EECE4510/5510 Fall 2013
Project 1 Specification
Due Date: Wednesday November 6, 2013 beginning of class period

This is a one-person project giving an introduction to the use of Matlab for signal processing.

1) Filter design and implementation

a) *Filter design.* Use the "`sptool`" GUI to design a bandpass IIR elliptical filter with a passband from 1500Hz to 2500Hz, passband transition bands of 200 Hz on either side, passband ripple of 1dB, and stopband rejection of 50dB, designed to minimum order. Use a sampling rate of 44100Hz (or choose an alternative sampling rate based on a sample audio input signal of your choosing). After designing, use sptool or the "`fdatool`" to analyze the performance of this filter, including magnitude and phase responses, impulse response, and pole-zero plot, and discuss and make plots of these (make sure axes are labeled). You can use the "`Export`" command to put the filter in the Matlab workspace. (Note: The default should be a filter structure called a "second order section (SOS) implementation, which we will learn about in Chapter 6.)

b) *Filter application.* Apply your filter to a signal using either the "`sptool`" GUI or the "`sosfilt`" command. You can import a music or audio waveform of your own choosing using the "`wavread`" command. Look at the frequency characteristics both before and after applying the filter, and listen to the result. Summarize your findings.

2) Examining more advanced signal processing through Matlab demos

a) *Preliminary: Learning about Matlab demonstrations.* Use the command "`help sigdemos`" to view the available signal processing toolbox demonstrations, and try them as desired to look at some of Matlab's capabilities. You may also want to try "`help imdemos`" or "`iptdemos`" to see the image processing toolbox functions and demos. (Nothing to submit.)

b) *Run demo:* Choose one of these demos that most interests you, and follow the steps given in the demonstration to implement it. Recommendations: If you are interested in audio, try the "`filterguitardemo`". If you are interested in communications, try the "`moddemo`". If you are interested in biomedical applications, try the "`ipexmri`" demo. Step through the demo one step at a time and try to follow it in detail. Submit 1 plot illustrating final results, along with a 1 paragraph summary giving an overview of the idea and methodology used.

c) **Grad students only.** In addition to your chosen demo, also run the "ipexnormxcorr2" image processing demo. Write a 1 paragraph summary explaining how and why this method works from a statistical signal processing perspective, based on your understanding of cross correlation.

3) **Audio effects generation** Research on your own about audio DSP effects, and write a Matlab function to implement a selected audio effect on a signal. There are many different kinds of audio effects possible, including among many others:

- Frequency band filtering / equalization
- Reverberation (including room impulse responses to simulate concert halls, etc.)
- Tremulo (amplitude modulation effect)
- Vibrato (frequency modulation effect)
- Chorus / echo
- Phase shifting (uses all-pass filters)
- Flanging (tempo effect)
- Frequency shifting

Write your function code in as general a way as possible, including allowing users to pass any necessary parameters and having good default values for these parameters.

***Undergrad students*:** Implement **2** audio effects ***Grad students*:** Implement **3** audio effects

Bonuses
Bonuses are available for

- Implementing additional audio effects beyond the minimum requirements (1-5 points per additional effect, depending on complexity)
- Integrating the audio effects function(s) into a single GUI tool (5-15 points depending on usability and flexibility of the interface)

Documentation and software issues
Your audio effects code should be written to be useable by others. Your report (see Deliverables section, below) should include an appendix with a "User Manual" that explains how to run each effect. Use good documentation practices, and make sure to include appropriate function and parameter descriptions at the top of the functions so that the Matlab help command will give all information needed to use the programs. Wherever possible and reasonable, assign parameters default values so that their inclusion is optional.

Deliverables
Deliverables for the project will include a written project report, all Matlab code, and a folder of short (3-5seconds) example .wav audio files demonstrating your audio effects. The report does not need to be long, but it should be complete, including an overview and any required plots for each of the problems, detailed descriptions of methods used for effects generation (with references as needed), and an appendix with a "User Manual" containing clear descriptions of how to run each of your effect programs. All deliverables should be placed in a single ZIP file and submitted to D2L by the deadline. *Both* electronic submissions and hard copies of the report are due at the beginning of class on the project due date.

References
Below are a few references to texts or online material that may be useful to you:

- READ THIS: http://en.wikipedia.org/wiki/Audio_effects (also has external links)
- Harmony Central web site http://www.harmony-central.com/Effects/
- Musicdsp.org http://www.musicdsp.org/
- Digital Signal Processing by Steven Smith http://www.dspguide.com/pdfbook.htm
- Introduction to Signal Processing by Sophocles J. Orfanidis (has audio effects section) http://www.ece.rutgers.edu/%7Eorfanidi/intro2sp/