University of Moratuwa
Faculty of Engineering
Department of Electronic & Telecommunication Engineering
EN4353 Radar and Navigation

Assignment 2

B.Sc. Eng., Semester 8 — 2016 Batch

1. Doppler filter bank holds a paramount importance in practical moving target detectors on a fully-coherent radar, facilitating clutter filtering and coherent integration. In this assignment, you are required to identify and classify objects into several classes by implementing a Doppler filter bank.

Description

The signal($I(t)$ and $Q(t)$) is sampled at a very high sampling rate (1080KHz) so that $A(t)$ can be assumed to be same for 3 consecutive samples. However to make visualization and processing easy we downsample the signal by 20 and represent it using 30 range slots.

Note: This means that 20 samples of the original signal represent a single range slot. So the downsampling process is done by taking the mid sample(10^{th}) of each range slot. This denoted by **Block 1** in Figure 1.

In this assignment you are given this downsampled complex sequence $I[n] + jQ[n]$ (27000 samples) in two ***csv*** files.

(Q1) Starting from $I(t)$ and $Q(t)$ derive an expression for $I[n] + jQ[n]$. You must show all the necessary steps and assumptions made.
$I(t) = A(t)Cos(\theta(t))$
$Q(t) = A(t)Sin(\theta(t))$
where $I(t)$ and $Q(t)$ are quadrature components after coherent detection and $\theta(t) = 2\pi f_{\text{d}}t - \pi$

(Q2) Ground clutter has close to zero velocities. By analyzing the complex number at each cell describe how you can remove ground clutter from the signal.

(Q3) Implement the procedure you described in **(Q2)** as the Zero Velocity Filter and remove any ground clutter present(i.e set those complex numbers which represent GND Clutter to zero.)

(Q4) This filtered signal is then fed into a Doppler filter bank with 4 velocity filters. In the filter bank the complex sequence is represent as a matrix of order (N, C) where N is the number of pulses transmitted and C is the number of range slots. Then **fft** is applied column wise to this complex matrix treating each column as a separate sequence. Then each sequence is passed through a given velocity filter and **ifft** is applied for each sequence to revert back to form the columns of a complex matrix. Therefore, for each velocity filter, a separate complex matrix needs to be generated.

i. By considering the expected number of echoes for a point target and the DFT of a column in the complex matrix, determine a suitable bandwidth for these velocity filters(The same bandwidth can be used for all the velocity filters)

ii. Calculate the centre frequencies of these velocity filters by referring to Table 1

(Q5) Implement Doppler filter bank using the velocity filters calculated in **(Q4)**.As shown in Figure 3 the magnitude values of each complex matrix generated per velocity filter must be subjected to thresholding and encoded using the thresholds given in Table 1. Your task is to output these encoded maps for each categories present in Table 1 prefably as a **csv file** with N rows and C columns in the form of a radar matrix .

Radar Description:

Pulse Repetition Frequency = 1800Hz
Horizontal Beam Width = 2 ^{o}
Number of Revs per minute = 12
Radar frequency = 720MHz

Submission Details:

You are expected to use ***Python*** language to implement your algorithm. The details of the implementation must be properly explained in your report along with the necessary calculations and visualization. You can submit your work in the format of ***.ipynb*** or ***.pdf*** along with five ***.csv*** files . A clean and a tidy work is appreciated.

Object	Velocity(ms^{-1})	Threshold	Encode
Cloud	50	1.05	1
Ground Clutter	0	-	2
Rain Clutter	20	0.9	3
Birds	35	1.05	4
Air-crafts	150	0.5	5
No object	-	-	0

