



Moving Target Detection Using VI-CFAR Algorithm on MATLAB Platform

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Abstract- This paper details the design and implementation of The Target detection system using Variability index constant false alarm rate (VI-CFAR) algorithm on MATLAB platform. VI- CFAR, one of intelligent CFAR algorithms, is the most popular composite CFAR algorithm. The VI- CFAR dynamically selects one of the mean levels CFAR algorithms based on a variability index and a mean-ratio test to perform robustly in heterogeneous environments. So we have tried to make a system which will detect the target using VI-CFAR algorithm on MATLAB platform.

Keywords- CFAR, variability index, target detection, probability of false alarm (PFA).

I. Introduction

Radar has been employed to detect targets on the ground, on the sea, in the air, in space, and even below ground. Radar is an important part of air-defence system as well as the operation of offensive missile and other weapons [1]. In air defence it performs the function of surveillance and weapon control. Surveillance includes target detection, target tracking and designation to a weapon system. There are different algorithms for target detection but VI-CFAR is best suited for heterogeneous environment as compared to other CFAR algorithm.

The key factor of CFAR algorithms lies in setting the threshold adaptively by estimating the background noise power included in a test cell. A mean-level CFAR algorithm is the simplest one and uses arithmetic averaging to estimate the noise power. The most well-known mean-level CFAR algorithm is the cell averaging (CA) CFAR which averages all cells in the reference window. This property of the CA CFAR yields the optimal Performance in homogeneous environment [2]. However, it does not work well for heterogeneous cases which are frequently produced by masking targets and clutter edges. For this reason, many alternative CFAR algorithms have been proposed to cope with such diverse heterogeneous environments but do not still succeed in combating robustly to environment changes. The difficulty in finding a solution based on a single CFAR algorithm to deal with diverse noise environments has led to the development of composite CFAR algorithms [3]. The VI CFAR, one of intelligent CFAR algorithms, is the most popular composite CFAR algorithm. The VI CFAR dynamically selects one of the mean-level CFAR algorithms based on a variability index and a mean-ratio test to perform robustly in heterogeneous environments.

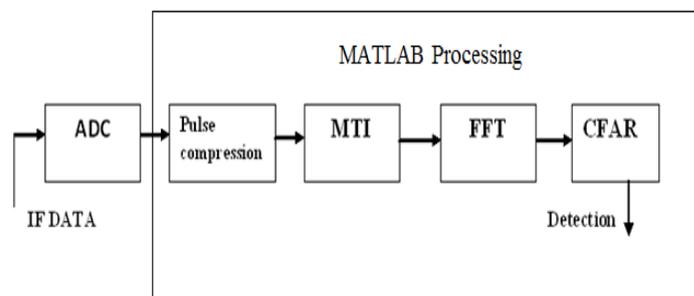


Figure1: Block Diagram

II. VI-CFAR

The VI CFAR is the composite CFAR algorithm and the structure of the VI CFAR is described in Figure 5.16. The VI CFAR selects one of the mean-level CFAR algorithm based on the real time test of the reference window. The reference window is divided into the leading window and the lagging window. Mean and variance of each window are calculated

to determine the noise environment condition of the each window. By comparing the mean ratio (MR) and the variability index (VI) with predetermined threshold KVI , KMR , the state of the noise environment is determined as follows [3]:

$$MR = \sum_{i=1}^M X_i / \sum_{j=M+1}^{2M} X_j, \begin{cases} K_{MR}^{-1} \leq MR \leq K_{MR}, & \text{same mean} \\ \text{otherwise,} & \text{diff erent mean} \end{cases} \dots\dots (1)$$

Scaling factor T_N is given by:

$$T_N = \left(\frac{1}{P_{FA}}\right)^{-1/N} - 1 \dots\dots(2)$$

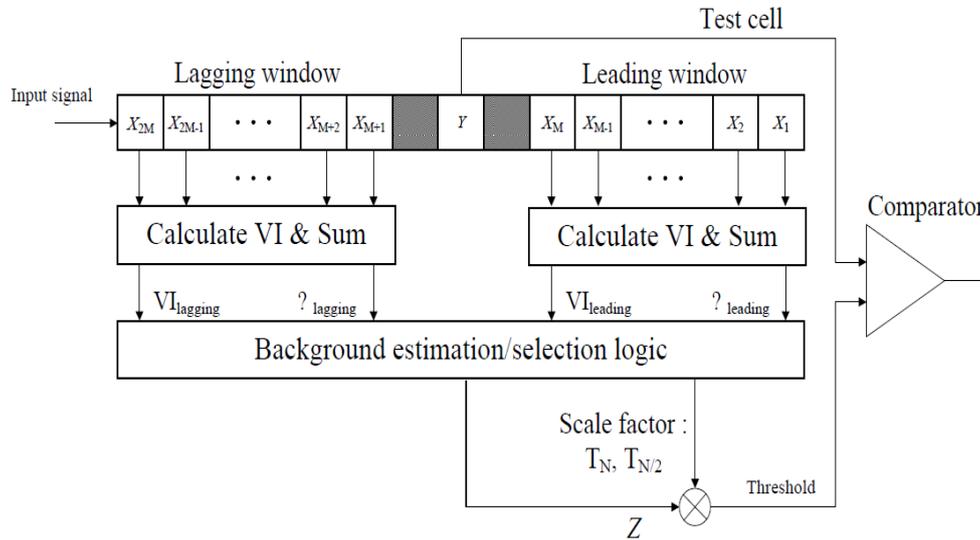


Figure 2: Structure of VI-CFAR [3]

