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EE 214 Module 1
Lab Exercise 2: Binary Communications Channel

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. Binary Symmetric Channel

This lab exercise models a binary communications channel with some channel noise. Let us start with a binary symmetric channel (BSC). First, we assume that the probability of generating a '0' and '1' at the transmitter side is equally likely. Second, we assume that the communication channel is symmetric, that is, the probability (p) of the channel making an error in the transmission is the same whether the transmitted symbol is '0' or '1', as shown in Figure 1 below.

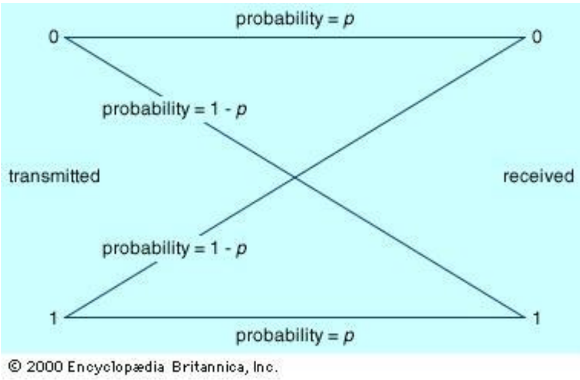

Figure 1. BSC

Let us assume that the probability of channel error is (1-p) = 0.05, and the probability of successful transmission p = 0.95.

Exercise:

1. (Hand calculation) Calculate the following probabilities:
   a. P(received '1') and P(received '0')
   b. conditional probabilities: P(received '1'| transmitted '1'), P(received '0'| transmitted '1'), P(received '1'| transmitted '0') and P(received '0'| transmitted '0')

c. 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’)

Now let us simulate this in MATLAB. Start by generating N=100 bits of input data with equal probability of being a ‘0’ or a ‘1’. Use the function rand() to generate a uniformly distributed random variable. From the uniform RV, we can set the transmit bit to ‘0’ if the random value is less 0.5 and ‘1’ otherwise.

```
clear; close all;
N = 100;
% generate equally likely bits
tx = rand(1,N) > 0.5;
figure; subplot(2,1,1)
stem(tx);
xlabel('Transmitted bits');
```

Next, we simulate the channel error is (1-p) = 0.05 by generating a random number and flipping the bit if the value is greater than 0.95.

```
% determine if successfully transmitted or not
ch = rand(1,N) > 0.95;
rx = xor(tx,ch);
% plot the results
subplot(2,1,2), stem(rx);
xlabel('Received bits');
```

Discussion:

1. Based on this experiment, what is the value of the probabilities P(received ‘1’) and P(received ‘0’)? How does this compare to your hand calculations?
2. Based on this experiment, compare the following probabilities with your hand calculations:
    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’)
3. Repeat the experiment for N=1,000 and N=10,000 bits. Compare the value of the probabilities with those in your calculations. Draw some conclusions.

II. Non-Symmetric Channel

Now assume the channel is non-symmetric. That is, the probability that a ‘1’ is correctly received as ‘1’ is p_1=0.95, while the probability that a ‘0’ is correctly received as ‘0’ is p_0=0.85.

Exercise:

1. (Hand calculation) Calculate the same probabilities as in the BSC
2. (MATLAB) Generate N=10,000 bits and compare the probabilities derived from the experiment with the calculated values.
3. (MATLAB) Assume the transmitter is slightly biased in generating a ‘1’ then a ‘0’ such that the probability of transmitting a ‘1’ is 0.6. What happens to the value of the probabilities? Is this expected? Explain and draw some conclusions.