**UCLA**

**Dept. of Electrical and Computer Engineering**

**EE214B**

**Problem Set 2**

**Due: 4/25/2018**

Reading Assignment:
Rabiner and Juang (R & J): Ch. 1, Sections 2.1-2.5.2 of Ch. 2, and all of Ch. 3.

1. Implement a complete MFCC front end that includes all the steps we talked about in class: pre-emphasis, framing, windowing, log DFT, DCT, parameter weighting, etc., and computing the 1st and 2nd temporal derivatives of the cepstral coefficients. Choose parameters that are appropriate for your sampling rate.

    a. Choose one of the vowels (preferably, the longest and most steady) in the posted sentence. Process the vowel through the system and examine and plot the log-spectrum of the output at each stage. Explain the effects of the different operations on the spectral shape of the speech sounds.

    b. What is the effect of increasing the number of cepstral coefficients?

    c. It is often thought that the low-order cepstral coefficients are more related to vocal tract information while higher-order ones, to pitch. Can you see any evidence of that? To do this part use synthetic vowels posted on the website. The vowels are /a/ and /i/ with F0 at 100 and 150 Hz for male vowels, and 150 and 200 Hz for the female ones. Examine the effect on the cepstral coefficients when F0 is changed but the formants are fixed, versus changing the formants (male vs. female) while keeping F0 the same.

    d. For the male and female /a/ vowels with fundamental frequency at 150 Hz, add 10 dB SNR white Gaussian random noise to the waveform (you can use awgn() function of MATLAB) and plot cepstral coefficients for all the frames. On the

same figure, plot cepstral coefficients of clean waveform. Comment on the differences. Are MFCC features robust to noise?

e. Repeat parts (c) and (d) for LPCC features.

2. Implement Kmeans clustering algorithm in MATLAB. For the vowels /a/ and /i/ with fundamental frequency at 150 Hz, concatenate all the MFCC features of each frame into one matrix and perform PCA with 2 principal components. (You can use built-in pca() function in MATLAB.) Then perform kmeans clustering to 2-dimensional projections of these vowels. Plot 2-dimensional projections, and their cluster centers on the same figure.