Thresholding Approach Based on Test Cell Statistics

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Abstract

In radar system, There is a Test cell statistics for thresholding approach on constant falls alarm rate CFAR. The main function of CFAR algorithm is to detect target when the return signal consist of noise, interference and clutter.The property of constant false alarm rate (CFAR) is threshold or gain control devices that maintain approximately constant rate of false target detection. The CFAR CA, GO, SO, OS are the types of CFAR.“Cell average”(CA-CFAR) performance is degraded in the presence of interfering target or change in background clutter noise.“ Greatest Of ”(GO-CFAR) isdesigned to maintain constantvalue of false target detection during reverberation edges and is unable to detect target which is closely spaced. “Smallest Of ”(SO-CFAR) performance is better in case of multiple target. But none of them perform well in all three background environment such as homogeneous , reverberation edges and multiple target.“Ordrer Statistic” (OS-CFAR) composed of Cell average CFAR, Smallest of CFAR and Greatest of CFAR preform using 2-D OS-CFAR well in presence of homogeneous, reverberation edges and multiple target environment respectively.

Keywords — *Clutter background,Radar signal detection, Constant false alarm rate (CFAR), 2-D Order Statistic.*

I. INTRODUCTION

The principle of radar is transmitting high energy pulse which will be return back from target consist of undesiredecho.The radar antenna illuminates the target with a microwave signal, which is then reflected and picked up by a receiving device. The electrical signal receiving by antenna is called echo. figure 1.1 shows the block diagram of Radar. The radar signal is generated by a powerful transmitter and received by a highly sensitive receiver. The reflected signal is also called scattering. Backscatter is the reflections of incident ray in opposite direction. In a radar system , noise and clutter is present in receivedsignal. From scattererstheir arise unwanted radar signal called clutter for examples reflections from sea, rain, birds, insects and so on.Received background noise fluctuates randomly up and down.The target echo also fluctuates. To decide the presence of target, it is necessary to set threshold.

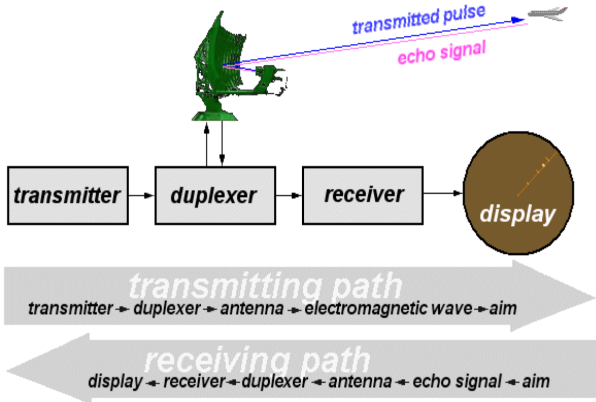

Figure 1.1: Block diagram of a primary radar

A PPI has routing vector with the radar at the origin, which indicates the pointing direction of the antenna and hence the bearing of target. Figure1.1 shows the basic working principle of Radar.

1. Transmitter : The radar transmitter produces the short duration high power RF pulses of energy that are into space by the antenna.

2. Duplexer : The duplexer alternately switches the antenna between the transmitter and receiver so that only one antenna need be used. This switching is necessary because of the high power pulses of the transmitter would destroy the receiver if energy were allowed to enter the receiver.

3. Receiver : The receiver amplify and demodulate the received RF signal. It provides video signal on the output.

4. Radar Antenna : The antenna transfer the transmitter energy to signals in space with the required distributions and effciency.

5. Indicator : The indicator should indicate to the observer a continuous, easily understandable graphic picture of the relative position of radar target.
Basic feature of CFARalgorithm to maintain constant value of false alarm probability. When Targets in

presence of echo power can still be detected. General structure of adaptive CFAR processor is shown in figure 1.2. Here input signal is radar return which may be homogeneous , non-homogeneous ,reverberation environment. Which is given to the square law detector which square the input data. This data is now given to the CFAR algorithm. CFAR algorithm generate adaptive threshold value which is compare with the cell under test. Based on comparision it is decided whether target is present or not.

