PS #2 , Spring 2015
Signal Processing Using MATLAB, ECE-495/595
Instructor: Balu Santhanam
Date Assigned: 02/03/2015
Date Due: 02/12/2015

In class, we covered MATLAB functions from the statistics toolbox. In this assignment, we will specifically look at the use of some of these functions specifically in the context of sinusoidal frequency estimation.

Generate Noisy Sinusoid

Generate L-samples of a noisy sinusoid using the built-in MATLAB function `awgn.m` at a SNR of 30 dB. The frequency of the sinusoid is $\omega_c = \frac{\pi}{3}$. Plot the noisy sinusoid along with the noise-free sinusoid. Distinguish between the two using appropriate line-types. Plot the histogram of the noisy sinusoid using the command `hist.m`

DFT Based Estimation

Using a FFT of size N and the function `fft.m` calculate the location of the spectral peak. The location of the peak in radians is given:

$$\omega_p = \frac{2\pi}{N} k_p.$$

Plot the absolute error between the estimated frequency from the actual in dB versus SNR for different FFT sizes $N = 256, 512, 1024$.

Subspace Frequency Estimation

Using the function `xcorr.m` calculate the *autocorrelation function* (ACF) of the noisy sinusoid. Plot this ACF. Subspace frequency estimation is done using the following procedure:

1. Compute the autocorrelation matrix of the noisy sinusoid using the function `corrmtx.m` for a specified covariance window size.
2. Using the eigenvalue decomposition function `evd.m` compute a matrix of eigenvalues $\mathbf{D}$ and eigenvectors $\mathbf{V}$.
3. Using the eiggenvector $\mathbf{v}_{\min}$ corresponding the smallest eigenvalue compute the function:
$$\hat{P}_{xx}(e^{j\omega}) = \frac{1}{|\mathbf{e}^H \mathbf{v}_{\min}|^2},$$

where $\mathbf{e}$ is the Fourier frequency vector. Accomplish this by taking the N-pt FFT of sequence $\mathbf{v}_{\min}$.

4. The location of the peak of this function gives us the subspace frequency estimate.

Repeat what was done for the DFT exercise for different SNR's and for the four different FFT sizes. Compare the errors for the DFT approach to the subspace approach for different SNR's.