EE679: Computing Assignment 2 Due date: Sep 28, 2016

Linear predictive analysis

Make a single document presenting each question followed by the corresponding solution (method, code fragment, plots, discussion). You may use Python or Scilab.

A. Synthesized vowel: Consider the synthesized vowel /a/ (formants: 730, 1090, 2440 Hz; bandwidths: 50 Hz) at two fundamental frequencies: 120 Hz, 300 Hz. Sampling rate = 8 kHz. Using a 30 ms Hamming window, implement LP analysis on a single segment using LP orders 2, 4, 6, 8, 10 using the Levinson algorithm. Compute the gain, and plot the LP spectrum magnitude (i.e. the dB magnitude frequency response of the estimated all-pole filter) for each order "p". Superimpose each plot on the original 6-pole spectral envelope with the discrete harmonic components shown with vertical lines. Comment on the characteristics of the spectral approximations of different orders.

B. Natural speech: Consider the speech signal in "machali.wav" (male voice), sampled at 8 kHz. Consider the following signal segments in the final word "pani": (1) /a/ (first half); (2) /n/; (3) /I/; and (4) /s/ in the word "uska".

Use PRAAT to extract the above segments to separate .wav files for further analyses as below. (Note: for /s/, 16 kHz sampled audio is better.)

1. Compute and plot the narrowband spectrum using a Hamming window of duration = 30 ms before and after pre-emphasis.

2. Using a 30 ms Hamming window centered in the segment of the waveform (pre-emphasised for the voiced sounds):

(a) Compute the autocorrelation coefficients required for LPC calculation at various p = 4,6,8,10,12,20. Use the Levinson algorithm to compute the LP coefficients from the autocorrelation coefficients. Show the pole-zero plots of the estimated all-pole filter for p=6,10.

(b) Compute the gain and plot the LPC spectrum magnitude (i.e. the dB magnitude frequency response of the estimated all-pole filter) for each order "p". Superimpose each plot on the narrowband dB magnitude spectrum of part 1 (after pre-emphasis). Comment on the characteristics of the spectra.

(c) Plot error signal energy (i.e. square of gain) vs p.

3. Based on the 10th-order LPCs, carry out the inverse filtering of the /a/ vowel segment and of the unvoiced sound /s/. Obtain the residual error signal in each case. Can you measure the pitch period of the voiced sound from the residual waveform? Use the acf to detect the pitch. Plot the magnitude spectrum of each of the residual signals.