The VI is a second-order statistic that is closely related to an estimate of the shape parameter. Its value is a function of the estimated population mean μ and estimated population variance σ^2 . The VI-CFAR design partitions the reference window in leading and lagging halves. The VI is then calculated for each split window using:

$$VI = 1 + \frac{\hat{\sigma}^2}{\hat{\mu}^2} = 1 + \frac{1}{n-1} \sum_{i=1}^n (X_i - \bar{X})^2 / (\bar{X})^2 \dots (3)$$

Where \bar{X} is the arithmetic mean of the n cells in a half reference window. The probability density function (pdf) of the VI is independent of the noise power in a homogeneous environment, but changes considerably in the presence of interfering targets or partial clutter within the reference window. The VI is compared with a threshold K_{VI} , to decide if the cells with which the VI is computed are from a homogeneous (non-variable) environment or from a non-homogeneous (variable) environment using the following hypothesis test:

$$\begin{cases} VI \geq K_{VI}, & \text{variable} \\ VI \leq K_{VI}, & \text{invariable} \end{cases} \dots\dots (4)$$

For implementation purposes, it is possible to reduce the computational requirements associated with generating the VI statistic using an alternative definition. In this case, the simplified statistic VI^* is obtained by using the biased, maximum likelihood estimate of the population variance rather than the unbiased estimate used in last one.

$$VI^* = 1 + \frac{\hat{\sigma}^2}{\hat{\mu}^2} = 1 + \frac{1}{n} \sum_{i=1}^n (X_i - \bar{X})^2 / (\bar{X})^2$$

$$\frac{\sum_{i=1}^n (X_i)^2}{(\sum_{i=1}^n X_i)^2} \dots\dots (5)$$

The threshold decision method in the VI CFAR is shown in table 1. If there is a variable window, the noise environment is regarded as the target masking environment. Otherwise, the existence of the clutter edge will be tested based on the mean ratio. In the clutter edge environment, the VI CFAR will become a GO (greatest-of) CFAR. When the interfering

signals are on the both side of the test cell, the VI CFAR will become a SO (smallest-of) CFAR. In other cases, the VI CFAR will operate as a CA CFAR, equivalently.

Threshold decision method for VI-CFAR algorithm [3]:

$VI \geq K_{VI}$		MR	adaptive threshold
Leading	lagging		
No	No	same	$(\sum \text{leading} + \sum \text{lagging}) \cdot T_N$
No	No	different	$\max(\sum \text{leading} + \sum \text{lagging}) \cdot T_{N/2}$
Yes	No		$\sum \text{lagging} \cdot T_{N/2}$
No	Yes		$\sum \text{leading} \cdot T_{N/2}$
Yes	Yes		$\min(\sum \text{leading} + \sum \text{lagging}) \cdot T_{N/2}$

Table: 1

III. RESULT

The Complete system is implemented on MATLAB; the data has been received from the serial port of the computer after ADC. Received Data from the serial port get processed on MATLAB and then passed through the VI-CFAR Algorithm. The complete processed output result has been shown in the figure (3) below. From the figure (3) we can see that there is target indication at 28km, 44km, and 72km approx as the signal amplitude level is more than the threshold. For this system the computed KVI, KMR, PFA are 4.76, 1.806, 1e-6 respectively.

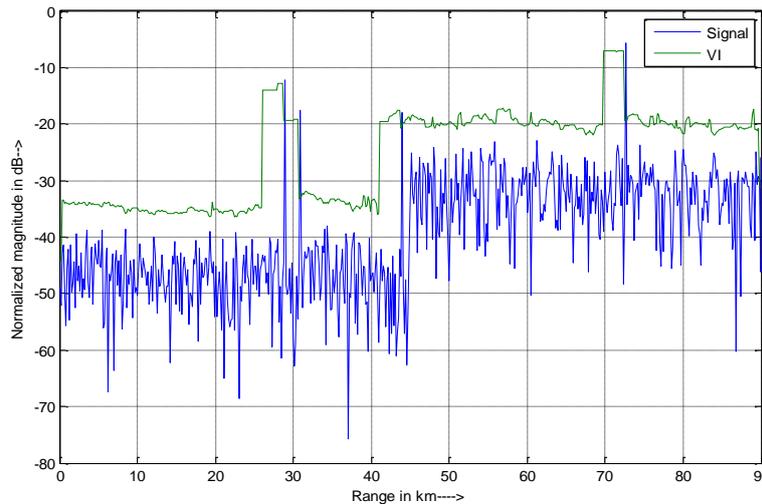


Figure: 3 Target Detected Result

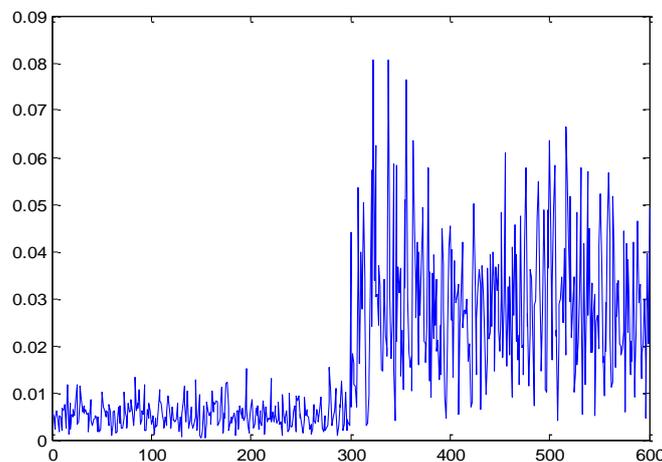


Figure: 4 Received signal

IV. CONCLUSION

The complete system will be very effective in many applications for defence armed forces. A target Detection system can be made using a laptop running with MATLAB and a Radar antenna. In future more of the CFAR algorithm can be implemented on MATLAB so that the user can change the algorithm according to the atmosphere or geographic condition.

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