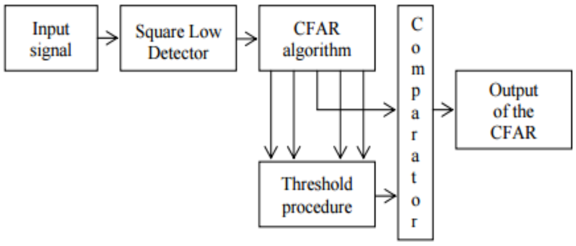

Figure : 1.2 General structure of adaptive CFAR processor

There are various types of CFAR algorithm, someof them are listed below
1] Cell averaging constant false alarm rate(CA-CFAR)
2]Greatest of conatant false alarm rate (GO-CFAR)
3]Smallest of constant false alarm rate (SO-CFAR)
4]Ordered statistic constant false alarm rate (OS-CFAR)

II. METHODS

While performing target detection using CFAR theiris a arises problem. For stationary Gaussian signal against a normal noise, the performance of CA-CFAR is good.In CA-CFAR detectors the threshold value is set adaptively based on local information on the background noise. The probability of detection is independence on the number of the reference cells and signal-to noise ratio.the figure1.3 shows the graph of effect of noise power With small increment in total noise power the magnitude of probability of false alarm is increased to several factor . The desired probability of false alarm is 10^{-8} at 0dB, but due to 3dB increase in signal to noise ratio actual probability of false alarm rate is increased by a factor of 10^{4}.

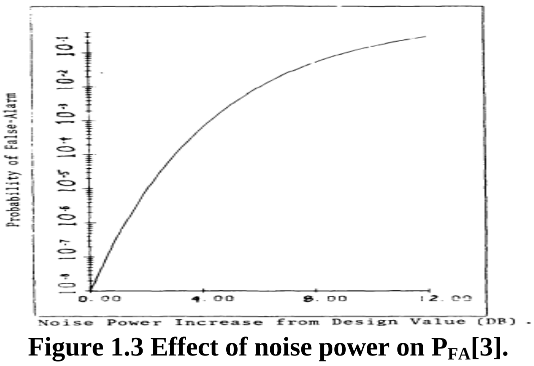

Figure 1.3 Effect of noise power on P_{FA}[3].

Radar signal detection consist of only noise in the absence of target [H_0] and signal plus noise in presence of target [H_1]. The detection efficiency of a radar is given by probabilityof detection P_d and the probability of false alarm rate P_f. Conditional probability in presence of target is given as ,

Pd□ □$P(Y$□ □$Z_T / H_0)$,

while Pf □ □$P(Y$ □ □$Z_T / H_0)$.

Performance of cell average constant false alarm rate(CA -CFAR) is good in case of homogeneous environment but its performance degraded during non-homogeneities such as multiple target and reverberation edges. When there is transition from clear to clutter region, the graph of total noise power density as a function of rangewhich isrepresent by a step function. Two cases may arises for such sitution .In first case group of reference cell are in the clutter whereas cell under test is in clear region then the resultant adaptive threshold have higher value and the probabilities of detection and probability of false-alarm are reduced . In second case a group of reference cell are in clear region but the cell under test is immersed to clutter then the adaptive threshold is relatively small and probability of false alarm get increased. In this case cell average constant false alarm rate (CA-CFAR) performance decrease so to control this increase in probability of false alarm greatest of constant false alarm (GO-CFAR) is proposed. In greatest of constant false alarm (GO-CFAR) adaptive threshold is obtain from maximum value between two reference window.

