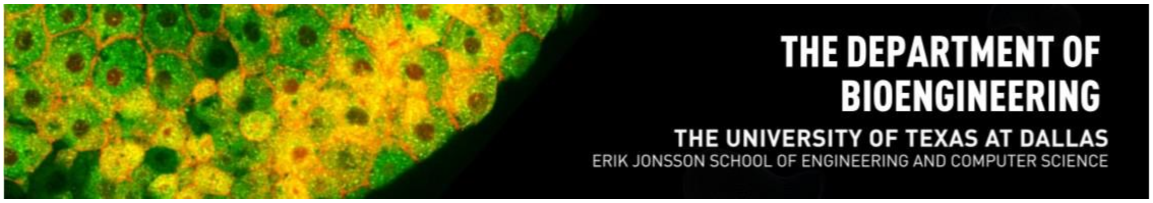

Signal Processing Project – The Sight of Music

BMEN3325 - Advanced MATLAB Programming for Biomedical Engineering

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April 14, 2023

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Overview

In this project, I analyzed three songs using three different algorithms in MATLAB and plotted the results. The purpose is to visualize the songs under three different conditions while you listen to them. The three conditions include the "original" song files, the "unvoiced" versions of those songs, and the "only bass" versions of those songs. The songs include "Can't Get Enough of Your Love, Baby" by Barry White, "So Fresh, So Clean" by Outkast, and "Can't Live Without You" by Charlie Wilson. The original songs come in stereo, which is a trait that exists in most songs, and allows us to remove most of the vocal aspects from the songs by simply subtracting the left channel from the right channel. This is known in my project as the "unvoiced" version of the songs. I also wanted to isolate the lower frequencies of each song to see if I could bring out the baseline from the instruments. So, I did that and called it the "only bass" version of each song.

