EEL 6504

HMW # 2
Due Sept 22, 2015
Problem I

An "unknown" plant has transfer function $H(z) = \frac{1 - z^{-10}}{1 - z^{-1}}$ and its output is added with white Gaussian noise of power N=0.1. The input to the plant is alpha stable noise with α=1.5 . To generate this noise use the characteristic function $\varphi(t) = \exp(-\gamma|t|^{\alpha})$ with α=1.8 and choose γ=1. Generate 10,000 samples of the alpha stable noise as well as the white Gaussian noise. Take the autocorrelation and PSD to confirm input and output.

The user has only access to the noisy output of the plant and to its input. The goal of this problem is to design a Wiener filter to identify the unknown plant transfer function. You can NOT use the fact that you know the plant to design the Wiener filter, but you can use this knowledge to evaluate and interpret the solution obtained. Use the normalized MSE as the quality of the identification (normalize by the power of the input, since the desired is noisy). I suggest that you use filters of order 5, 15 and 30, and windows of size 100, 500, 1000 samples to estimate the autocorrelation function and cross correlation vector. Compare the accuracy of the system identification by computing the weighted error power. $WSNR = 10\log\left(\frac{\mathbf{w}^{*T}\mathbf{w}^{*}}{(\mathbf{w}^{*} - \mathbf{w}(n))^{T}(\mathbf{w}^{*} - \mathbf{w}(n))}\right)$. Here w* is the optimal weight vector that you know because I supplied the unknown system (you have to think on how to size w*) Compute the Wiener filter in different windows of the input (you have 10,000 samples), and conclude if you need this procedure or not (i.e. just one window suffices). Show the effect of increasing the noise N (N=0.3, 1.5) from your experiments. Explain what you observe.

Problem II

In the CNEL website you will find a time series called speech 1. This file contains a spoken sentence "We were away a year ago" sampled at 10 KHz, 12 bits A/D. The purpose here is also to compare the quality of Wiener predictors in this time series. The difficulty is that speech is nonstationary!

I would like you to study the effect of the window size and of the filter length in the quality of the prediction. Normalize the error power by the input signal power and use this measure to compare the different predictors and windows. I suggest that you use filters of order 6 and 15, and windows of size 100, 200, 500 samples.