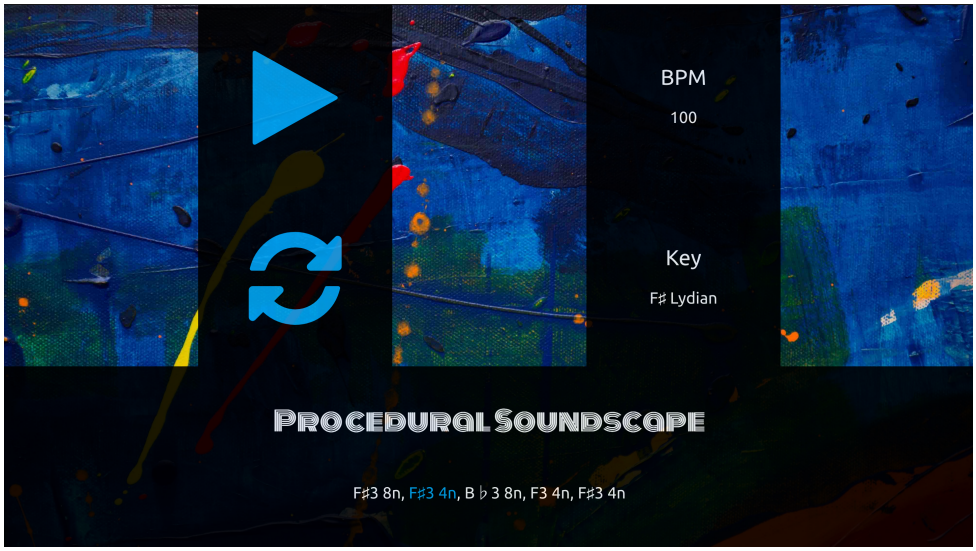


Figure 3: The post-interaction user interface as seen on Firefox Quantum 63.0. Users can interact with the play/pause button and the reload/refresh button.

(or, at the beginning, if toggled for the first time). Toggling the refresh button updates the background, BPM, and key. It necessarily restarts the music, as well.

The first time that either the play-pause button or refresh button is toggled, the program initializes a background, BPM, and key. These three qualities are *unlinked*, meaning they change independently of each other. We considered using a `constants.json` file to build dependencies between the backgrounds and the type of music. However, given the large variety of backgrounds we wished to use, we found that this functionality would be cumbersome without adding significant value to the project.

The program also features a count-down because we generate notes a full measure in advance (so that we may display them on screen). Without this extrapolative generation, we may encounter an issue with `Tone.js` where the first note is not scheduled in advance of being played, causing the first note to be 'dropped,' or not played at all.

3.2.2 Displays

There are 3 different kinds of dynamic information displays to the user: the notes, the BPM, and the key.

The notes are scheduled a full measure in advance, which allows us to display them on screen. The function `emphasizeNote()` uses the index of the currently sounded note to updated the displayed HTML. In this way, the user can visually track the notes (or rests!) as they are sent live to `Tone.js`.

3.2.3 Backgrounds

The project features approximately 50 unique backgrounds (the number fluctuates when we delete one we don't like). The backgrounds were selected for their flat, textured appeal from Unsplash [12]. Unsplash was used for its selection of "Over 550,000 free (do-whatever-you-want) high-resolution photos brought to you by the world's most generous community of photographers," with a very generous license.