Spectrogram

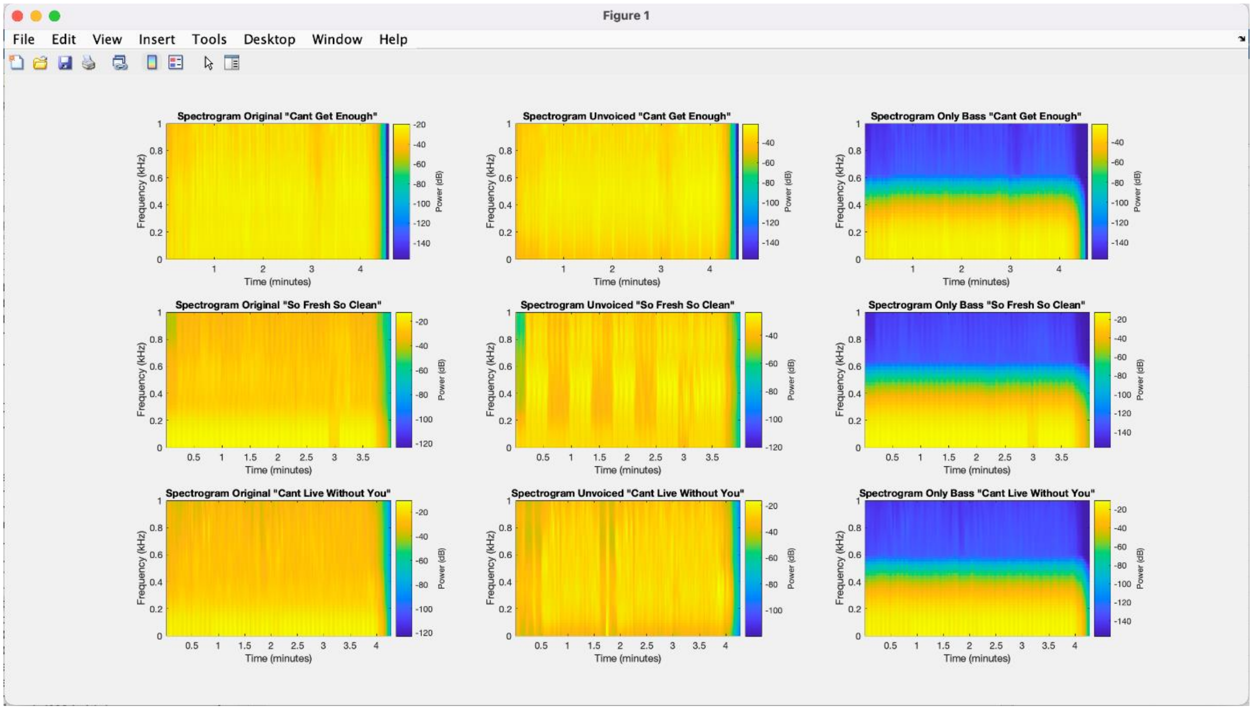

Figure 1: Spectrogram of "Original", "Unvoiced", and "Only Bass" versions of three songs.

The first algorithm to discuss is the spectrogram, which plots the frequencies of the song over time. As you can see in **Figure 1**, each song is represented in the rows, and each condition is represented in the columns. I used the "pspectrum()" command and subplotted each one to get this figure.

As you have probably noticed, the unvoiced versions of each song look different from the originals. To understand the difference, I would like to direct your focus to the coloring in each spectrogram. The vocal frequencies typically lie at the bottom of the graphs in the 80-180 Hz range. Notice how that range has become darker for each unvoiced version of the songs, indicating a lower Power (dB) in that range. This is just a visual representation of the lower volume in those regions, showing us that the vocal range has been cut out of the songs.

I found it interesting how, in the first song, the vocals are almost completely gone, but in the second and third songs it is clear that some of the vocals (particularly in the choruses) have been recorded in each channel individually and could not be cut out by simply subtracting the two channels. So, the vocals in the choruses tend to sit in front and become very loud compared to the vocals in the verses. You can see the periodicity of the choruses and verses in the second song very well.

However, this technique of using spectrograms for songs seems pretty useful for understanding different frequency characteristics in a time series. I assume there are much better biomedical uses for this technique, but it was very interesting seeing the differences in something we enjoy so much as music. I'm sure this could be used in something like ultrasounds to visualize the density of tissues as the instrument is moved across the body.

Frequency Filter

The second algorithm to cover is the frequency filtering algorithm. It is rather simple in that it takes the original sample (song) and uses a bandpass filter to allow only certain frequencies to be played. For my project, I wanted to see if I could isolate the bass portion of the frequency profile for each song. So, I chose the frequency range 20-200 Hz for the bandpass filter, using the "bandpass()" command. The rest of the instruments should fall outside of that range and not be audible after filtering. However, there is some overlap between the bass and the vocals, so some vocals will still be audible.

The point is to hear the difference between the original song and the filtered version, which you will find to be a rather striking difference. This difference can be visualized in the last column of **Figure 1**. Notice how the bottom portion of the graph is bright yellow while the top half is a deep blue, indicating that the top frequencies have been cut off and the bottom frequencies (low bass sounds) are still playing throughout the songs. This type of algorithm could be useful for anyone who might need to isolate certain frequencies of sound. It is a very basic algorithm, so it is probably most useful for someone who is trying to get a better "feel" for the signal they are analyzing. Musicians, audio engineers, or anyone who needs to pay close attention to certain frequencies will make use of this. Note: It may be helpful to turn up your speakers' volume when listening to the "only bass" sound because I found the filtered versions to be a bit quieter than the original.

