# Matlab - Homework 2

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# Task 1

LS-estimates of the ellipsoid parameters  can be calculated using following expression:



where matrix  are:





From the plot of the ellipse we can conclude that the bodies will collide.

# Task2

1. Write a program to automatically set detection threshold for power samples [dBm]. This

threshold should separate the power samples into H0: noise only and H1: signal + noise.

When setting the threshold, how did you solve the problem of having signals at unknown

locations (no known noise-only samples)?

Is this PFA reasonable? Please notice that using

solution that will only work for this speci\_c dataset will give less points.

We assume that noise before passing through bandpass filter is Gaussian (thermal in nature) and it has PDF

 (1)

After passing the filter a PDF of the post-detection envelope of the noise voltage output can be shown to be

 (2)

where *R* is the amplitude of the envelope of the filter output. This distribution has the form of the Rayleigh probability density function. A false alarm occurs whenever the noise voltage exceeds a defined threshold voltage  . It can be calculated by integrating the PDF :

 (3)

Threshold expressed as a power of signal can be calculated from threshold for the voltage as:

 (4)

First we convert measured data to dBm (X in the code). We filter the data point where value is zero (Y in the code), because, and it can not be used for calculating mean value, i.e. noise floor that is also average noise power. Precisely speaking this would be average power of noise and signal, however since the frequency of the impulses in the signal is not very high and we are considering dBm scale, we can assume that this is very close to average noise power. Next, we calculate mean value for data and we find the minimum, non zero value in the data set. The difference between floor and min(Y) is maximum variance (largest deviation) of the noise. So we can set the threshold to be equal to the sum of the floor and variance (maximum value of the noise (17th line in the script). Using values of threshold, floor and equation (3) we can calculate probability of false alarm. We use floor as the theoretical value of the variance of Gaussian noise, because floor is calculated in time domain and it is corresponding to  in the pdf. Since floor value is in dBm we need to apply conversion:

 (5)

After substituting (4) and (5) in (3) we can calculate  as (line 20 in the script)

 (6)

We obtain following results:

PFA= 0.000062 ,Threshold = -78.121331 dBm , Noise Floor = -90.996007dBm

Probability of false alarm is reasonably small. The value shouldn’t be too small because probability of detection



1. Using this threshold (if you could not solve the previous problem, then you may use here

manually selected threshold like 􀀀xx dBm), plot a figure showing which samples are H1 and

which samples are H0. Does the result look reasonable?



1. Our task in signal detection is to especially detect weak signals, how should you take this into

account when setting the threshold?

1. Using a detection threshold, automatically by MATLAB estimate the signal parameters: pulse

period (after what time is the pulse again repeated?) and pulse duration (how long is each

individual pulse?). Do the estimation by taking into account all the received data and not only

for example the \_rst pulse. How accurate would you say the signal generator which generated

these signals is (does pulse period and duration stay constant)? Hint: For some parts of this

problem ready made functions such as \_ndpeaks (with appropriate input parameters) could be

helpful!. Please feel free to use your own solution also.

1. How would you handle the case of very weak signals (sometimes under noise), sketch an

algorithm. Innovative solutions will give more points!