Lab Assignment

1 Goals

We will apply a constant false-alarm rate (CFAR) detector designed for targets in Weibull background [1]. The Weibull distribution has two parameters, named shape and scale. To run the detection test, these two parameters are estimated using the maximum likelihood (ML) algorithm. We will apply the ML-CFAR test to determine the range and range-rate of a small target embedded in sea clutter. We will use Matlab to process the radar data.

2 Radar Data

We will process data collected by the polarimetric IPIX radar from McMaster University [2]. Specifically, we will evaluate the dataset *stare0* recorded on Nov. 11, 1993 at Dartmouth, Nova Scotia, Canada. The radar was located on a cliff facing the ocean, at a height of 100 feet. The pulse repetition frequency was 200Hz, the sampling frequency was 10MHz, and the first range-cell is located at 2000m. More information about the radar and the databases is available at [3].

3 Lab Work

1. Open and load the file *procNov11stare0.mat* into Matlab workspace. There are four matrices that correspond to different polarimetric channels. Each matrix has 54 fast-time measurements and 2048 slow-time measurements. Each entry of these matrices is a complex number, whose real part and imaginary part are the in-phase channel and the quadrature channel, respectively, of the matched filter output. Generate a magnitude image of the VV data as a function of the fast and slow time.

2. Write a Matlab script to implement the ML-CFAR detector described in Section 2.1 of reference [1], considering that the shape parameter is $C = 2$. For a given pulse, run the test along the down range. In order to define the secondary data, consider that samples in the fast-time dimension are cyclic, i.e. cell 1 follows cell 54. Note that this ML-CFAR test is a linear envelop detector; then we process the magnitude of the data.

3. Plot the magnitude of the pulse 180 of the matrix VV as a function of range. Use your script to compute and plot the detection threshold for P_{FA} equal 10^{-2} and 10^{-3}, and considering the number of secondary data M equal 16 and 32. Repeat the procedure for the pulse 155 of the matrix VV. Compare and discuss the results.

4. Build a detection map as a function range and slow-time by running your script for every pulse of the dataset VV. Assign value one to the pixels of the map if the test detects a target (the magnitude of the matrix entry is larger than the threshold); or assign zero otherwise. Since you can guess where the target is located, use the other range cells to compute empirically the probability of false alarm $\hat{P}_{FA}$ and compare with the design P_{FA} used to define the threshold. Discuss the results.

5. Write a Matlab script to implement the ML-CFAR detector described in Section 3.1 of reference [1], considering that the shape parameter C is unknown. Build a detection processing the dataset VV for P_{FA} equal 10^{-2} and 10^{-3}, and considering the number of secondary data M equal 16 and 32. Compare with the former results.

6. Apply pulse-Doppler processing to generate a range-Doppler image of a window of 512 pulses. Run your detection script to determine the range and rate-range of the target. Repeat this procedure using a sliding window of 512 pulses and generate a movie of the target range and velocity.

References

[1] R. Ravid and N. Levanon, "Maximum-likelihood CFAR for Weibull background," *Radar and Signal Processing, IEE Proceedings F,* vol. 139, pp. 256-264, Jun. 1992.

[2] S. Haykin, C. Krasnor, T. Nohara, B. Currie, and D. Hamburger, "A coherent dual-polarized radar for studying the ocean environment," *IEEE Trans. Geosci. Remote Sens.*, vol. 29, no. 1, pp. 189–191, Jan. 1991.

[3] Webpage: http://soma.ece.mcmaster.ca/ipix/.