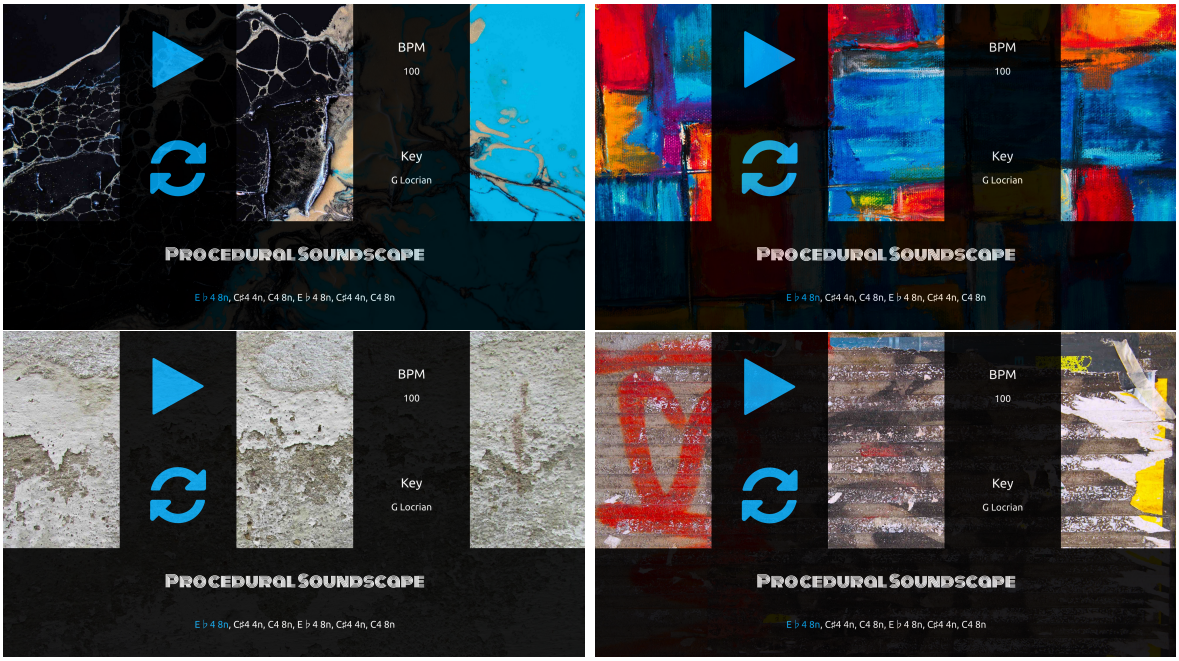
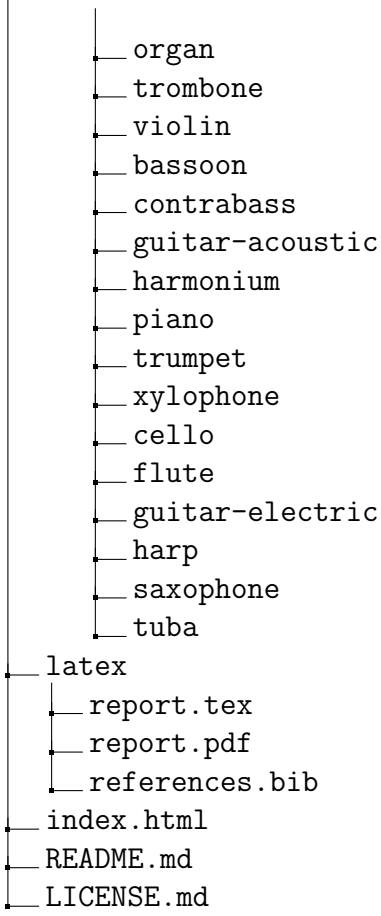


Figure 4: Various backgrounds.

3.3 File Directory Structure

```
procedural-soundscape
└── assets
    ├── backgrounds
    │   ├── bg0.jpg
    │   ├── bg1.jpg
    │   ├── ...
    │   └── bgN.jpg
    ├── css
    │   └── main.css
    ├── js
    │   ├── chords.js
    │   ├── constants.json
    │   ├── instruments.js
    │   ├── LICENSE-Brosowsky.md
    │   ├── LICENSE-Mann.md
    │   ├── LICENSE-Wheeler.md
    │   ├── main.js
    │   ├── music.js
    │   ├── rhythms.js
    │   ├── Tone.js
    │   └── Tonejs-Instruments.js
    └── samples
        ├── bass-electric
        ├── clarinet
        ├── french-horn
        └── guitar-nylon
```



3.4 Implementation Issues

Implementation issues, note any particular technical or audio difficulties and work-arounds

We looked into playing and modifying audiofiles (MP3s or WAVs) but the integration with Tone.js seemed too complicated [10]. This threw us off track for several weeks as we searched for good synths to use (we found none). Claire had switched to DuckDuckGo during the project, which has a much less 'intelligent' search algorithm, which would not return the repo "tonejs-instruments" from a search for "tone js instruments" [4]. In `tonejs-instruments`, they use publicly available WAVs from about a dozen instruments, including saxophone and piano (but no drums). Google, however, did, so eventually it was found. We relied heavily on this repo. https://github.com/Tonejs/Tone.js/issues/290 references why we can't use .wav files in Tone.js (simply not supported, it seems).

We discussed moving instruments synths into instruments.js, out of main.js. Moving roots/scales/chord progressions/rhythms/min & max on octaves in chords.js

3.5 Licensing

Licensing a no-licensed repository (wheelibin's synaesthesia) [13]. Choose-a-license, hosted and run by GitHub, was very helpful [7].

4 Analysis & Conclusion

4.1 Original Goals

How close did you come to achieving original goals?

4.2 Regrets

What would you do differently if you knew at the start what you know now.

