UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Electrical and Computer Engineering

ECE 498MH Signal and Image Analysis

Lab 2

Fall 2014

Assigned: Thursday, September 25, 2014 Due: Thursday, October 9, 2014

Reading: Mark Hasegawa-Johnson, *Lecture Notes in Speech Production, Speech Coding and Speech Recognition*, Chapter 1: Basics of Digital Signal Processing, `http://isle.illinois.edu/~hasegawa/notes/chap1.pdf`

Announcement: Exam 1, in class on Friday October 3, will cover homeworks 1-4

Lab 2.1

(a) Write a matlab function called `dampedsine.m`. Your function should be called with a syntax like `x=dampedsine(F,B,N,Fs);`. The three input parameters should be the frequency of the sine wave, its bandwidth, the number of samples to produce, and the sampling frequency. The output should be a signal constructed as

$$x[n] = e^{-n\pi B/F_s} \sin\left(n2\pi F/F_s\right), \quad 1 \le n \le N$$

In figure 1, plot 100 samples of a damped sine wave, at 8kHz sampling rate, with a bandwidth of 150Hz and a center frequency of 900Hz, versus sample time (in seconds). Label the axes.

(b) Write a matlab function called `vowel.m`. Your function should be called with a syntax like

`x=vowel(F0,F1,F2,B1,B2,A1,A2,Fs);`

It should call `dampedsine` to produce two damped sine waves, each of length F_s/F_0 samples, at frequencies of F_1 and F_2, with bandwidths of B_1 and B_2. These damped sine waves should be scaled by the amplitudes A_1 and A_2, then added together, then repeated twenty times, in order to output twenty pitch periods of a vowel. Produce an example of the vowel /a/ ($F_1 = 900$, $F_2 = 1200$, $B_1 = 150$, $B_2 = 150$, $A_1 = 1$, $A_2 = 0.75$) at $F_s = 8$kHz. Plot the vowel waveform (versus sample time in seconds; with labeled axes) in figure 2, and play it using `soundsc`.

(c) Use `fft`, which computes the DFT of your twenty-pitch-period waveform. Create two sub-plots in Fig. 3. In the top sub-plot, plot the positive-frequency components of the associated power spectrum, versus frequency in Hertz (from 0 to 4000), with labeled axes. In the bottom sub-plot, plot the positive-frequency components of the power level spectrum ($10\log_{10}|X(\omega)|^2$) versus frequency in Hertz (frequencies from 0 to 4kHz), with axes labeled "Frequency (Hz)" and "Level (dB)."

(d) Repeat parts (b) and (c) in order to produce the vowel /i/ ($F_1 \approx 300$Hz, $F_2 \approx 2000$Hz). Experiment with bandwidths and amplitudes, to find bandwidths and amplitudes that make the vowel sound as natural as possible. Plot the waveform in Fig. 4; plot the power spectrum and level spectrum in Fig. 5; use `soundsc` to listen to the waveform.