ECEN321 Notes on Lab 3 Noise

This document is to provide you a kick-start (i.e. more guidance), so read it together with Lab 3.

For the Labs, you need to submit an individual report, explaining what you have done and achieved in the Lab. This includes, explaining your working steps, show your Matlab results, and include your Matlab codes. Remember to plot your graph(s) properly by providing a title, labelling the axis, and showing legends (i.e. what is what on your plot). Also remember to provide commentary for your Matlab coding.

```
% This is to show you how to provide commentary for your Matlab coding.
% You will type % and followed by the comments on the right.
% An example is shown here for you:

popMean=2.5;     % this is the population mean
stdDev=4;        % this is the population standard deviation

```

The suggested time schedule for completing Lab 3 is as follows:

1st week: Part 1 and Part 2,

2nd week: Part 3,

3rd week: Part 4,

4th week: Part 5,

5th week: Write and submit the individual report.

But of course, you may proceed in your own pace and schedule within the given time frame.

Part 1 Generate a Noisy DC Signal

A noisy DC signal of 3 V (i.e. a clean DC signal of 3V added with a noise of variance $4V^2$) is to be amplified by a factor of 10. Remember that in our lecture, when a variable is multiplied by a constant, the mean and variance of the resulting new variable will be changed (but how? Go and check the lectures). Here, we use Matlab to simulate and observe this effect.

Part 2 Effect of Taking the Average

In lectures, we also learnt that by taking the average of many independent measurements, we can reduce the standard deviation (i.e. uncertainty, or error) of the resulting measurement (but how? Go and check the lectures). Here, we use Matlab to simulate and observe this effect.

Part 3 Covariance and Correlation Coefficient

Here, we generate a pure sine wave. Then create an exact copy of the sine wave, and add random noise of variance 1 to it. Now we have two copies of the sine wave – one copy is the pure sine wave, the other is a noise-corrupted sine wave.

We then look at the scatter plot of both sine waves. Then calculate (can use Matlab to calculate for you) the covariance and correlation coefficient between these two copies of waveforms. Do they resemble each other? Use the formulae of covariance and correlation coefficient we learnt in lectures.

Part 4 Quantization Error

Here, we want to measure the difference of two voltage levels (they are uniformly distributed), measured on different ranges of a volt meter (i.e one has an uncertainty of 0.001, while the other has 0.01), and this will introduce different quantization errors which is assumed to be uniformly distributed.

We introduce a new concept here:

"In probability theory, the probability distribution of the sum of two or more independent random variables is the **convolution** of their individual distributions. The term is motivated by the fact that the probability mass function or probability density function of a sum of independent random variables is the convolution of their corresponding probability mass functions or probability density functions respectively."

Since the two voltages are independent, the theoretical distribution of their difference will also be the convolution of their individual distributions and the resulting distribution will be centred on the mean which is $(V_2 – V_1)$. Hints on how to proceed with the convolution is given below:

a) Plot the (continuous) uniform distribution of V_1 (this is waveform 1).
b) Plot the (continuous) uniform distribution of V_2 (this is waveform 2).
c) Do a convolution of the above two waveforms (this is waveform 3). This will give the distribution of the difference in V_2 and V_1.
d) Centre waveform 3 on the mean of $(V_2 – V_1)$.

What we want to do next is to compare the above theoretical distribution with the distribution obtained from a simulation of 100,000 random variable. We would expect both the results to agree with each other. Hints on how to proceed with the simulation is given below:

a) Generate 100,000 random sample of voltage 1 according to the V_1.
b) Generate 100,000 random sample of voltage 2 according to the V_2.
c) For each pair of V_1 and V_2, find the difference in $(V_2 – V_1)$.
d) Produce a histogram of the difference in $(V_2 – V_1)$.
e) Remember, you need to scale the histogram to form a probability density function (pdf).
f) Compare this pdf with the (waveform 3) above, and see if they agree with each other (they should).

Part 5 Simulation of the Probability Distribution of Rolling 2 Dice

This part is already quite self-explanatory within the actual Lab 3 materials, so there is not much extra hints that can be given.

Use the Matlab simulation knowledge that you have learnt thus far to finish this part.

~*~ *End of notes* ~*~