EE 627 - Speech Signal Processing

Assignment # 5

1. Prove that for a LPC model described by $Q(z) = 1 - a_1 z^{-1} - a_2 z^{-2} - \ldots\ldots - a_n z^{-n}$, The poles migrate towards the unit circle as $a_n \rightarrow \infty$. Sketch the same on the unit circle.

2. Show that the phase derivative $\angle X(\omega)$ of the Fourier transform $X(\omega)$ of a sequence $x[n]$ can be obtained through the real and imaginary parts of $X(\omega)$, X_r (w)and X_i (w), respectively, as

$$\angle X(\omega) = \frac{X_r(\omega)\bar{X}_i(\omega) - X_i(\omega)\bar{X}_r(\omega)}{|X(\omega)|^2}$$

Where $|X(\omega)|$, the Fourier transform magnitude of $x[n]$, is assumed non-zero.

3. (MATLAB) In this problem, you use the speech waveform *speech1_10k* (at 10000samples/s) in the workspace *ex6Ml.mat*. The exercise works through a problem in homomorphic deconvolution, leading to the method of homomorphic prediction.

a)Window *speech1_10k* with a 25-ms Hamming window. Using a 1024-point FFT, compute the real cepstrum of the windowed signal and plot. For a clear view of the real cepstrum, set the first cepstral value to zero (which is the DC component of the log-spectral magnitude) and plot only the first 256 cepstral values.

b) Estimate the pitch period (in samples and in milliseconds) from the real cepstrum by locating a distinct peak in the quefrency region.

c) Extract the first 50 low-quefrency real cepstral values using a lifter of the form

$$l[n] = \begin{cases} 1, & n = 0 \\ 2, & 1 \leq n \leq 49 \\ 0, & \text{otherwise} \end{cases}$$

Then Fourier transform (using a 1024-point FFT) and plot the first 512 samples of the resulting log-magnitude and phase.

d) Compute and plot the minimum-phase impulse response using your result from part (c). Plot just the first 200 samples to obtain a clear view. Does the impulse response resemble one period of the original waveform? If not, then why not?

e) Use your estimate of the pitch period (in samples) from part (b) to form a periodic unit sample train, thus simulating an ideal glottal pulse train. Make the length of the pulse train 4 pitch periods. Convolve this pulse train with your (200-sample) impulse response estimate from part (d) and plot. You have now synthesized a minimum-phase counterpart to the (possibly mixed-phase) vowel *speech1_10k*. What are the differences between your construction and the original waveform?