Table 1: Required parameters

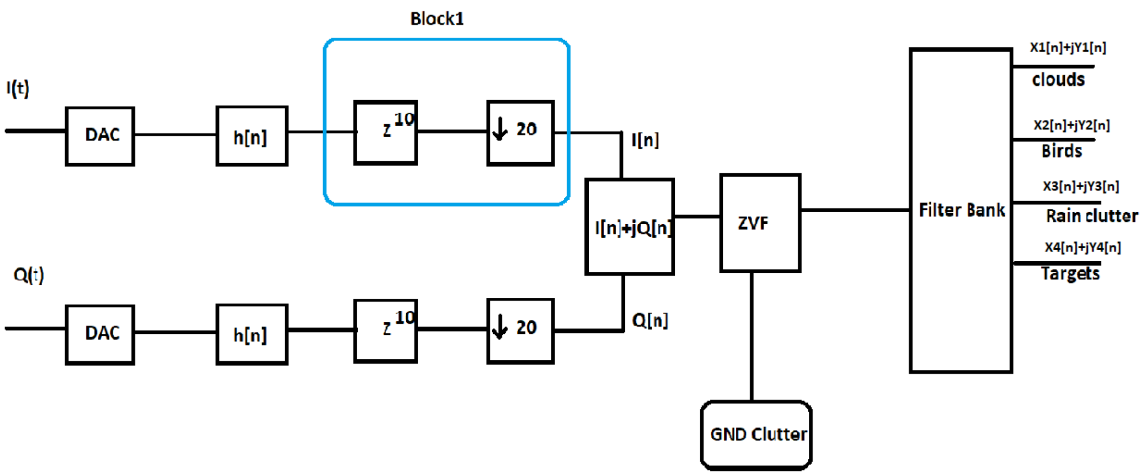

Figure 1: Filter bank

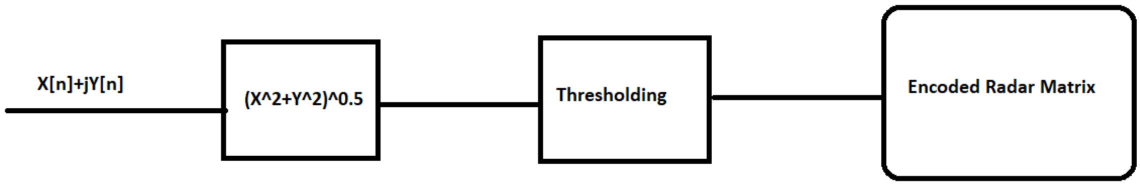

Figure 2: Encoding block

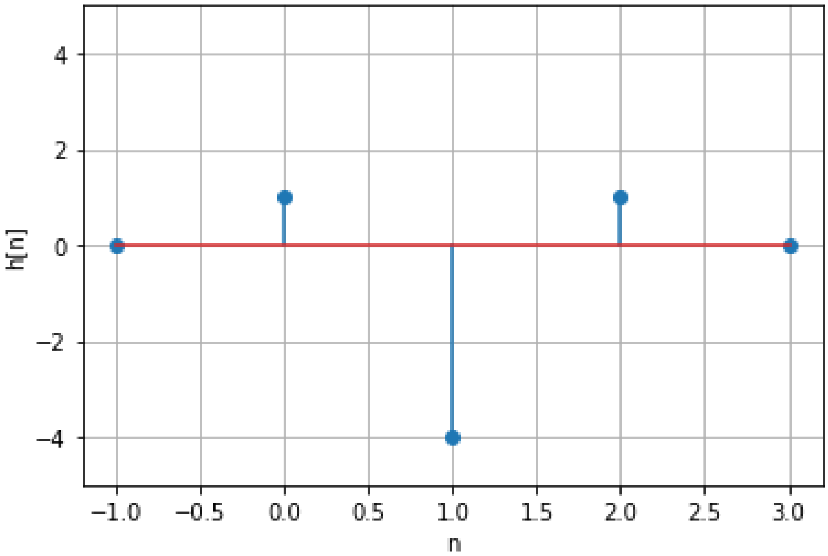

Figure 3: Impulse response ($h[n]$)

References

1. You can use Colab online note book.
2. You can use Numpy to handle matrices.
3. To visualize the output you can use Seaborn and Matplotlib.