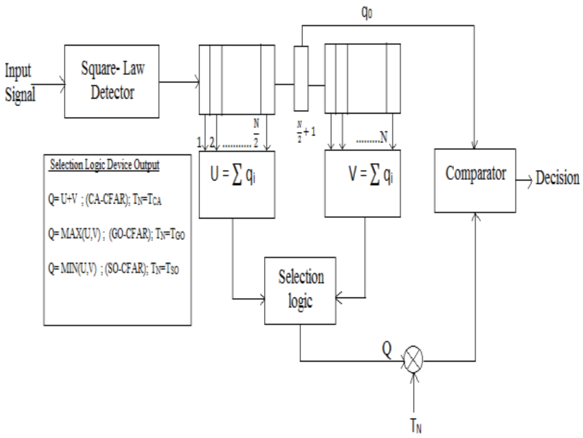

Figure1.4: Cell Averaging CFAR Detector

In presence of another target, CA-CFAR cannot detect the target to overcome this disadvantage smallest of constant false alarm rate (SO-CFAR) is proposed. In SO-CFAR adaptive threshold is obtained by minimum value between to reference window. In SO-CFAR detection losses is very small if there is small no of reference cell. In SO-CFAR probability of detection increase for dense civilian or military target environments when there is closely separated targets and detect both the target that was not detected in CA-

CFAR and GO-CFAR.Ordered statistic CFAR overcome the disadvantage of CA-CFAR. figure 1.4 shows the differnt CFAR detecter. OS-CFAR performance is well in case of homogeneous environment and its performance is improved when the target is fluctuating in non-homogeneous environment .But performance decrease in presence another interfering target in same environment .To overcome these disadvantage order staticstic constant false alarm rate (OS-CFAR)is proposed.

A. Order Staticstic Constant False Alarm Rate (Os-Cfar)

Order Staticstic constant false alarm rate(OS-CFAR) is an algorithm composed of GO-CFAR, SO-CFAR and CA-CFAR, perform depending upon different environment OS-CFAR block diagram is shown in figure 1.5. This is specialy known as 1-D OS CFAR.

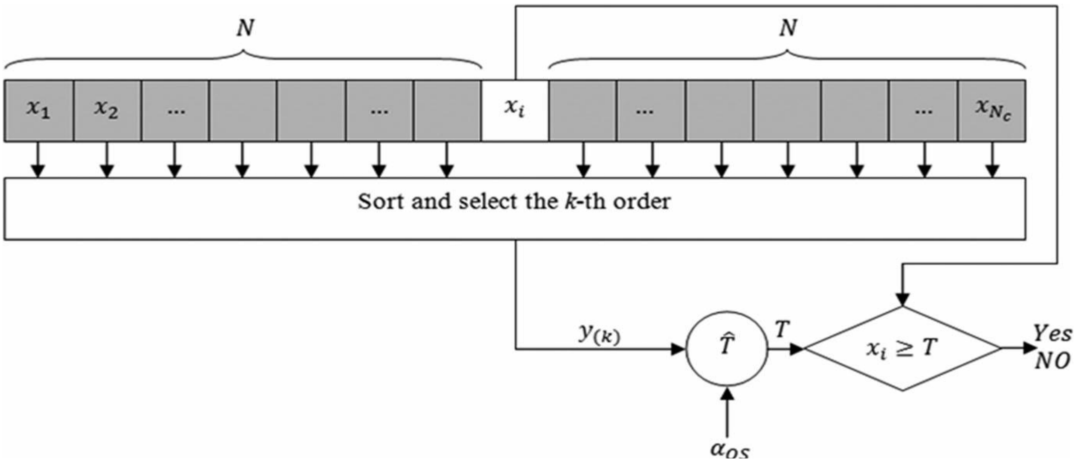

Figure 1.5: Generic architecture of the OS-CFAR 1-D process.

B. 1-D Order Statistic Cfar

The Problem in radar technology consist of detecting the radar sample's presence or absence status of target, so in these hypothesis were define for this analysis.

1.Background (H0).

