# Lab 5:
# An Initial Exposure to mmWave Radar Sensing

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# 1 Goal of the lab:

The goal of this lab is to provide an initial exposure to the fundamentals of radar sensing, with parameters consistent with emerging mm wave sensing applications.

# 2 Laboratory assignment:

For this lab I created the function that was the result of all three targets at distances $3m$, $10m$ and $30m$, and added random noise to it.

```
y1 = A1.*exp(1j*2*pi.*f1.*t);              %First target
y2 = A2.*exp(1j*2*pi.*f2.*t);              %Second target
y3 = A3.*exp(1j*2*pi.*f3.*t);              %Third target
n = 0.5.*(randn(1,N)+1j.*randn(1,N));      %Noise

x = y1 + y2 + y3;                          %No-noise signal
X = fft(x, nfft);                          %Fourier Transform
X = abs(X);                                %Absolute Value
y = y1 + y2 + y3 + n;                      %Total signal
Y = fft(y, nfft);                          %Fourier transform
Y = abs(Y);                                %Absolute Value
```

Then I created a function to find the peaks of the signal:

```
function [peaks,peak_indices] = find_peaks(row_vector)
    A = [0 row_vector 0];
    j = 1;
    for i=1:length(A)-2
        temp=A(i:i+2);
        if(max(temp)==temp(2))
            peaks(j) = row_vector(i);

            peak_indices(j) = i;
            j = j+1;
        end
    end
end
```

I sorted them from higher to lower maintaining both X and Y axis tied together, and then picked up the first five of them.

```
for h = 1:length(peaks)-1                    %First sorting loop
    for i = 1:length(peaks)-1                %Second sorting loop
        if peaks(i)< peaks(i+1)              %Condition for sorting
            comodin = peaks(i);              %Sorting
            peaks(i) = peaks(i+1);           %Sorting
            peaks(i+1) = comodin;            %Sorting
            comodin_i = peaks_i(i);          %Sorting
            peaks_i(i) = peaks_i(i+1);       %Sorting
            peaks_i(i+1) = comodin_i;        %Sorting
        end                                  %End of contidion
    end                                      %End of second loop
end                                          %End of first loop

peaks_5 = peaks(:, 1:5);                     %5 highest peaks
peaks_i_5 = peaks_i(:, 1:5);                 %Location of 5 highest peaks

index_5 = zeros(1,5);                        %Index vector
for i = 1:5                                  %Loop
    index_5(i) = fi(peaks_i_5(1,i));         %Frequency of every peak location
end                                          %End of loop
```

Lastly, I translated these frequencies into range estimates to be able to calculate the error:

```
range = index_5./S.*c./2;                    %Range estimate

e1 = [e1 min(abs(range - R1))];              %Error for target 1
e2 = [e2 min(abs(range - R2))];              %Error for target 2
e3 = [e3 min(abs(range - R3))];              %Error for target 3
```

I did these calculations for three different SNRs:

## 2.1 $SNR = 1$

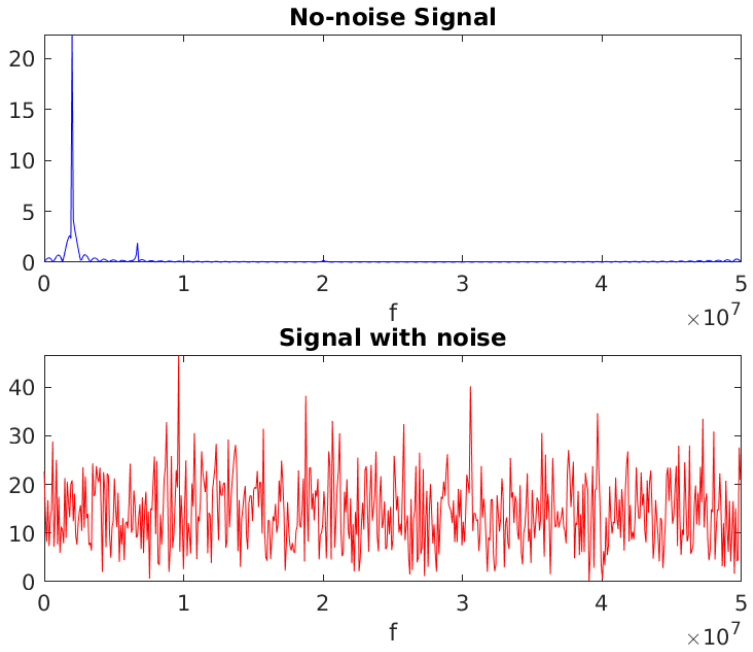


Figure 1: Resulting Signals

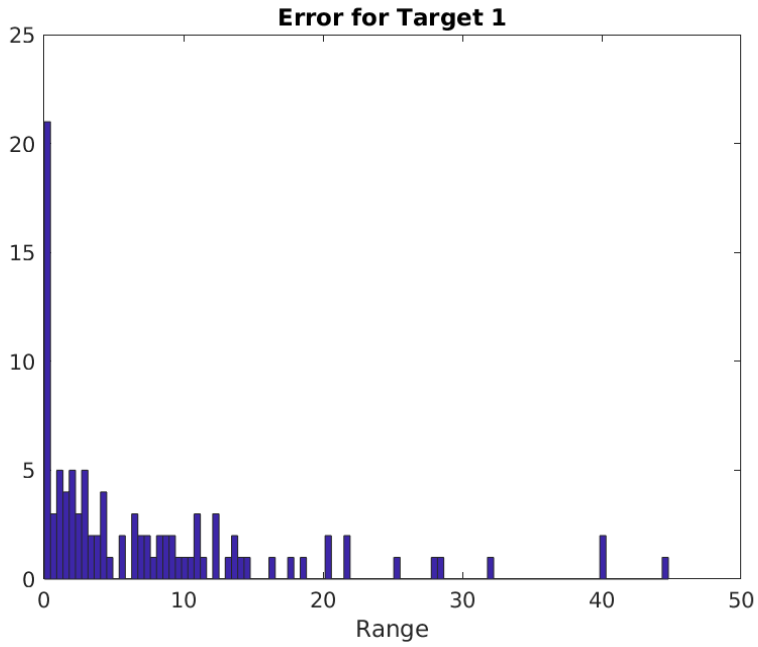


Figure 2: Histogram of the error for Target 1

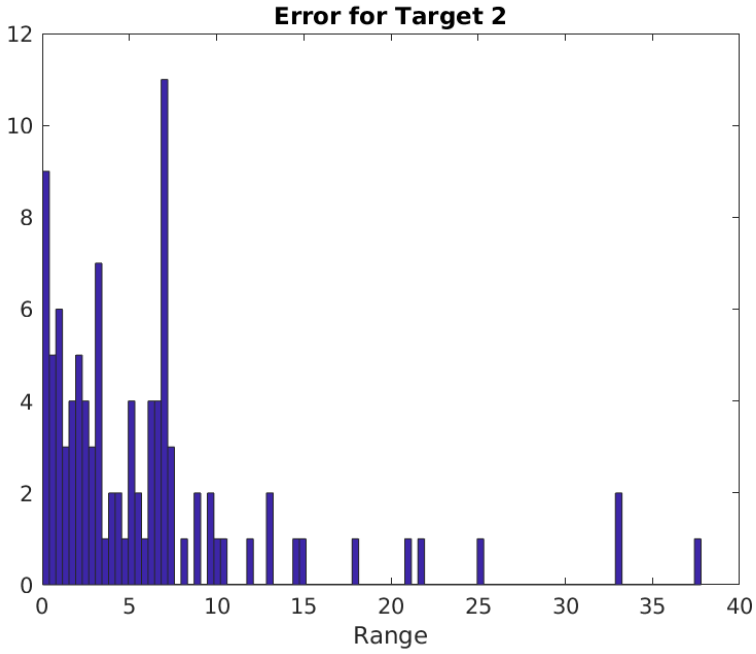


Figure 3: Histogram of the error for Target 2

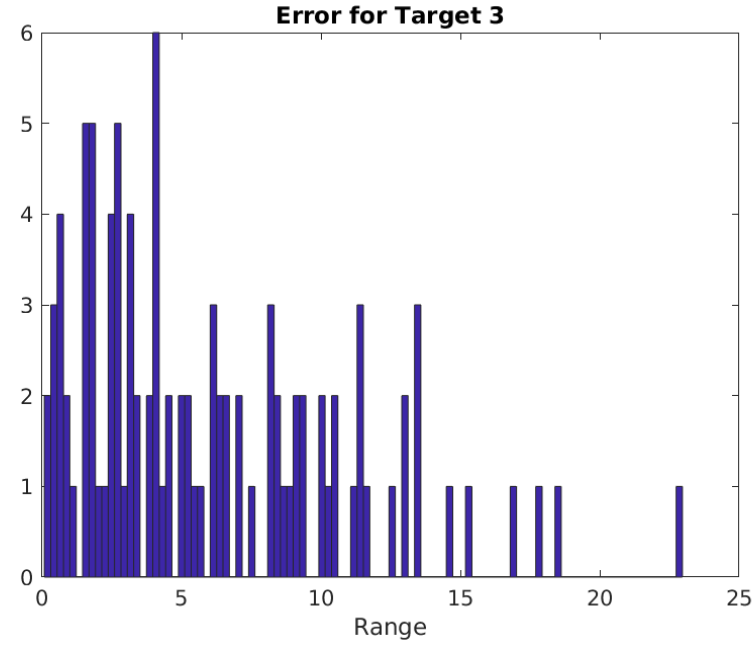


Figure 4: Histogram of the error for Target 3

## 2.2 $SNR = 10$

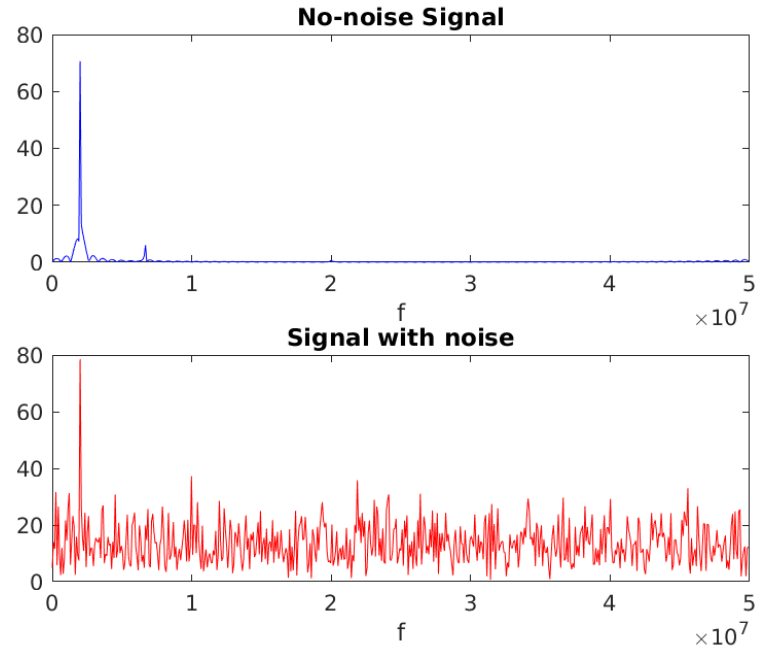


Figure 5: Resulting Signals

