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EE 214 Module 2
Lab Exercise 3: Random Variables

General Instructions when submitting machine problems and lab exercises

1. Answers to the questions and additional discussion must be in the form of a written report and submitted in PDF format.
2. Your MATLAB scripts should be executable from the command line with no additional user inputs.
3. Include comments in your code to make your code more understandable
4. Use variable names that are meaningful to make your code more readable
5. Submit all the necessary files (pdf document, m-files, output images) as a zipped file using the following naming convention: **surname_nickname_EE214-LabXX_EE214.zip**
6. Submit the zip file through the UVLe submission bin

I. Gaussian Random Variable

Let us start by generating a Gaussian distribution in MATLAB. Let us start with a Gaussian (also called normal) distribution with mean, μ=10, and standard deviation, σ=5, using the *makedist* command.

```
clear; close all; clc;

% Generate a Gaussian distribution with mean = 10 and stdev = 5
gaussdist = makedist('normal','mu',10,'sigma', 5);
x = -10:0.1:30;
pdf1 = pdf(gaussdist,x);
cdf1 = cdf(gaussdist,x);
```

Now let us generate N = 10000 samples from the distribution we just created using the *random* command.

```
N = 10000;
samples1 = random(gaussdist,N,4);
% Plot the samples
figure; title('Sampling distribution');
histogram(samples1(:,1),50,'Normalization','pdf');
hold on; plot(x,pdf1,'r');
```

Discussion:

1. Plot the pdf and cdf we just generated. Is this consistent with your expectation of a Gaussian random variable?
2. Plot the histogram of all 4 samples. Compute (using MATLAB) for the mean and standard deviation of each of the 4 samples. How do they compare with out original distribution? Draw some conclusions.

II. Binary Symmetric Channel

Let us now go back to the binary symmetric communications channel with some channel noise, as we did in the previous lab exercise. Instead of defining the probability of error, we model the noise as an additive white gaussian noise (AWGN) with mean of 0 standard deviation of 1. Assume the transmitter sends 1V for logic '1' and 0V for logic '0'. The received signal then becomes the sum of the transmitted signal and the AWGN. At the receiver end, a signal less than 0.5V is decoded as logic '0' and any signal greater than 0.5V is interpreted as a logic '1'.

Exercise:

1. (Hand calculation) Calculate the following probabilities:
    a. conditional probabilities: P(received '1'| transmitted '1'), P(received '0'| transmitted '1'), P(received '1'| transmitted '0') and P(received '0'| transmitted '0')
    b. posteriori probabilities based on Bayes theorem: P(transmitted '1'| received '1'), P(transmitted '0'| received '1'), P(transmitted '1'| received '0') and P(transmitted '0'| received '0')
    c. P(received '0'), P(received '1')
2. (MATLAB) Model the system with N=1,000 input bits (equal probability of 0 and 1). Compare the value of the probabilities with those in your calculations. Repeat the process for N=10,000. Draw some conclusions.

III. Queuing Theory

Queuing theory is the analysis of waiting lines in queues. The elements of a queue are (1) the arrivals that need some kind of service; (2) the service facilities that take care of the arrivals; and (3) the queue itself, where the arrivals wait until they are serviced. Consider, for example, a triage queue. The number of patients waiting to be serviced at a given time period can be modeled using a Poisson distribution, X. The pmf of X is

$$p(x; \mu) = \frac{e^{-\mu} \cdot \mu^x}{x!} \qquad x = 0, 1, 2, 3, \ldots$$

where μ is the average number of patients waiting in the queue (note that in MATLAB this parameter is lambda).

Discussion:

1. Plot the pmf and cdf the distribution for different values of μ. Draw some conclusions.
2. If $\mu = 2$, what is the probability that there is exactly 1 patient in queue? What is the probability that there would be at least 3 in queue?

Now that you have completed this exercise, you can now answer the LabEx3Quiz. Note that you will need your answers to this exercise for this quiz.