ECE 421 Project 1

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Plots for Part B

σ = .01



σ = .1



σ = 1



Code for B)

%% Project 1 problem 2.65 b)

% x(n) = [1,1,1,1,1,-1,-1,1,1,-1,1,-1,1]; n = [0:199];

% v(n)= Random Gaussian sequence with zero mean and

% standard deviation sigma = .01

% y(n)= .9\*x(n-20)+v(n)

k = 0:199;

x = [1,1,1,1,1,-1,-1,1,1,-1,1,-1,1]; n = 0:199;

x(13:200) = 0;

% plot x(n)

subplot(4,1,1)

plot(k,x);title('Barker Sequence');

xlabel('n');ylabel('x(n)');

axis([0,200,-3,3]);

%autocorrelation of x(n)

R = xcorr(x);

subplot(4,1,2)

plot(R); title('Autocorrelation of the Barker Sequence');

xlabel('l');ylabel('R\_x\_x(l)');

xlim([200-29 200+29]);

% calculate y(n)

X = circshift(x,[0,20]);

sigmasquared = .01;

v = sqrt(sigmasquared).\*normrnd(0,1,[1,200]);

y = .9.\*X + v;

% plot y(n)

subplot(4,1,3)

plot(k,y);title('Received Signal, y(t)')

xlabel('n');ylabel('y(n)');

axis([0,200,-3,3]);

%Cross-Correlation of Barker Sequence and output signal, y(t)

z = xcorr(x,y);

subplot(4,1,4)

plot(z); title('Cross-Correlation of Input, x(n), and Output, y(t)');

xlabel('l');

ylabel('R\_x\_y(l)');

xlim([180-29 209]);

Plots for Part E

σ = .01



σ = .1



σ = 1



Code for E:

%% Project 1 problem 2.65 e)

% x(n) = [-1,-1,-1,1,1,1,1,-1,1,-1,1,1,-1,-1,1]; n = [0:199];

% v(n)= Random Gaussian sequence with zero mean and

% standard deviation sigma = .01

% y(n)= .9\*x(n-20)+v(n)

k = 0:199;

x = [-1,-1,-1,1,1,1,1,-1,1,-1,1,1,-1,-1,1]; n = 0:199;

x(15:200) = 0;

% plot x(n)

subplot(4,1,1)

plot(k,x);title('x(n)');

xlabel('n');ylabel('x(n)');

axis([0,200,-3,3]);

%autocorrelation of x(n)

subplot(4,1,2)

plot(R); title('Autocorrelation of the x(n)');

xlabel('l');ylabel('R\_x\_x(l)');

xlim([200-29 200+29]);

% calculate y(n)

X = circshift(x,[0,20]);

sigmasquared = 1;

v = sqrt(sigmasquared).\*normrnd(0,1,[1,200]);

y = .9.\*X + v;

% plot y(n)

subplot(4,1,3)

plot(k,y);title('Received Signal, y(t)')

xlabel('n');ylabel('y(n)');

axis([0,200,-3,3]);

%Cross-Correlation of Barker Sequence and output signal, y(t)

z = xcorr(x,y);

length(z)

subplot(4,1,4)

plot(z); title('Cross-Correlation of Input,x(n), and Output, y(t)');

xlabel('l');

ylabel('R\_x\_y(l)');

xlim([180-29 209]);

Plots for Part F

σ = .01



σ = .1



σ = 1



Code for F:

%% Project 1 problem 2.65 f)

% Generate Sequence x(n)

x(1:150) = zeros(1,150);

x(1:7) = [1,0,0,0,0,0,0];

for i = 1:128

x(i+7) = mod(x(i)+x(i+6),2);

end

for k = 1:150

if(x(k) == 0)

x(k) = -1;

else

x(k) = 1;

end

end

x = x(2:128);

n = 0:199;

x(127:200) = 0;

% plot x(n)

subplot(4,1,1)

plot(n,x);title('x(n)');

xlabel('n');ylabel('x(n)');

axis([0,200,-3,3]);

%autocorrelation of x(n)

R = xcorr(x);

subplot(4,1,2)

plot(R); title('Autocorrelation of the x(n)');

xlabel('l');ylabel('R\_x\_x(l)');

xlim([200-29 200+29]);

% calculate y(n)

X = circshift(x,[0,20]);

sigmasquared = 1;

v = sqrt(sigmasquared).\*normrnd(0,1,[1,200]);

y = .9.\*X + v;

% plot y(n)

subplot(4,1,3)

plot(n,y);title('Received Signal, y(t)')

xlabel('n');ylabel('y(n)');

axis([0,200,-3,3]);

%Cross-Correlation of Barker Sequence and output signal, y(t)

z = xcorr(x,y);

length(z)

subplot(4,1,4)

plot(z); title('Cross-Correlation of Input,x(n), and Output, y(t)');

xlabel('l');

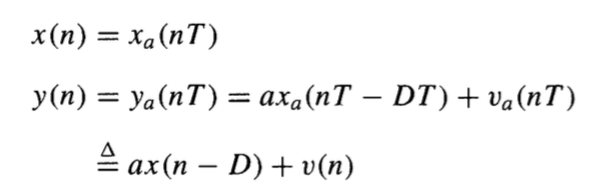
ylabel('R\_x\_y(l)');

xlim([180-29 209]);

Discussion Section

a) Each of the three autocorrelations have a main spike in the middle, which is the energy of the signal, and reflect across the y axis. As the shift gets farther away from from zero, the values of the autocorrelation get closer and closer to zero. Eventually, the values will become zero because the signals will reach a point where the shifted signal and the original signal are no longer overlapping.

b) The delay can be estimated by the shift in the center spike of the autocorrelation in the cross-correlation plot. Because the shift in time is the same for both the cross-correlation and the autocorrelation, the shift can be estimated by measuring the shift in the plot. Using the equations below, you can calculate D. This shift will be the shifted value in the cross-correlation.



c) These three sequences were chosen because one can clearly see how increasing the amount of Gaussian noise in each of them changes the output of the signal. These sequences closely model polar modulated signals, which are seen in most communication systems; an application of digital signal processing.

d) i) As the noise variance increases, the accuracy of the estimations goes down.

ii) The first sequence would be able to detect the shift the best because there are less changes in the values in the sequence. In the plot of y(n) with σ = 1, you can clearly see a large spike located at n = 20. Notice how in the other two 2 sequences (e and f), this determination cannot be seen and is drowned out by the Gaussian noise. Because of this, you can estimate the shift to be 20, which it is.

e) This project allowed us to take a real world signal processing method, polar modulation, and see applications of how white Gaussian noise can affect the output of the signal. Because noise is always present in communication systems, filters need to be designed in order to get rid of the noise and be left with a closely modeled reconstructed signal.