Project 1 Generating AWGN

I. Objectives

1. Get familiar with the programming of Matlab.
2. Learn to generate AWGN with different power.
3. Analyze the statistical properties of AWGN

II. Questions

Write the mathematical expressions of the pdf, autocorrelation function, and PSD of AWGN with variance σ^2.

III. Procedures

A. Generation of Gaussian distributed RVs.

The Matlab command randn(m,n) will generate an m x n matrix, with each element being Gaussian distributed with 0 mean and variance 1.

1. If X is Gaussian distributed, then Y = a*X+b is also Gaussian distributed. Assume $X \sim N(0,1)$, find the mean and variance of Y.
2. Use Matlab generate a size 1 x 100,000 vector with elements being Gaussian distributed with 0 mean and variance 1.
3. Use the command mean(A) to evaluate the mean of the RV, where A is the vector containing the generated RV.
4. Based on the definition of variance, write your own function to find the variance of the generated RV, and save it in varnew.m (use "help function" to get more information about write your own function). The input of the function is a random vector, and the output is the variance of the vector.
5. Evaluate the variance with your new function.
6. By using the result given in Step 1, generate a size 1 x 100,000 vector with elements being Gaussian distributed with mean 3 and variance 4.
7. Evaluate the mean and variance of the generated samples.
8. Use the function [y, x] = pdf(A) (the function pdf.m can be downloaded from the course website) to evaluate the empirical pdf of the random valriables in A. Plot the pdf with x being the x-axis and y being the y-axis.
9. In the same figure, plot the theoretical value of the pdf by using the Gaussian pdf equation. The empirical pdf and theoretical pdf should match very well.
10. Repeat the Step 6 – 9 by generating Gaussian RVs with mean 3 and variance 1. What is the impact of variance on the shape of the pdf?
11. Repeat Step 6 – 9 by generating Gaussian RVs with mean 0 and variance 4. What is the impact of mean on the shape of the pdf?

B. Time domain correlation

We are going to evaluate the autocorrelation function of the random process generated by the Matlab command randn( ).

1. Generate a size 1 x 10,000 vector with elements being Gaussian distributed with mean 0 and variance 1. Store the process in a vector h.
2. Find the normalized time domain correlation function by using the command corr_mat(1, :) = xcorr(h)/10000. The time domain autocorrelation information is stored in the 1st row of the matrix corr_mat.
3. Use for loop, repeat the above two steps 100 times to generate 100 Gaussian processes. For the kth loop, the correlation information is stored in the kth row of corr_mat.
4. Evaluate the ensemble average of the auto-correlation function by averaging over the 100 auto-correlation functions stored in corr_mat. The ensemble average is an approximation of the actual correlation function of the Gaussian process.
5. Plot the averaged auto-correlation function. Compare it with the auto-correlation function of AWGN. What do you observe?
6. Perform fast Fourier transform (Matlab function: fft) over the averaged auto-correlation function renders an approximate of the PSD of the Gaussian process. Compare it with the PSD of AWGN. What do you observe?

7. Based on the above analysis, explain how to generate 1000 AWGN samples with variance 0.5 using Matlab.