Computer Assignment (CA) No. 5:
COVariance and COrrelation

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ECE 3512: Signals – Continuous and Discrete

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# Problem Statement

This computer assignment we would be dealing with covariance and correlation. In the first part of the assignment, we would needs to define a vector, **x**, of length 240 (30 m sec) that contains the 240 samples of the signal starting at t = 0.9 secs. And we would also need to define a second vector, **y**, which also represents 240 samples, but consists of samples shifted by k samples. We would then needs to plot the statistical correlation between **x** and **y** for k = 0, 1, ..., 512 and repeat this for t = 3.0 secs. Compare the two functions and relate them to properties of the audio signal.

For the second part of the assignment, again, start at t = 0.9 secs. Take the first 16 samples as a vector: **x** = [x1 x2 x3 ... x16]. Compute the covariance matrix using 240 samples. Each element in the matrix is governed by the equation:



Where i is defined over the range [0, 15] and j is defined over the range [0, 15]. Do this for t = 1.1 secs and t = 3.0 secs. Compare the two matrixes and explain why they are different.

# Approach and Results

# MATLAB Code

clear; clc; close all;

%open the raw speech data file and store its values in a vector fn

fp=fopen('rec\_01\_speech.raw', 'r');

fn=fread(fp,inf,'int16');

fclose(fp);

L\_speech = length(fn);

%Sample Frequency

fs = 8000;

%find the min/max val, mean, median, and variance

fn\_min = min(fn);

fn\_max = max(fn);

fn\_mean = mean(fn);

fn\_median = median(fn);

fn\_var = var(fn);

%Print our findings

out = sprintf('Speech data: min = %f, max = %f, mean = %f, median = %f, variance = %f\n'...

 , fn\_min, fn\_max, fn\_mean, fn\_median, fn\_var);

disp(out);

L\_speech = length(fn);

timeL = L\_speech/fs;

%find the length of our signal given our sample frequency

t= linspace(0, timeL,L\_speech);

figure('name','[ECE 3522] Class Assignment [5]');

plot(t, fn);

title('Non-shifted portion of the signal (240 Samples)');

xlabel('time (secs)');

ylabel('Amplitude');

xlim([0.9+60/fs 0.9+(240+60)/fs]);

%Define starting points

t\_window1 = 0.9;

t\_window2 = 3.0;

t\_window3 = 1.1;

s\_window1 = t\_window1\*fs;

s\_window2 = t\_window2\*fs;

s\_window3 = t\_window3\*fs;

%Define window size

xL = 239;

yL = 239;

kL = 512;

%Define index variable

i = 1;

%Find correlation at 0.9secs

for k = 1:kL

 xSam = fn(s\_window1:s\_window1+xL);

 ySam = fn(s\_window1+k+1:s\_window1+xL+k+1);

%Find correlation Coefficient.

 temp = corrcoef(xSam, ySam);

 corCoeff1(i) = temp(2,1);

 i=i+1;

end

k = linspace(0,kL,i-1);

figure('name','[ECE 3522] Class Assignment [5]');

plot(corCoeff1);

title(sprintf('Correlation for t = %0.1f secs', t\_window1));

xlabel('K shift');

ylabel('Correlation Coeff');

ylim([-1 1]);

%Reset index

i = 1;

%Find correlation at 3.0secs

for k = 1:kL

 xSam = fn(s\_window2:s\_window2+xL);

 ySam = fn(s\_window2+k+1:s\_window2+xL+k+1);

 %Find correlation Coefficient.

 temp = corrcoef(xSam, ySam);

 corCoeff2(i) = temp(2,1);

 i=i+1;

end

figure('name','[ECE 3522] Class Assignment [5]');

plot(corCoeff2);

xlabel('K shift');

ylabel('Correlation Coeff');

title(sprintf('Correlation for t = %0.1f secs', t\_window2));

ylim([-1 1]);

%Part 2

%Covariance when t = 0.9secs

for i = 0:1:15

 for j = 0:1:15

 index1 = 1;

 for n = s\_window1:1:s\_window1+xL

 x1(index1) = fn(n-i)\*fn(n-j);

 index1 = index1 + 1;

 end

 coVar1(i+1, j+1) = 1/xL\*sum(x1);

 end

end

coVar1

%Covariance when t = 3.0secs

for i = 0:1:15

 for j = 0:1:15

 index1 = 1;

 for n = s\_window2:s\_window2+xL

 x2(index1) = fn(n-i)\*fn(n-j);

 index1 = index1 + 1;

 end

 coVar2(i+1, j+1) = 1/xL\*sum(x2);

 end

end

coVar2

%Covariance when t = 1.1secs

for i = 0:1:15

 for j = 0:1:15

 index1 = 1;

 for n = s\_window3:1:s\_window3+xL

 x3(index1) = fn(n-i)\*fn(n-j);

 index1 = index1 + 1;

 end

 coVar3(i+1, j+1) = 1/xL\*sum(x3);

 end

end

coVar3

# Conclusions