2.The sample is a combination of the interference and echoes of the target (H1),

If system decided that H0 is selected means target is not present else H1 is selected that means,target is present. Fig 1.5 shows generic architecture of the OS-CFAR 1D on a row vector 1*NC samples. Cell contain an interference power value β^2 . The reason of squared value β^2 is because it is a real positive quantity an the central cell Xiis called the cell under test Xi is calculated using ,

$$Nc = 2N + 1$$

Where N represent the number of refrencecells . 2N is a total of neighboring cells. The kth element of the ordered list is called the kth order statistic.

In OS-CFAR rank order statistic the interference power values{X1,X2……..XN} from a new sequence in asending number order denoted by {X(1),X(2)…..X(N)}.

Threshold T is set applying a multiplier or scale factor

$$T= \alpha \text{ OS}$$

C. 2-D Order Staticstic Cfar

To carry out this adaptation, different modification are necessary. They will beexplained as follows:

OS-CFAR technique extension to 2-D. Application of effcientrank-order strategies to reduce computational resources and extension to multiclass segmentation.In the acoustical domain, radar interference power is interpreted as digitized acoustical reverberation power. For an acoustical image I of size h * w (height *width), each digitized acoustical reverberation power is represented with a relative cell value to a spatial coordinate (i, j). Figure. 1.6 shows where the general architecture using OS-CFAR 2-D is shown[1].

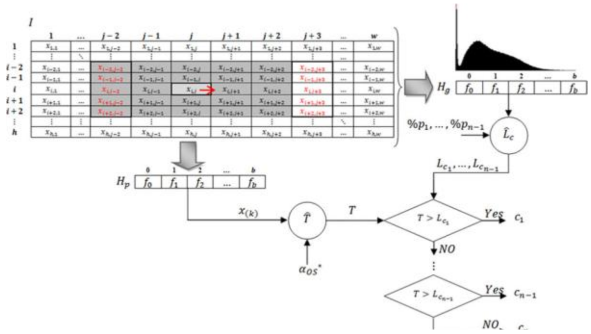

Figure 1.6: General architecture using OS-CFAR 2-D.

Order Statistics-Constant False Alarm Rate Extension to 2-DOS-CFAR extension to 2-D requires implementing a sliding window or kernel that moves over the entire acoustical image. This sliding window consists in a square matrix of size r* r and distance N to the kernel center, (where N is the number of reference cells)]. Figure. 1.6 shows a sliding window (dark graycells) with its center in the cell under test xi,j (light gray cell). The size of this kernel radius is r = 5 ,(N = 2) and, therefore, it contain Nc = 25 cells. The calculation of the total number of cells according to the reference cells for each estimation is obtained as follows[1]:

$$Nc = (2N + 1)^2$$

This represent a trade off situation between a desired result and the processing time.

$$MR = \frac{\overline{X_A}}{\overline{X_B}}$$

Where $\overline{X_A}$ and $\overline{X_B}$ are mean of leading and lagging reference window respectively. Probability density function of mean ratio is not depend on noise power but it is expected to increase when there is interfering target present in the leading reference cells and decrease when the interfering target is present in lagging reference cells. Comparison of calculated MR and threshold K_{MR} (1.806) [2] is decided whether the population mean in the leading reference window and lagging reference window are same or different. If MR is greater than or equal to inverse of threshold K_{MR} and smaller than or equal to threshold K_{MR} then it is consider as same mean otherwise it is consider as different mean.

