EECS 861

Homework #11

1. Under H_0 the observed signal is N and H_1 the observed signal is 10 + N where N is a Gaussian with zero mean and a standard deviation of 4.

a. Assuming $P(H_1)= P(H_0)$=0.5 derive the MAP decision rule.

b. Find the P_D, P_M, and P_{fa} given the MAP decision rule. Verify your results using http://demonstrations.wolfram.com/SignalDetectionTheory/ in this demonstration Noise = standard deviation and the difference between the means is called discriminability.

c. Find the P_e.

2. For the parameters given in problem 1 the costs are given as C_{10}= C_{01}=3, C_{00}=0, and C_{11}=1. Find the decision rule that minimizes the average cost.

3. In a target detection problem, the target is present for 0.01 μs. When the target is not present only noise N(t) is received. N(t) is additive zero mean Gaussian WSS random process, N(t) has the following PSD

$$S_N(f) = \begin{cases} \frac{\eta}{2} = 0.25 * 10^{-9} & |f| < 2\text{ GHz} \\ 0 & elsewhere \end{cases}$$

When the target is present the received signal is Y(t)=A+ N(t) where A=1. Y(t) is sampled every 0.001 μs. One sample of Y(t) is used to detect the presence of the target.

a. Assuming P(target is present)= P(target is not present)=0.5 derive the MAP decision rule.

b. Find P_D, P_M, and P_{fa} given the MAP decision rule. Verify using http://www.ittc.ku.edu/~frost/EECS_861/Mathematica_files/Detection_example_General-Gaussian-Case.cdf

c. Design an N-P detector is to obtain a P_{fa} =0.01

d. Find P_D, P_M, and P_{fa} given the N-P detector.

4. Repeat Problem 3 part c and d using a decision variable Z where assume T=0.01μs and that you know the target is present starting at t=0 or not present starting at t=0. Z= $\frac{1}{T}\int_0^T Y(t)\,dt$

5. A digital signal X(t) has a bit rate of 500 b/s where X(t) is -A V (bit=0) or +AV (bit=1) and A=2 and bits are transmitted with equal probability. T_B is the bit duration. The transmitted signal is corrupted by additive zero mean WSS random process, where N(t) has the following PSD. The received signal is Z(t)=X(t)+N(t). Assume the receiver is in bit synchronization.

$$S_N(f) = \begin{cases} \frac{\eta}{2} = \frac{1}{1000} & |f| < 10\,000 \\ 0 & elsewhere \end{cases}$$

The decision variable, Y is given by

$$Y = \frac{1}{T_B}\int_0^{T_B} Z(t)\,dt$$

a. Find the distribution of Y|0 bit is transmitted.

b. Find the distribution of Y|1 bit is transmitted.

c. Derive the MAP decision rule.

d. Find the probability of bit error, P_e.

6. Trade-offs using system specified in Problem 3 and Problem 5.

a. Using system specified in Problem 3 will the P_D increase or decrease or stay the same as A increases with the N-P detector?

b. Using system specified in Problem 3 will the P_{fa} increase or decrease or stay the same as A increases with the N-P detector?

c. Using system specified in Problem 3 will the P_e increase or decrease as η increases in Problem 3?

d. Using system specified in Problem 5 will the P_e increase or decrease or stay the same as the bit rate increases in Problem 5?

7. Under H_1 (target present) the observed signal is A+N and under H_0 (target absent) the observed signal is N where N is a Gaussian with zero mean and a standard deviation of σ. Define S/N (dB) = $10\,\mathrm{Log}\left(A^2/\sigma^2\right)$. On the same graph plot the ROC for S/N = 0.5dB, 1.0dB, 3.0dB, 6dB. Verify your answer using http://www.ittc.ku.edu/~frost/EECS_861/Mathematica_files/ROC.cdf

8. Under H_1 (target present) the observed signal has a pdf of

$$f_{Y|H_1}(y \mid H_1) = \frac{u(y)}{5} e^{-y/5}$$

Under H_0 (target not present) the observed signal has a pdf of

$$f_{Y|H_0}(y \mid H_0) = \frac{u(y)}{2} e^{-y/2}$$

Two S.I. samples of the observed signal are collected.

a. Derive the MAP decision rule.

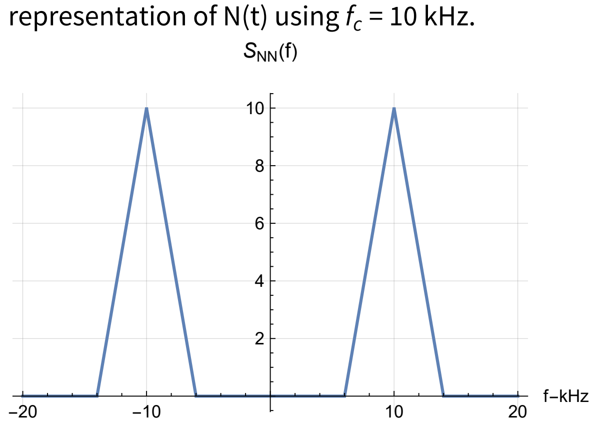
b. Find the pdf of the decision variable given H_0.

c. Find the pdf of the decision variable given H_1.

d. Find P_M

e. Find P_{fa}

9. The spectral density of a narrowband Gaussian process N(t) is shown in Below. Find the following spectral densities associated with the quadrature representation of N(t) using f_c = 10 kHz.



a. $S_{N_c N_c}$(f)

b. $S_{N_c N_s}$(f)

c. If f_c is changed to f_c=9.95 kHz, does $S_{N_c N_c}$(f), and $S_{N_c N_s}$(f) change, if so why?