EXPLORATION OF RHYTHM GENERATION AND SPECTROGRAMS

Rebecca Rashkin

SPRING 2016

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INTRODUCTION

The goal of this project was to explore toned rhythm generation and audio visualization through spectrograms. In addition, the author used this project to reinforce concepts of percussive and modal theory.

In rhythm theory [4] there are two basic types of rhythms: framing rhythms and syncopated rhythms. A framing rhythm is any one or two beat continuous repeating rhythm. A syncopation is any non-repeating rhythm on a beat-to-beat basis. A framing rhythm is meant to provide static support for other syncopated rhythms.

In this project, four tunes were generated in MATLAB, each containing the notes in four versions of the C7 chord. A "7" chord contains the 1st, 3rd, 5th and 7th notes in an eight note scale. For example, the C Major scale is C-D-E-F-G-A-B-C so the C Major 7 chord has notes C, E, G, and B. Four modes of a 7 chord are major, minor, dominant, and diminished and each are slightly varied from the major as shown below:

major	C	E	G	B
minor	C	E$^\flat$	G	B$^\flat$
dominant	C	E	G	B$^\flat$
diminished	C	E$^\flat$	G$^\flat$	B$^\flat$

Table 1: Notes of C7 chord - The tones in each of the four modes are slightly varied.

The four generated tunes in this project each have the same rhythmic elements; the variations are in the tones of the syncopated rhythms. Spectrograms were created for each tune, and parameter modifications were explored.

METHODS

Platform

The author used MATLAB R2015b Student Version on a Macbook Pro with OS X version 10.10.5.

Tone Generation

To create the tones, the author started with the function **key2note** as a template provided in Lab 4 of DSP First labs [2]. This function takes an integer number mapped to a specific piano key and converts it to a sinusoidal signal with the corresponding frequency. This function was modified to use the MIDI standard integer to key mapping using the equation:

$$f_{midi\#} = 440 \cdot 2^{(midi\#-69)/12}$$

Equation 1: MIDI note to sinusoidal frequency

Rhythm Generation

To convert a continuous tone to a rhythm, a "masking" function called **binMask** was designed. A rhythm is created by multiplying a tone signal with a binary mask of the same length. The mask is a square wave where the one values indicate where the tone will be heard.

Figure 1: <u>Musical notation</u> - Western musical notation for the synthesized rhythm depicted in the succeeding plots.
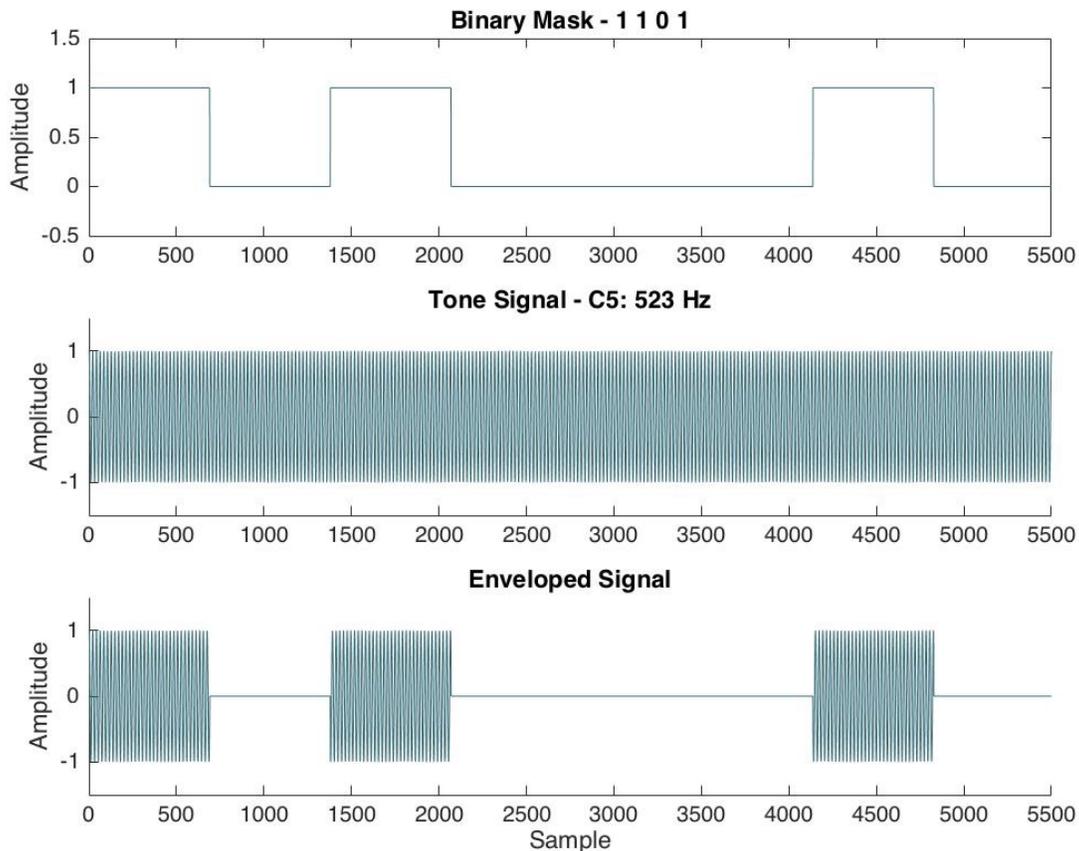