Periodogram

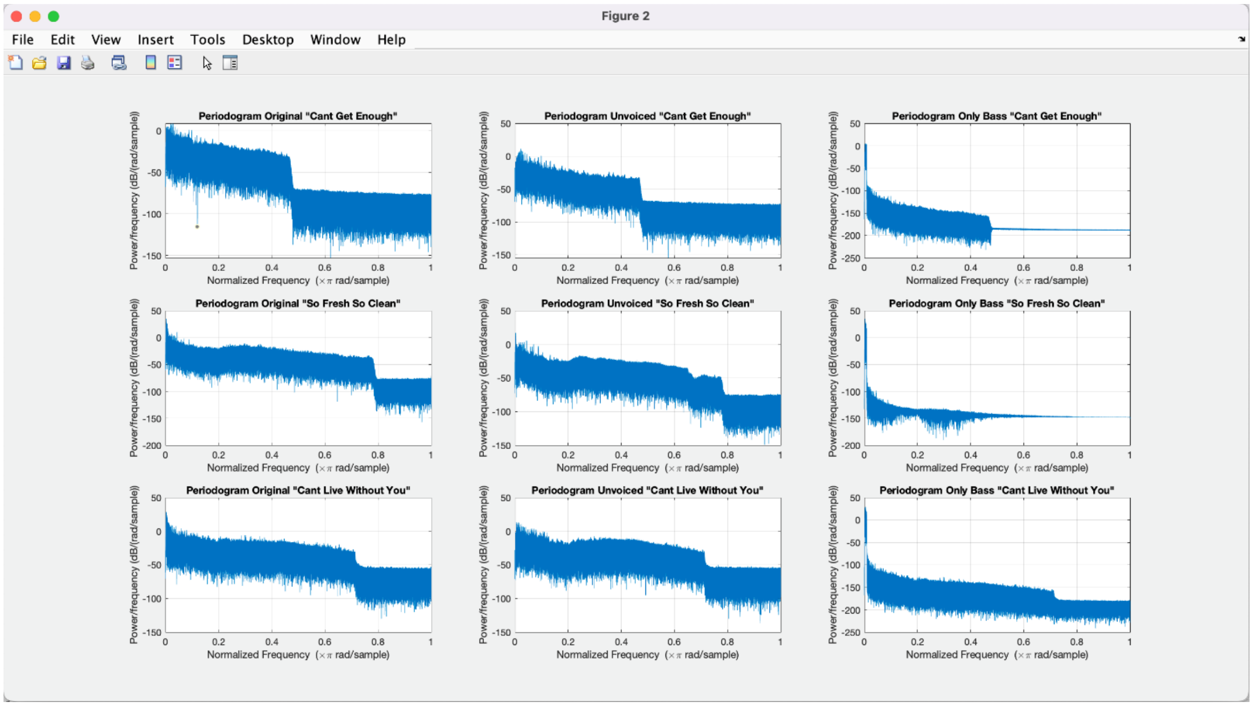

Figure 2: Periodogram of "Original", "Unvoiced", and "Only Bass" versions of three songs.

Lastly, here is a discussion of the periodogram algorithm. For this, I took the same three songs and three conditions and used the "periodogram()" command to plot all of them on **Figure 2**. These periodograms will give us an idea of which frequencies have their volumes turned up and which ones have been turned down for the listener. Since sounds of lower frequency will have lower amounts of energy, they often have their volumes turned up relative to the higher frequencies in songs to give the listener the most even sound. If the higher frequencies had the same power as the lower frequencies, the higher pitches would feel much louder, and the song would most likely sound sharp or hurtful to the listeners' ears. So, for example, if you look at the periodograms, they all have a characteristic downward slope. Additionally, "Can't Get Enough of Your Love, Baby" by Barry White shows a steep decrease in gain at a much lower frequency than the other songs. If you listen to the song, you can tell that is because Barry White has a much deeper voice than the other artists, and the song takes on a much lower and more seductive energy to it.

Another thing to note is how the "only bass" versions of each song have a greater magnitude in the lower frequency range and a very skinny tail on the higher frequency range. That is to be expected because, remember, we cut off those higher frequencies. This method of analyzing an audio file is similar to the spectrogram because it measures the power of certain frequencies, except that the periodogram is in the frequency domain. It is different because it does not show how the frequencies change over time. So, this may be more useful for understanding the overall prevalence of certain frequencies in an entire song rather than their existence over a period of time.