MATLAB Assignment 9

Spring 2017, Section A

In this assignment, you will perform some simple simulations and make observations on them. The assignment should be submitted to so@cooper.edu by May 3, 2017 . The lesson plan, which is extremely useful in helping you through this assignment, is up on my github page

1. **AWGN BPSK SNR BER**
   (a) A BPSK (binary phase shift keying) signal takes on either a value of plus or minus 1. Simulate a BPSK signal where a +1 has a probability of 0.732 and a -1 has a probability of 0.268. Create 100000 samples.

   (b) Now, generate two sets of real AWGN (additive white Gaussian noise) with 0 mean for the signal using *randn*. DO NOT USE THE AWGN FUNCTION (never use the AWGN function.) Create them so that one results in an SNR of 7 dB and one results in an SNR of -3 dB. You can think of SNR as the ratio of the power of the signal to the variance of the noise.

   (c) To prove to me, and yourself, that you generated everything correctly, create a histogram of each result. Normalize by probability. Give the histograms of the noises 50 bins each.

   (d) Now attempt to convert the noisy signal, n, back to the original signal using the decision rule: 1 if $n > 0$, -1 if $n < 0$. Find the BER (bit error rate, or, probability of error) for each SNR.

   (e) (optional) What is the theoretical BER? You can integrate the normal distribution or use *qfunc* to find this. Does it match your estimate? Can you come up with a scheme that has a better BER? See the 'MAP' section of the class notes for a hint.

2. **A random walk in the park**
   You can think of a random walk as a running (cumulative) sum of i.i.d. random variables. In this case we will study a random walk with the property: The next value in the series is the last value plus or minus one with a 50% chance. Begin with initial value zero.

   (a) Generate 50 random walks with the properties described above.

   (b) Plot the random walks you generated

   (c) Now plot a random walk for when the probability of +1 is 75% and the probability of -1 is 25% . What is the difference between this plot and the previous plot?

   (d) It turns out, the PMF of the sum of two random variables is the convolution of their PMF's. A random walk is a repeated summation of random variables, and thus repeated convolutions of their PMF's, how is this represented in the Z-domain? (Not Laplace, since we are dealing with PMF's and not PDF's).

(e) (optional) What is the PMF of the thing we are adding each step? What is it's Z transform (symbolically)? Using the previous part, what is the Z transform of random walk at time step n (symbolically)? Using this, you COULD use the inverse z transform to find the PMF of the random walk at any given time, but I won't ask you to.

(f) (optional) Initialize an array of zeros (101 x 100) called P. Set P(51,1) to 1 (this represents an initial condition with probability 1). Now, in a for loop, calculate the P(:,n) by convolving P(:,n-1) with the PMF. Make sure to use the 'same' option for *conv*, and get the ordering right.

(g) (optional) Use *imagesc* to show an image representation of the PMF. Overlay the plots of your random walk - you will have to add 50 to center it properly. Do the results match approximately match?