Figure 2: <u>Binary masking</u> - Rhythms are created by multiplying the binary mask with a tone signal.

Spectrograms

For spectrogram generation, the author followed the same process as defined in the chirp signals demo from the textbook website [1]. In order for accurate timing reflection on the x axis, the sampling frequency had to be one of the inputs into the spectrogram function, so the five-input function signature was implemented [3]. These inputs were (1) the signal, (2) number of windows, (3) number of overlapped samples, (4) cyclical frequencies, and (5) sampling frequency. The number of windows and overlapped samples were experimented with to see their affect on the spectrogram.
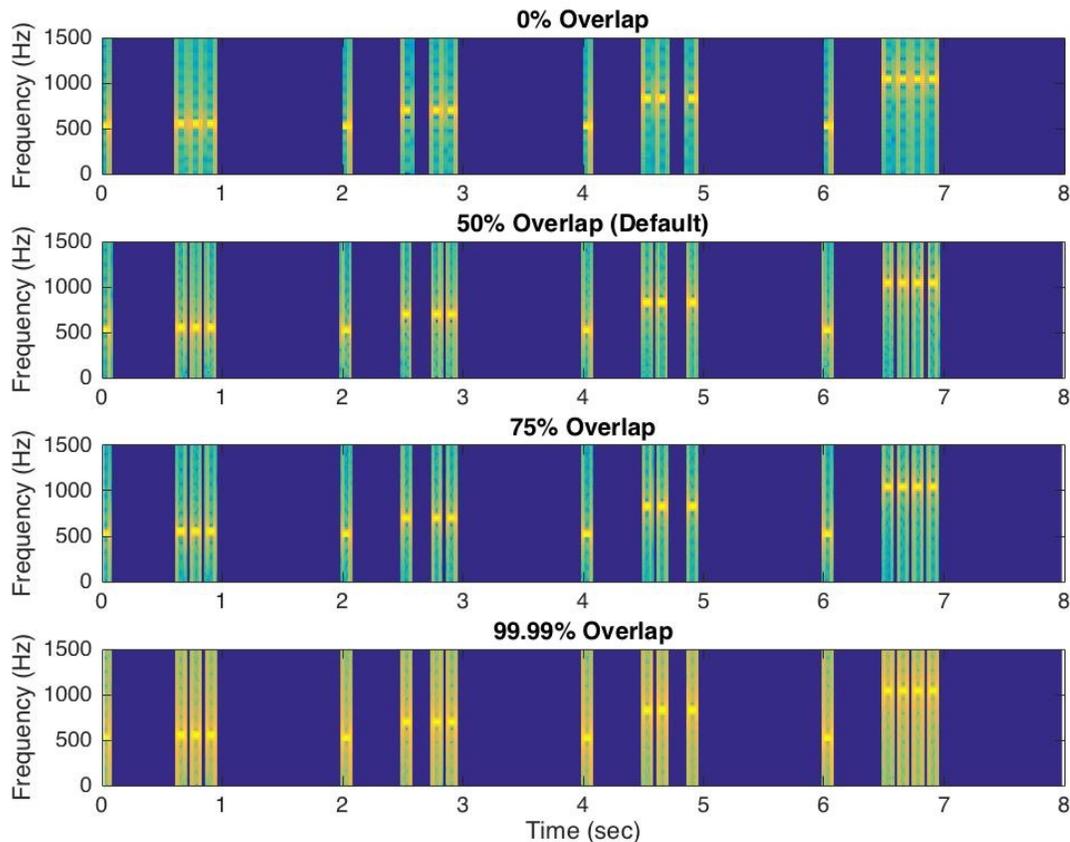
Window Size