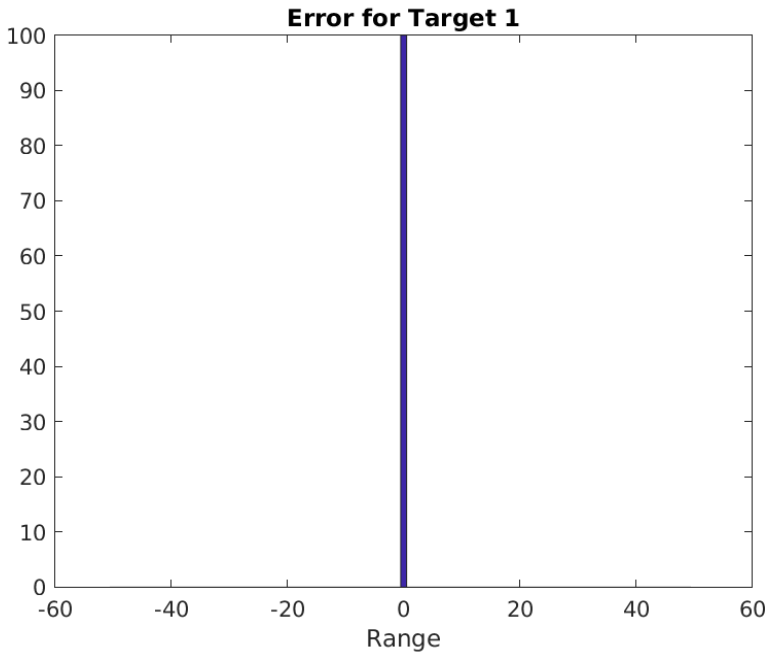


Figure 6: Histogram of the error for Target 1

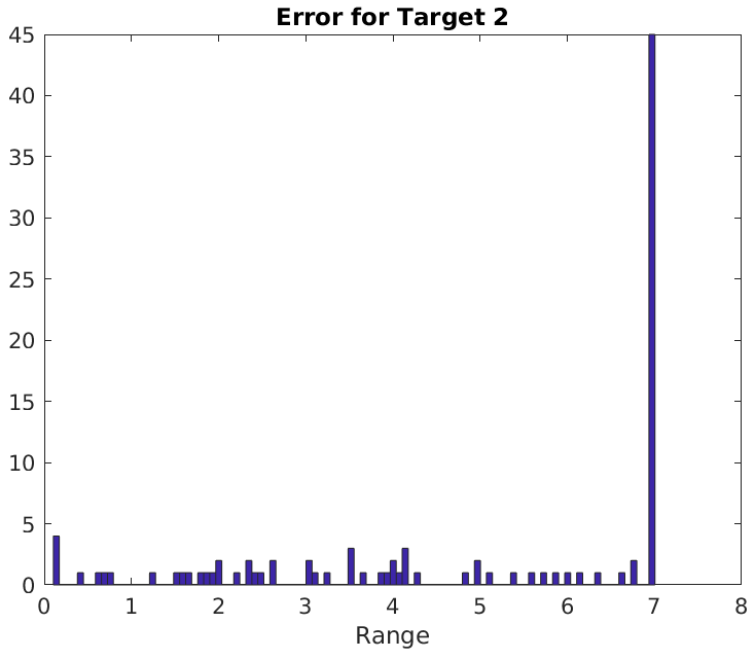


Figure 7: Histogram of the error for Target 2

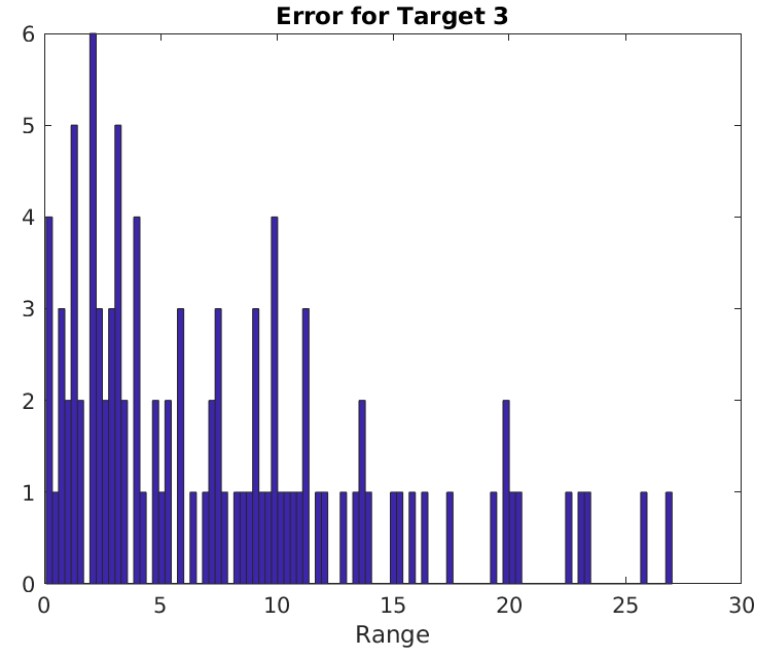


Figure 8: Histogram of the error for Target 3

### 2.3 $SNR = 50$

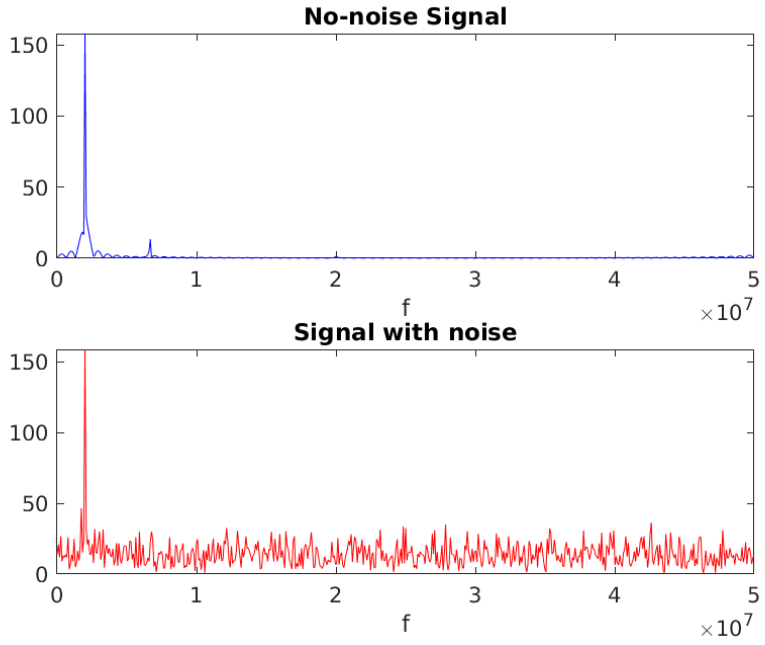


Figure 9: Resulting Signals

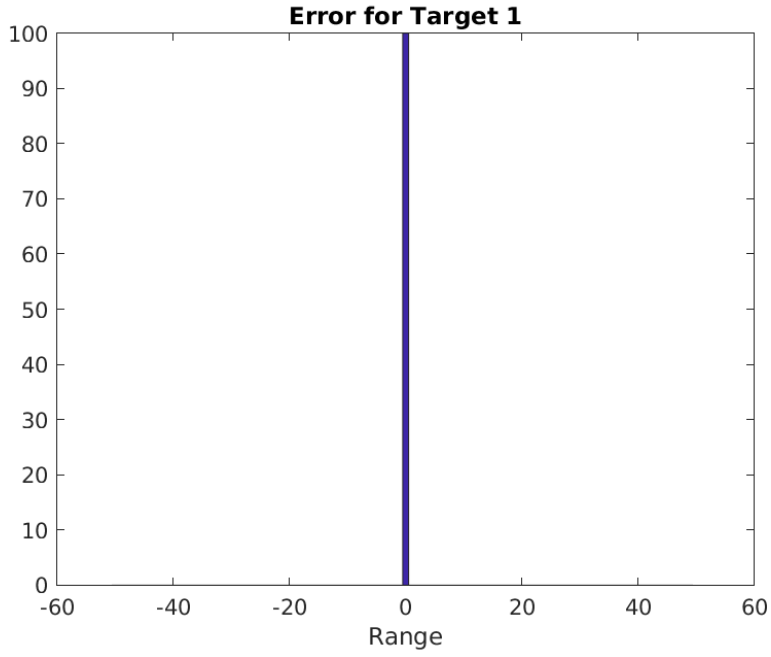


Figure 10: Histogram of the error for Target 1

