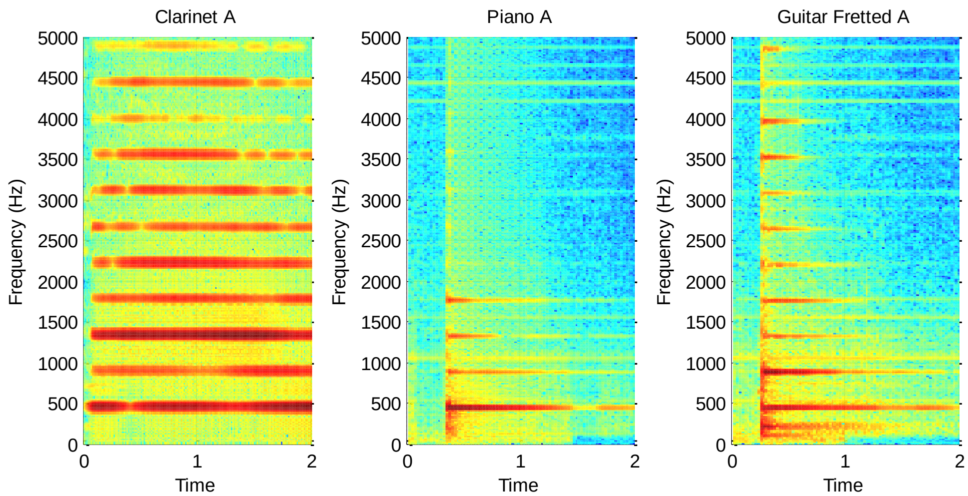
# ECE 321 Spring 2014
# Matlab Project 2
# Due March 25, 2014

In this project, you will modify the spectral characteristics of the melody you generated in Project 1. Naturally-produced notes are not pure sinusoids. They also include harmonics of the fundamental. Different instruments have different harmonic structures. Some examples are below:




**Part 1**: In Part 2 you are going to add harmonics to your notes in the Beethoven melody.

a) First, write a new function, harmonics.m, that calls gentone and generates a specified number of harmonics. The syntax should be:

Y = harmonics(Frequency, Duration, N, A_vect, Shape)

where Frequency is in Hz, Duration is in sec, N is the number of harmonics, A_vect is a vector of length N storing peak amplitudes for each harmonic, and Shape specifies whether the shape is sustained like the last project or exponential decays. The output, Y, is the time waveform.

The fundamental frequency is almost always the strongest so you need to make the harmonics softer as the harmonic number increases. As shown in the spectrograms above, some instruments, like the clarinet, have sustained harmonics while others have fewer harmonics and they fade more rapidly than the fundamental.

b) Use your function to generate a 440 Hz note with 9 harmonics. It should be 1 sec in duration. Initially define your A_vect to be all ones. Plot the note's spectrogram. What would happen if you tried to add a $10^{th}$ harmonic? Try it and discuss what you noticed (either by listening or looking at the spectrogram) in your report.

c) Using subplot, plot 2 periods of the original note in one frame and 2 periods of the note including harmonics in the other. What effect did adding the harmonics have on the waveform?

d) Now synthesize two modified 440 Hz notes. The harmonic peak amplitudes should be $0.707^{k}$ where k is the harmonic number. The first note should have the envelope shape used in the last project and the second note should have an exponential decay shape that should decay by 5 time constants at 2 sec. Plot the two notes vs time in sec and their spectrograms. Also plot 2 periods of the first note and compare that plot with the 2-period plots in c). What affect did changing A_vect have on the waveform?

**Part 2:**

Write a script clar.m that synthesizes your Beethoven melody to sound like the clarinet. Also write a script piano.m that synthesizes it to sound more like the piano. You will need to use the exponential decay to simulate a piano sound. At this point you may modify (lengthen, shorten or even remove) the pauses at the end of each note if you think it makes the melody sound better.

When you have made all your modifications, name the final melodies clar_melody and piano_melody. Plot their spectrograms.

**Include in a .zip file all scripts, .m files and the report. Use the same naming convention as for the first project.**

**Questions:**

1. What difference(s) did you notice between the 2-period time plots of the pure tone at 440 Hz, the tone with harmonics added at equal amplitudes and the tone with harmonics at decreasing amplitudes?

2. What is the mathematical expression for the exponential decaying note in Part 1?

3. Describe how the sound of the clar_melody differed from the first project due to the added harmonics.

4. What other modifications can you think of that might make a melody sound more natural?