Fall 2017
CSCE 630 Speech Processing
Homework #1

Due date: 9/29/2017 at 1:00pm

In recognition of the Texas A&M University policies of academic integrity, I certify that I have neither given nor received dishonest aid in this homework assignment.

Name: ______________________ Signature: ______________________

PLEASE FOLLOW THESE GUIDELINES:

1. *Download the compressed file 'hw1.zip' from the course web page*
2. *Prepare your answers/solutions in the form of a report, with each problem being a separate section of the report –you may use this assignment as a template*
3. *Submit your code as a ZIP file through csnet, each problem on a separate subfolder. This ZIP file should include (1) a single PDF document containing your written report (see above) and any relevant supporting graphics, Matlab code for each problem, and any additional result such as 'wav' files.*
4. *Please show your work and discuss your findings; it ensures full credit if your results are correct, and allows me to give you partial credit otherwise*
5. *Sign and return this page with your finished assignment*

Problem 1 (25%)

In this exercise you will familiarize yourself with the use of the PRAAT speech processing tool, which is available for download at http://www.fon.hum.uva.nl/praat. Describe your work throughput the exercise.

1) Generate a narrowband spectrogram (25ms windows with 1ms step) and a broadband spectrogram (5ms; 1ms) for the speech recording '*s1.wav*'. Discuss the similarities and differences between both spectrograms.
2) Generate narrowband spectrograms for the speech recordings '*s1.wav*' and '*s2.wav*' included in the homework's zip file. Discuss the similarities and differences between both spectrograms.
3) Identify a voiced segment in the speech recording '*s1.wav*' and plot its power spectrum. Repeat the same but for an unvoiced segment in the same recording. Discuss the similarities and differences between the two spectral slices.

Useful resources: http://www.fon.hum.uva.nl/praat/manual/Intro.html

Problem 2 (25%)

In this exercise you will perform a similar analysis, but in this case using Matlab. Describe your work throughput the exercise.

1) Load the speech recording '*s1.wav*' into Matlab, and display the waveform. Identify two different segments, one voiced and one unvoiced, and plot the results. How did you establish whether the segment was voiced or unvoiced? Play the two segments to confirm the results. Save each segment as a separate 'wav' file. (Hint: use commands '*wavread*', '*wavwrite*', '*plot*' and '*soundsc*').

2) Compute the Fast Fourier Transform of the two segments, and plot their magnitude in logarithmic scale. Make sure that the x-axis displays frequencies in Hz, not FFT indices. Are the results consistent with those on PRAAT? Can you identify the fundamental frequency? (Hint: use command '*fft*').
3) Compute the narrowband spectrogram for the two speech recordings '*s1.wav*' and '*s2.wav*'. Select the appropriate widths and shifts. Are the results consistent with those on PRAAT? (Hint: use the MATLAB command '*spectrogram*')

Problem 3 (25%)

In this exercise you will learn to design, analyze and utilize a pole-zero filter. Assume a sampling frequency of $F_s = 16kHz$ throughout this experiment. Describe your work throughput the exercise.

1) Compute the poles of an all-pole filter with a single resonance at 1000 Hz and a bandwidth of 250 Hz.
2) Compute and plot the frequency response of the filter (log magnitude only) over the range $[0, F_S/2]$. Does the frequency response look as expected?
3) Compute and plot the impulse response of the filter. Can you interpret it? Compute and plot the FFT of the impulse response. Can you interpret it?
4) Generate an input sinusoidal waveform with a frequency of 250Hz (unit amplitude, zero phase, 1 sec duration) and pass it through the filter. Plot the original signal and the filtered signal; what happens to the signal after going through the filter?
5) Repeat the previous step for inputs with frequencies of 500Hz, 750Hz, 1000Hz, 1250Hz and 1500Hz. What is the effect of the filter on these signals? Is it consistent with the filter's frequency response you computed earlier?
6) Modify the filter by adding a zero at a frequency of 750Hz with bandwidth of 500Hz, and repeat steps 2) through 5).

Problem 4 (25%)

In this exercise you will develop an algorithm to invert a spectrogram, that is, to reconstruct the original waveform from which it was generated. The Matlab file '*sgram1.mat*' contains a spectrogram generated with the built-in Matlab command '*spectrogram*', as well as the parameters used (window length, overlap, windowing function, sampling rate of the original signal, and number of FFT components).

1) Write a Matlab script to reconstruct the original waveform. What is the content of the original recording? Save the result as a 'wav' file.
2) Repeat the process for Matlab file '*sgram2.mat*' . What is the content of the original recording? Save the result as a 'wav' file.
3) How successful were these reconstructions? Can you tell any differences between the two files (aside from the actual content)? Discuss your results.