The following plots depict spectrogram representations of the major mode syncopated rhythm with different window sizes. Values for number of overlapped samples and cyclical frequencies were left as '[]' to allow the program to insert default values.
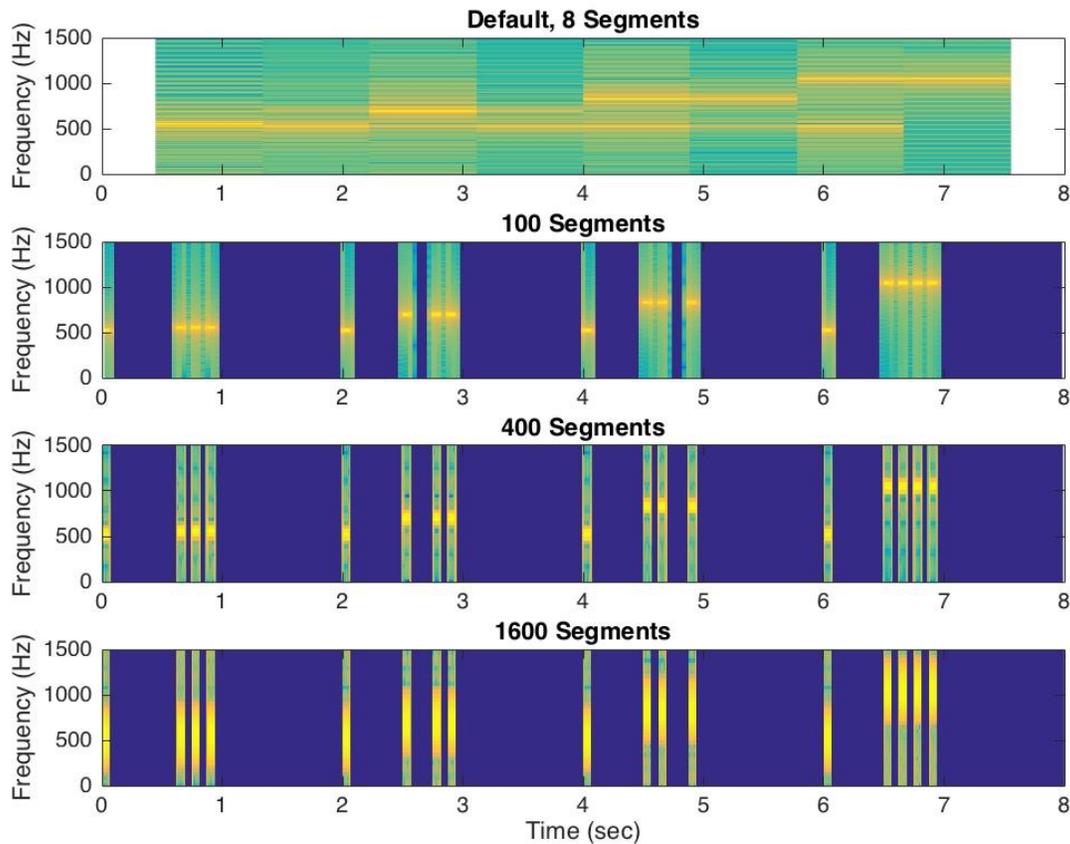
Figure 3: Spectrogram window size variation - As window size decreases (and segments increase), rhythmic timing is more accurately represented, but frequencies are shown with less precision.

Overlapped Samples

The following plots depict spectrogram representations of the major mode syncopated rhythm with different values for overlapped samples. Window length was set to the length of the signal divided by 200 to create 200 segments. Cyclical frequencies were set to the program's default value by entering in '[]' for that parameter.