D. Different Os-Cfar Modes Of Operation

Leading window A variable	Lagging window B variable	Different mean	OS-CFAR Adaptive threshold	CFAR Methods
No	No	No	$C_N.\sum_{AB}$	CA-CFAR
No	No	Yes	$C_{N/2}.\max(\sum_A, \sum_B)$	GO-CFAR
Yes	No	-	$C_{N/2} . \sum_B$	CA-CFAR
Yes	Yes	-	$C_{N/2} . \sum_A$	OS-CFAR
Yes	Yes	-	$C_{N/2}. \min(\sum_A, \sum_B)$	SO-CFAR

Where $C_N = P_{fa}^{\frac{-1}{N}} - 1$ and $C_{N/2} = P_{fa}^{\frac{-1}{N/2}} - 1$

The above table shows Different OS-CFAR modes of operation OS-CFAR adapts itself to different CFAR method depend upon background environments explain as follow :

A. Homogeneous environment :

Homogeneous environment is one in which noise is equally distributed. For homogeneous environment both VI and MR crosses threshold K_{VI} and K_{MR} .CA-CFAR is used for background estimation .

B. Non-Homogeneous environment:

For non-homogeneous environment, reference window consist of one or more interfering target. When such condition occur for any of the reference window then other reference window is used for background estimation, for such condition CA-CFAR algorithm is used. This is similar to that of third and fourth row of table 1. If both the reference window is variable then the reference window with minimum mean is chosen to estimate background using SO-CFAR algorithm .

C. Reverberation Edge Environment

Reverberation first started to enter in a leading reference window i.e some of reference cell must contain higher noise, then other reference window is used to estimate background. This reverberation continue to move into that reference window and get close to fill it up.This window is homogeneous as it contain noise. For such condition mean of two windows are different .The window with greater mean is chosen to estimate background which is represent by second row in a table. This reverberation is continue to move into second reference window. This window become non-homogeneous and first become homogeneous. For this homogeneous window is chosen to estimate background. Finally reverberation will enter in both the reference window and it is similar to that of first row of table1.

III. RESULT

While considering homogeneous environment i.e black sample imageshown in figure 1.7 when pass to the algorithm.

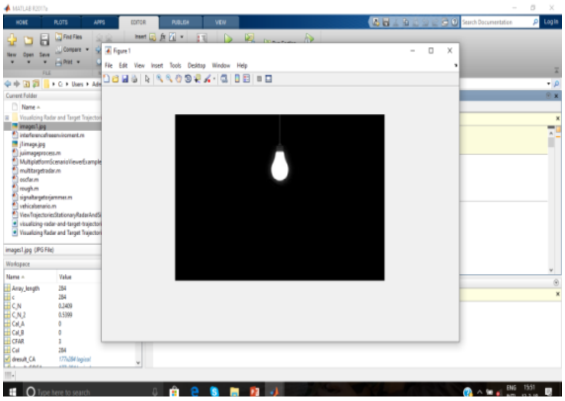

Figure 1.7: Sample image with black environment

When the sample image is passed through the CA-CFAR algorithamand get a results from that the target is not detect clearly.

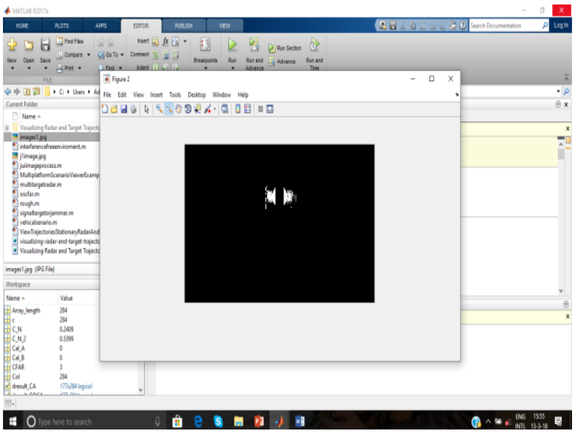

Figure 1.8: CA-CFAR image with black environment

When the sample image is passed through the GO-CFAR algoritham and get a results from that the target is not detect clearly it contain a noise.