4.3 Next step

What would be your next steps if you were to continue working on the project.

5 Code

5.1 File

Description:

```
Verbatim code.
```

6 Contact

Claire Goeckner-Wald (claire@caltech.edu) or Amy Xiong (axiong@caltech.edu)

7 Amy's Stuff

The first challenge was in getting Tone.js to produce random music that would play forever.

Tone.js's has a scheduling system for producing music.

Tone.js had scheduling components that allowed you to play a series of notes in a row (e.g. Tone.Part).

Tone.js can only repeat in regular intervals—it could not, for example, calculate the amount of time a section of music would take, then automatically repeat after that section was finished. This meant we had to make each randomly-generated section of music be of the same length, in order for them to fit together without breaks in the music. We thus decided to generate music one measure at a time.

Tone.js allows you to have multiple notes playing at the same time. Thus, you must specify both the duration of the note and when it should be played, not just one or the other. We had to thus separately track the time elapsed as we randomly generated our notes, in order to be able to know when to schedule the next note.

`triggerAttackRelease(note, duration, time)`

For random rhythm patterns, we used a set of 8 rhythms patterns [1]:

whole	quarter half quarter
half half	half quarter quarter
quarter quarter quarter quarter	quarter dotted-half
quarter quarter half	dotted-half quarter

Note that each of these rhythms take up exactly one measure (in 4/4 time). We then augmented this set by using the same patterns with shorter notes. We halved all the note lengths to get an equivalent set of rhythm patterns that take up half a measure, and then halved the lengths again to get another set that take up one quarter note.

We generate music one measure at a time, but within each measure, we generate the measure by connecting together these rhythm patterns. Since some of the patterns are shorter than a measure (the length of either one quarter note or one half note), we must be sure to generate the appropriate number of rhythm-segments, of the appropriate length, to exactly equal one measure of music.

For example, we might generate a measure of music by first generating four sixteenth-notes (a one-quarter-note rhythm pattern), then one half-note (a one-half-note rhythm pattern), then finally two eighth-notes (a one-quarter-note rhythm pattern again). We cannot, however, generate first four sixteenth-notes, then four quarter-notes, as that will last longer than one measure. We also cannot generate four sixteenth-notes, then one half-note, then stop, since that will last shorter than one measure.

We have the function `createMeasure(maxLength, offset)` to create notes with a single rhythm pattern. The parameters specify the maximum length of music to generate (1-4 quarter notes) and the offset into the measure the notes should start at (0-3 quarter notes in). The function first randomly decides what length of music to generate (1, 2, or 4 quarter notes of music) that falls within the maximum length. It randomly picks one of the 8 possible rhythms. The shorter rhythms (half-note-length or quarter-note-length) are obtained by dividing the note lengths according to whether it's generating 1, 2, or 4 quarter notes of music.

7.1 Pitch Generation

Pitches are also randomly generated. When the website is first loaded, it randomly picks a tonic note and a scale type to build a scale (e.g. C Major, A-flat Minor, D-sharp Dorian). Note pitches are chosen only from this scale.

8 Appendix

Include resources here.

8.1 Original Proposal

We aim to build a procedurally-generated soundscape inspired by 'coffeehouse jazz'. The ideal end-product is jazz-esque music that can respond in live time to environmental variables. We selected jazz as our target because we believe it will be easier to procedurally generate due to the improvisational and diverse nature of jazz. We will initially follow this Procedural Music Generation tutorial. To begin, we select a 'palette' of frequencies and sounds that function well together. Then, we will add rhythm and beat to generate our base product. After this is accomplished, we may add additional complexities such as palette-changes, instrument modifications, etc. We may additionally attempt to link these complexities to environmental variables for an interactive soundscape.

We will use SuperCollider for the sound synthesis and algorithmic composition. We will begin with MdaPiano for a piano synthesizer. We will also add drums, saxophone,

bass, and other instruments, as appropriate. Ideally we will have large suite of instrument synthesizers. We have considered creating a web application for this project, a la https://asoftmurmur.com/ and similar websites, which allow the client to modify the mixture directly. If we chose to do this, we might use Google App Engine.

8.2 MIT License

```
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LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM,
OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE
SOFTWARE.
```

[3]

8.3 The GNU General Public License v3.0

```
<one line to give the program's name and a brief idea of what it does.>
Copyright (C) <year>  <name of author>

This program is free software: you can redistribute it and/or modify
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the Free Software Foundation, either version 3 of the License, or
(at your option) any later version.

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```

[2]

References

[1]

[2] GNU General Public License.

[3] MIT License.

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