AV332: Digital Communication Lab

Lab 9
Matched filter

Date: 19th and 20th October 2016

Please note that this experiment has to be done in MATLAB.

1 Matched filter

Prelab assignments

1. Study baseband digital transmission using bi-polar NRZ coding. Pay special attention to the derivation of average bit error probability under the assumption that the sampling is done at the middle of the bit period and the noise is additive white Gaussian.
2. Study matched filtering. What is the advantage of matched filtering over the above scheme? What is the advantage in terms of the average bit error probability?

In lab tasks

1. In this task, you have to implement a baseband digital transmission system using bi-polar NRZ coding. Note that you have to implement a sampled version of the following continuous time system. Our objective is to transmit a sequence of random bits (B_n) where each B_n is Bernoulli with probability 0.5 and are mutually independent. Let N be the length of the sequence. Assume that these bits are being produced at the rate of 1 bit per second. The NRZ code uses rectangular pulses $p(t)$ of amplitude $A = 2$ and duration $T_b = 1$ second. The output from the transmitter is therefore $X(t) = \sum_n B_n p(t - nT_b)$. Assume that the receiver obtains $Y(t) = X(t) + N(t)$, where $N(t)$ is an IID Gaussian process with variance 2. The receiver samples $Y(t)$ at the middle of each bit period to obtain a sequence (Y_n). Then an estimate $\hat{B}_n$ of the transmitted bit B_n is obtained by the following decision rule

$$\hat{B}_n = \begin{cases} 0, & \text{if } Y_n \leq 0, \\ 1, & \text{if } Y_n > 0. \end{cases}$$

   Note that you can use the "IIDProcess" function from lab 8 to generate the noise process. The bit sequence (B_n) can be generated from a modification to the "IIDProcess" function. Note that the length of the bit sequence sample function is N while that of the noise would be greater than N (depends upon the rate at which you sample the continuous time process).

2. Find the average bit error probability for the above baseband system with the sequence length $N = 1000$. The average bit error probability is defined to be $\frac{\sum_{i=1}^{N} \mathbb{I}(\hat{B}_n = B_n)}{N}$. Plot how the average bit probability varies as a function of A (try finding out the average bit error probability for a few values of A).
3. Now you have to implement the digital transmission system with a matched filter at the receiver. For the pulse $p(t)$ what is the matched filter impulse response $h(t)$? For the receiver with the matched filter note that $Y(t)$ is filtered with $h(t)$ and then sampled at the end of each bit period. Suppose the sampled output of the matched filter is again denoted as Y_n. An estimate $\hat{B}_n$ of the transmitted bit is obtained using the decision rule shown above.
4. Find the average bit error probability for the baseband system with the matched filter for a sequence length of $N = 1000$. Plot the average bit probability as a function of A (use the values of A that you had used before). Compare the average bit error that you have obtained as a function of A for the cases with and without a matched filter. What do you observe?