Figure 4: Spectrogram sample overlap variation - Similar to the window sizing variation plots, as sample overlap increases, rhythmic timing is more accurately represented, but frequencies are shown with less precision. The default of 50% overlap is the best value for this parameter .

Program Execution

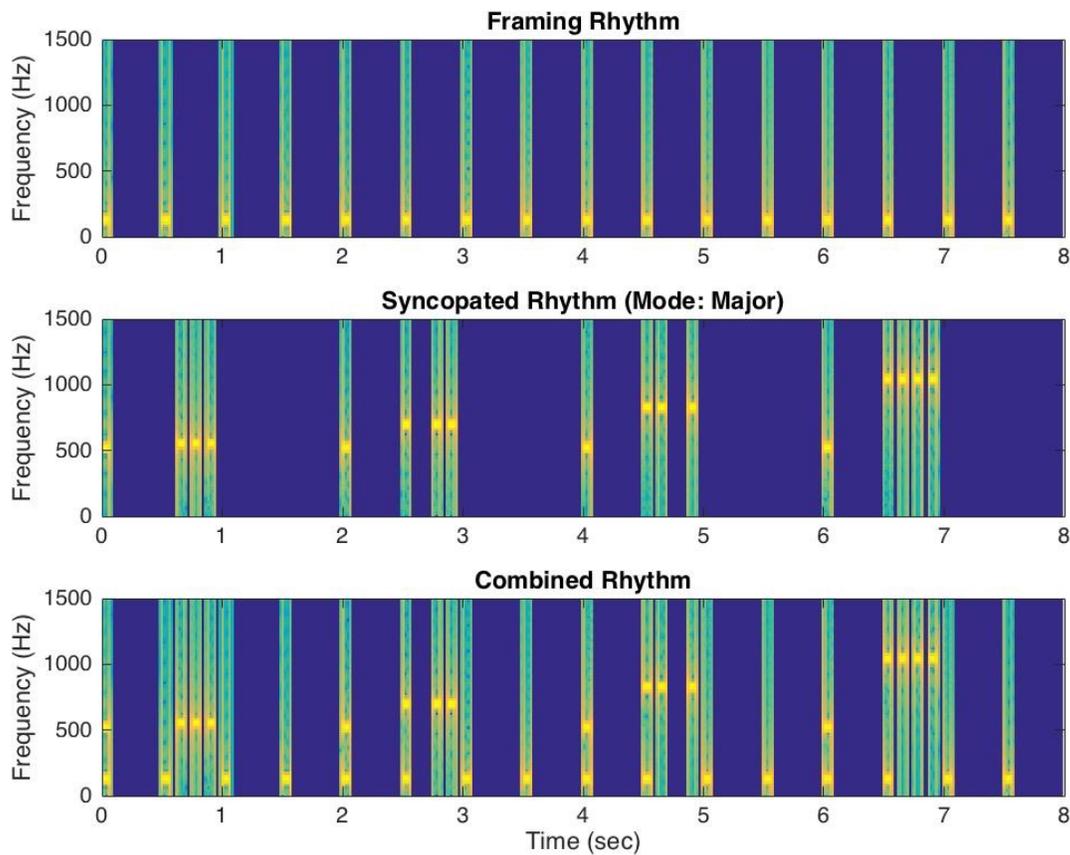To execute this program, include the following files in the executing folder:

binMask.m
key2note.m
metronome.m
practice1.m
rashkin.m
rhythmAlphabet.m

Open rashkin.m in MATLAB and select run.

RESULTS

Combined Rhythm

The following figure shows the spectrogram of the generated framing rhythm, syncopated rhythm and the combined rhythm.

Figure 5: Combined rhythm spectrogram - The framing rhythm has a lower frequency than any of the tones in the syncopated rhythm. The combined spectrogram shows frequencies of both rhythms, even when the timing is overlapped.

