Polar Hough Detector in the Presence of Randomly Arriving Impulse Interference

Ivan Garvanov, Stoyan Vladimirov, Magdalena Garvanova

University of Library Study and Information Technologies, 1784 Sofia, Bulgaria,

E-mail: igarvanov@yahoo.com, stoyanvladimirov@ yahoo.com, mgarvanova@yahoo.com

Abstract: *In this paper is studied average decision threshold (ADT) of Hough detector with CFAR BI processor in the presence of randomly arriving impulse interference (RAII). The randomly arriving impulse interference is mathematically described as Binominal pulse sequences with Raleigh amplitude distribution. This model of impulse noise is used for numerical analysis of Cell Averaging Constant False Alarm Rate (CA CFAR) pulse detector and CFAR BI (binary integration) pulse train detector with Polar Hough transform. The effectiveness of research CFAR detectors is expressed in terms of the detection probability and the average decision threshold. The ADT of the researched detectors are obtained as values of SNR when detection probability is equal to 0.5.*

The experimental results are obtained by numerical analysis in MATLAB environment.

Keywords: Polar Hough Detector, Average Decision Threshold, Randomly Arriving Impulse Interference

1. Structure of a CFAR BI Hough detector

The structure of a Hough detector is shown on Figure 1. The signal processing includes CFAR BI detection, plot extraction in (*r*-*a*) space, Polar Hough Transform and Binary integration. The range-azimuth observation space is formed after N_{SC} radar scans. After CFAR detection, using the PHT, all points of the polar data space, where targets are detected, are mapped into curves in the polar Hough parameter space. In the Hough parameter space, after binary integration of data, both target and linear trajectory are detected if the result of binary integration exceeds the detection threshold T_H.

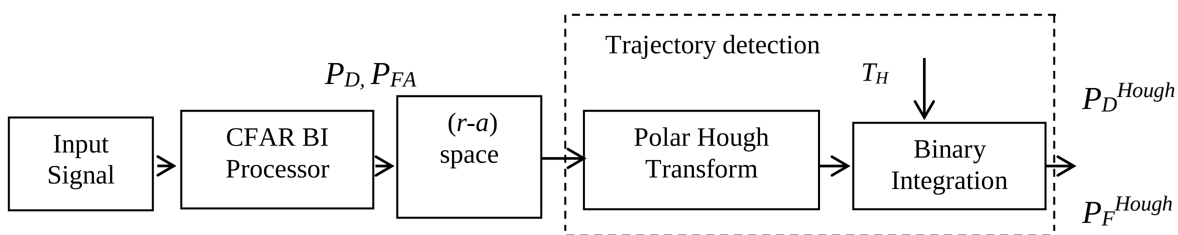

Figure 1: Structure of a CFAR BI Hough detector

2. Polar Hough detector analysis

In real radar applications, the estimated target coordinates are given in the polar coordinate system (distance and azimuth). The input parameters for the polar Hough transform are the output parameters of the search radar. For that reason, the detection algorithms using the polar Hough transform for trajectory and target detection. Another important advantage is the signal processing stability when the target changes its speed and moves at different azimuths. According to [1], the Polar Hough transform is defined by two polar coordinates, distance and azimuth (*r*-*a*). In such a way, the Polar Hough transform represents each point of a straight line in the form:

$$\rho = r\cos(a-\theta), \quad 0 < (a-\theta) \le \pi$$

where θ is the angle and ρ is the smallest distance to the origin of polar coordinate system.

The cumulative probability of target detection in Hough parameter space P_D^{Hough} cannot be written in the form of a simple Bernoulli sum. As a target moves with respect to the radar, the SNR of the received signal changes, depending on the distance to the target. The detection probability of a pulse $P_d^{(*)}$ changes as well. Then the probability P_D^{Hough} can by calculated by Brunner's method. For N_s scans we have

$$P_D^{Hough} = \sum_{i=T_H}^{N_S} P_d^{(*)}(i, N_S)$$

where T_H is the detection threshold in Hough parameter space and $P_d^{(*)}$ is the detection probability of CA CFAR by P_d or CA CFAR BI by P_D detectors.

We study the performance of a CA CFAR detector and a CA CFAR BI detector with polar Hough transform in the presence of randomly arriving impulse interference with binomial distributed flow. The detection probabilities of the considered detectors are obtained by numerical analysis. The average decision thresholds of the detectors are obtained as values of SNR when detection probability is equal to 0.5.

3. Numerical results

The ADT of a CA CFAR and CA CFAR Hough processors are shown on Figure 2.

The ADT for CFAR BI and CFAR BI Hough processors are shown on Figure 3.

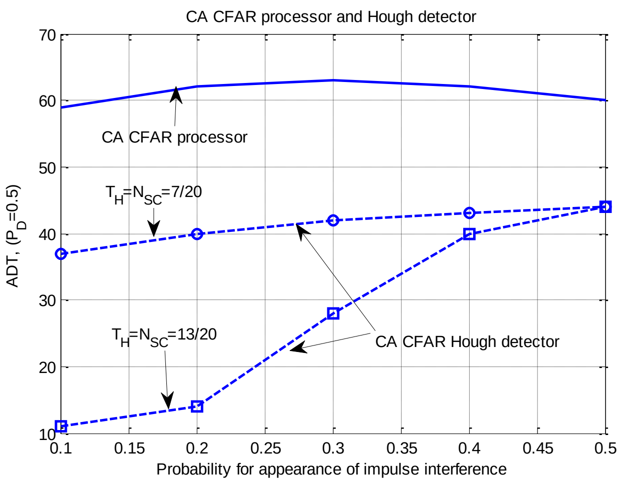

Figure 2: ADT of a CA CFAR and of CA CFAR Hough detectors for T_H=7 and 13

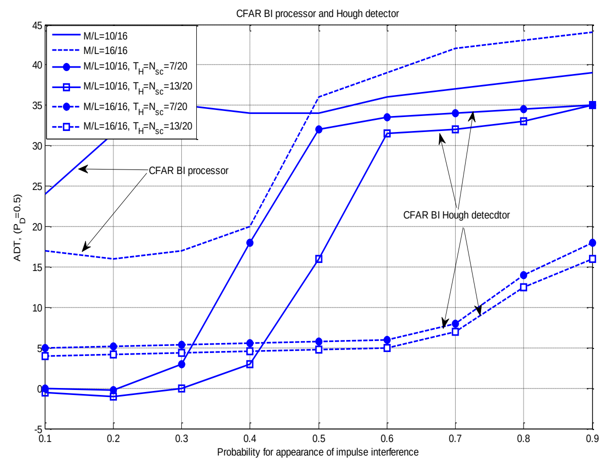

Figure 3: ADT of a CA CFAR BI detector and of CA CFAR BI Hough detector for T_H=7 and 13, M/L = 10/16 (solid line) and 16/16 (dashed line)

4. Conclusions

The results show that the CA CFAR BI Hough detector, in which the binary decision rule is 10/16, is the most effective in case when the probability of occurrence of a random pulse is lower than 0.4. In a contrary situation, when the probability of occurrence of a random pulse is higher than 0.4, the CA CFAR BI Hough detector with binary decision rule is 16/16 is more appropriate.

Reference:

1. Гарванов И., "Откриване на подвижни цели и траектории", София, "За буквите – О писменех", ISBN 978-954-2946-90-8, 270 стр., 2013 г.

2. Carlson B., Evans E. and S. Wilson - "Search Radar Detection and Track with the Hough Transform", IEEE Trans., vol. AES - 30.1.1994, Part I, pp. 102-108; Part II, pp. 109-115; Part III, pp. 116-124, 1994.