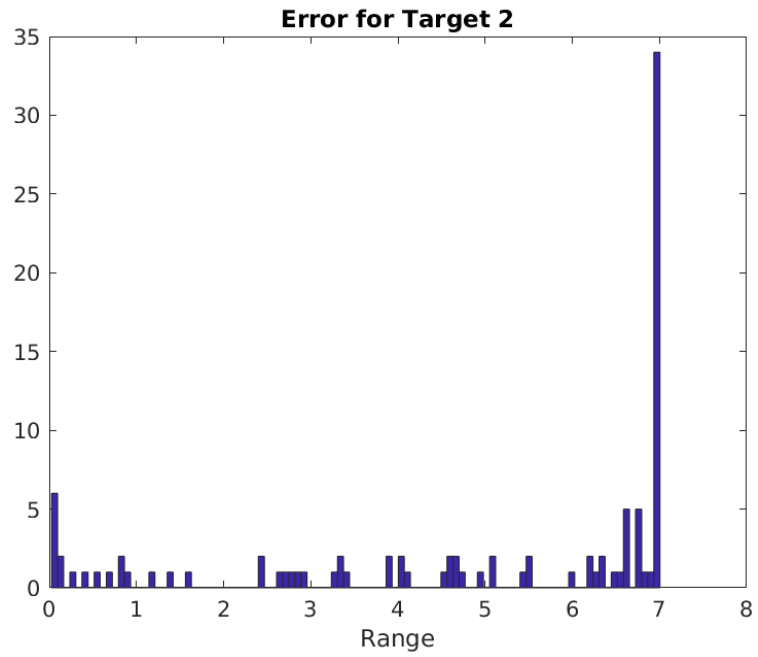


Figure 11: Histogram of the error for Target 2

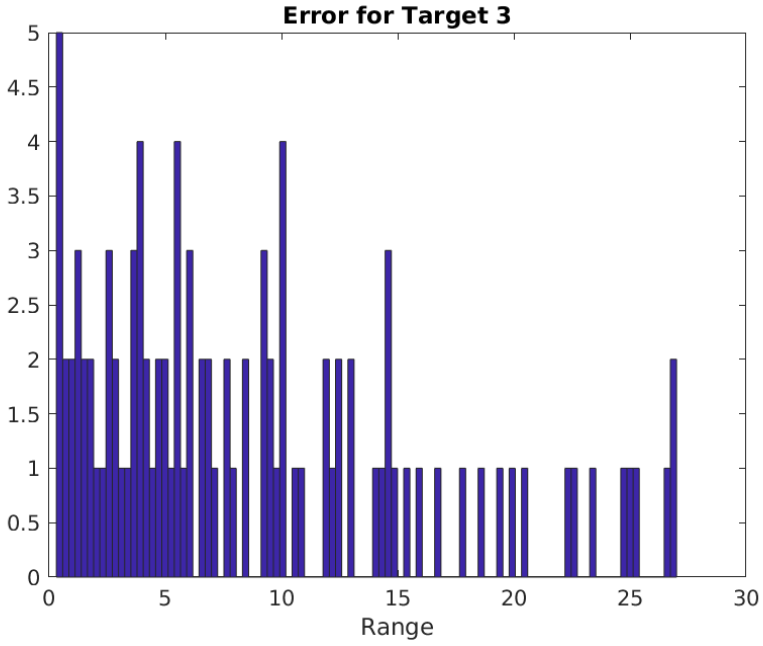


Figure 12: Histogram of the error for Target 3

## 3 Analysis:

As we can see, the error for target 1 is always smaller than for the other two targets. This is due to the fact that the distance affects the clearness of the signal squared, that is, multiplied by $\frac{1}{R^2}$. The error for target 2 is quite high for $SNR = 1$, but it gets smaller the higher our SNR is. Nevertheless, the error for target 3 is always very high compared to the other two because $30m$ is a very long distance compared to $3m$ for target 1, even if the SNR is 50.

## 4 Conclusions:

This lab was a good review of how receivers and transmitters work, and useful to work with distances and other variables that have a huge impact on the signal.
The only problem I experienced with this lab is that I was not storing my error vector correctly in the beginning so I had the same error for every iteration according to my histogram. Once that was fixed, it was very smooth to continue with all the calculations.
Unfortunately, due to the time of the quarter (dead week) I could not do the optional part of the lab in time to hand it in. Nevertheless, I worked a bit with it and I will study it before the final exam.