Modal Differences

Spectrograms were created for each of the four tunes as shown below.
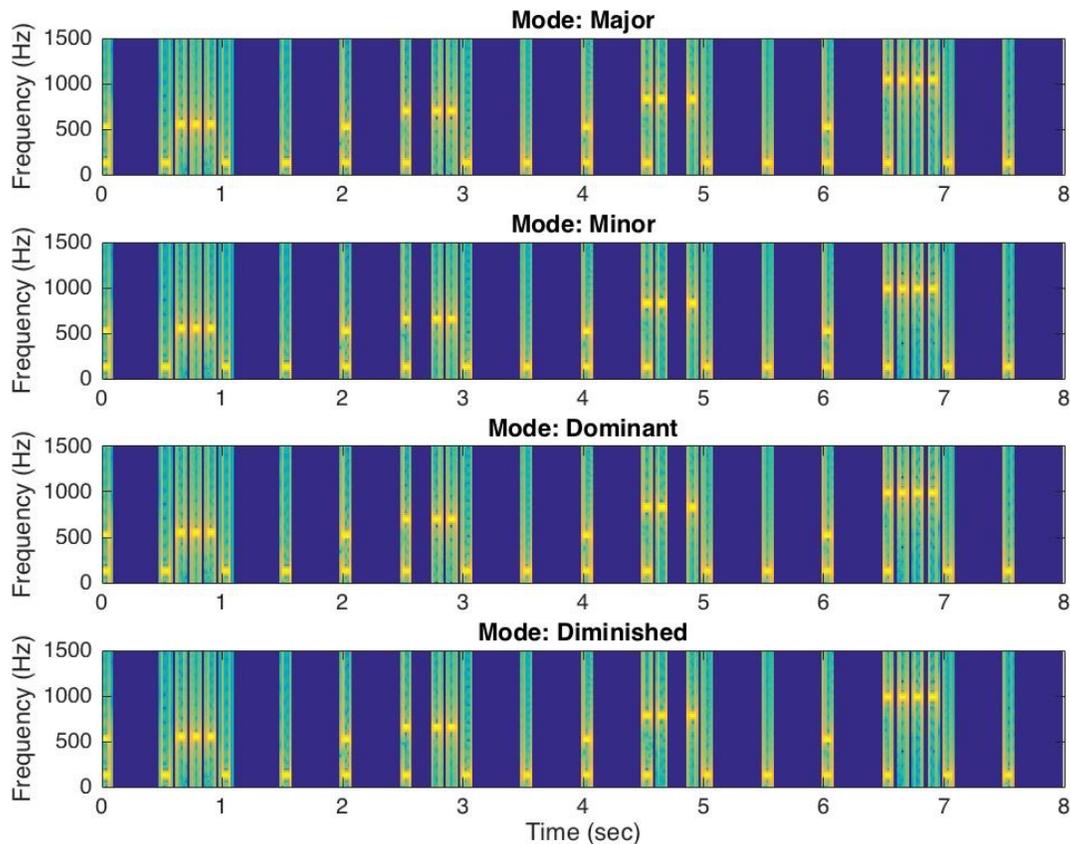
Figure 6: <u>Modal differences</u> - Though not immediately obvious, these spectrograms reflect the subtle frequency differences in each of the four modes.

DISCUSSION

Summary

The goal of this project was to explore audio creation and corresponding spectrograms. Rhythmic sounds were generated by enveloping a tone signal in a square wave masking function. A repeating framing rhythm was created and combined with four similar syncopated rhythms. Each syncopated rhythm contained the notes of each of the four different modes of a C7 chord: major, minor, dominant and diminished.

The author experimented with spectrogram window size and sample overlap and determined 200 windows (segments) with the default 50% sample overlap gave the most representative results.

Future Work

There are many ways that this project could be improved or expanded. For instance, the masking function, **binMask** is always used by multiplying it with a tone function. Instead, binMask could take inputs of midi number and sound duration and output a toned rhythm directly. Also, the **metronome** function could be modified to read in any one or two beat framing rhythm.

The author plans to apply some of the rhythm generation techniques presented here in her thesis topic of exploration of the human heart's response to audio.

REFERENCES

[1] McClellan, Schafer, and Yoder. Chirp Signals. http://spfirst.gatech.edu/chapters/03spect/demos/spectrog/chirps/index.html

[2] McClellan, Schafer, and Yoder. Lab 04: Synthesis of Sinusoidal Signals—Music Synthesis. http://spfirst.gatech.edu/chapters/03spect/labs/lab04/lab04.pdf

[3] Spectrogram. http://www.mathworks.com/help/signal/ref/spectrogram.html

[4] Walker, Rick. http://www.looppool.info