Computer Projects

Project 2.1

In this project, you are to simulate a simple binary communication channel characterized by appropriate conditional and prior probabilities and estimate the probability of error as well as the probability of receiving either a 1 or a 0.

We start out with a symmetric binary communication channel characterized by the conditional probabilities $\Pr[0_R|0_S] = \Pr[1_R|1_S] = 0.975$ and $\Pr[0_R|1_S] = \Pr[1_R|0_S] = 0.025$. The prior probabilities of a 0 or a 1 are given by $\Pr[0_S] = 0.512$ and $\Pr[1_S] = 0.488$. The input to the binary communication channel is to be a sequence of 0s and 1s. Each 0 or 1 in the sequence is statistically independent of the others and is generated according to the probabilities $\Pr[0_S]$ and $\Pr[1_S]$ given above.

1. Generate the data input sequence of 0s and 1s according to the required probabilities. The size of the sequence is your choice; however, to obtain meaningful results, it should be at least 5000 points long.
2. Simulate the channel by writing a computer program to do the following:
   (a) When a 0 is presented as input to the channel, the channel should generate an output of 0 with probability $\Pr[0_R|0_S]$ and an output of 1 with probability $\Pr[1_R|0_S]$ (where these numerical values are given above).
   (b) When a 1 is presented to the channel, the channel should generate a 0 with probability $\Pr[0_R|1_S]$ and a 1 with probability $\Pr[1_R|1_S]$.
3. Compute the theoretical values for the following probabilities: $\Pr[0_S|0_R]$, $\Pr[1_S|1_R]$, and Pr[error] (see Section 2.5.1).
4. Apply the input data sequence generated in Step 1 to the channel in Step 2, estimate the probabilities in Step 3. To estimate the probability, use relative frequency; for example, to estimate $\Pr[0_S|0_R]$ you would compute

$$\frac{\#\text{ times 0 sent and 0 received}}{\#\text{ times 0 received}}$$

5. Compare the estimated values to the theoretical values. If necessary, repeat the experiment using a longer input sequence. You may also wish to compare the results for *various* length input sequences.

Repeat Steps 1 through 5 for a nonsymmetric binary communication channel with conditional probabilities $\Pr[0_R|0_S] = 0.975$, $\Pr[1_R|1_S] = 0.9579$, $\Pr[1_R|0_S] = 0.025$, $\Pr[0_R|1_S] = 0.0421$. Let the prior probabilities be $\Pr[0_S] = 0.5213$ and $\Pr[1_S] = 0.4787$.

MATLAB programming notes

You can generate a binary random number with the following statement:

```
x=rand(1)<P;
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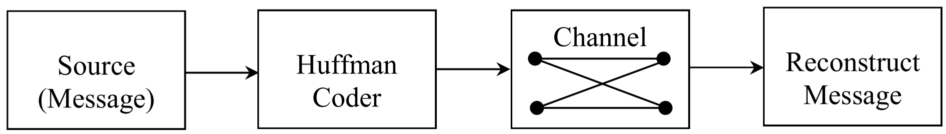
where P is the desired probability of a 1. Note that the expression to the right of the equal sign is a boolean expression; thus MATLAB assigns a 0 or 1 to the variable x. You can replace the argument '1' of the 'rand' function with the size of a vector or matrix and generate a whole vector or matrix of binary random numbers.

Project 2.2

The Huffman coding algorithm is described in Prob. 2.52 (above). In this project, you will measure the average information, code the given message using the Huffman algorithm, transmit the coded message over a simple binary channel, reconstruct the message, and compare the performance to that without coding. The following schematic diagram illustrates the sequence for implementing these operations.



1. Consider the following message for source coding and transmission:

   APPARENTLY NEUTRAL'S PROTEST IS THOROUGHLY DISCOUNTED AND IGNORED. ISMAN HARD HIT. BLOCKAGE ISSUE AFFECTS PRETEXT FOR EMBARGO ON BY-PRODUCTS, EJECTING SUETS AND VEGETABLE OILS.

   This message is included in the data package for this book (msg.txt).
2. Following the procedure of Section 2.5.2, determine the average information for this message. (You may ignore hyphens, spaces, and punctuation.)
3. Using the Huffman algorithm, code the above message.
4. Determine the average codeword length.
5. Transmit the codewords in binary form across the binary symmetric communication channel specified in Project 2.1.
6. Reconstruct the message from the received codewords.
7. Determine the average information of the received message. Would you expect it to be larger or smaller than that of the transmitted message?