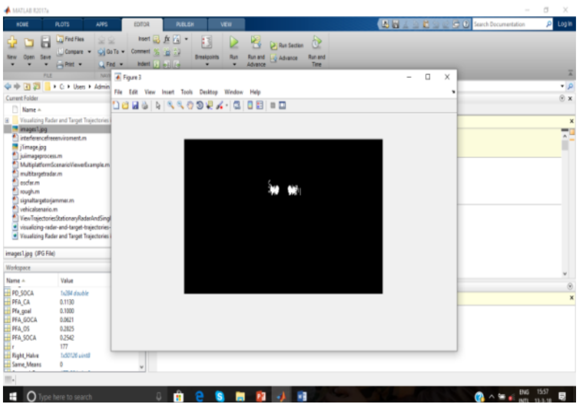

Figure 1.9: GO-CFAR image with black environment

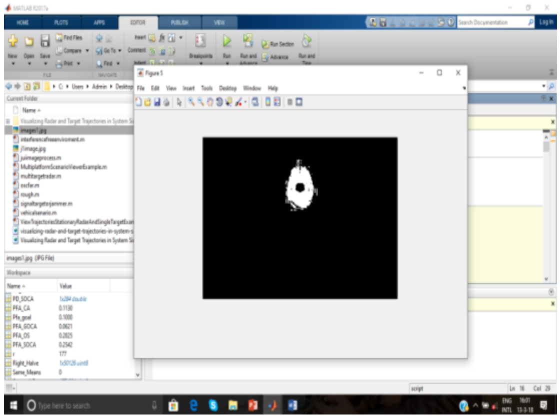

Figure 1.10: SO-CFAR with black environment

When the sample image is passed through the SO-CFAR algoritham and get a results from that the target is not detect clearly it contain a noise and figure 1.10 shows the result of target.

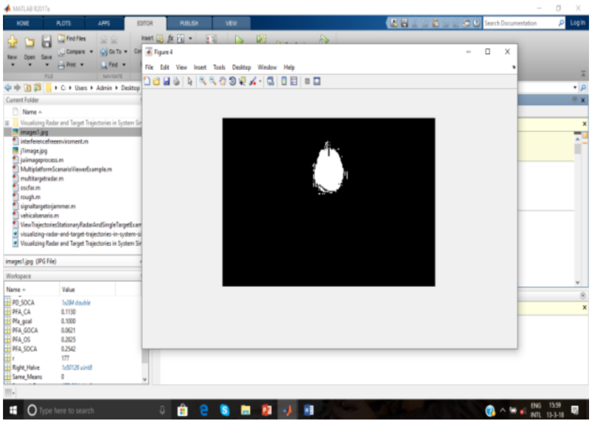

Figure 1.11: OS-CFAR image with black environment

Above Figure shows result of CA-CFAR, GO-CFAR, SO-CFAR,OS-CFAR when Black Background sample image with whitetargethighlighted is pass through algorithm.

Then we created a source image with white Gaussian noise for that we consider Number of monte-carlo trials is $10^5$and SNR is 3dB and then calculate noise amplitude for each channel.When pass through OS-CFAR algorithm we obtain result which is shown in figure 1.11.

IV. CONCLUSION

OS-CFAR uses different algorithm such as CA-CFAR, GO-CFAR and SO-CFAR depending upon whether the environment is homogeneous ,non-homogeneous and reverberation respectively. 2-D OS-CFAR performance is low loss for homogeneous environment and performance increase in non-homogeneous environment i.e in multiple target environment and clutter edges. Performance of 2-D OS CFAR is better than Cell averageCFAR. OS-CFAR has better probability of false alarm rate during clutter edges and increases probability of detection for multiple target.

REFERENCES

[1] Sebasti´an A. Villar,"A Framework for Acoustic Segmentation Using Order Statistic-Constant False Alarm Rate in Two Dimensions From Sidescan Sonar Data",IEEE International Conference on Advances in Communication and signal processing IEEE 20017.
[2] Tri-Tan Van Cao, "A CFAR Thresholding Approach Based on Test Cell Statistics'', IEEE International Conference on Advances in Communication and signal processing IEEE 2004.
[3] Hermann Rohling ," Radar CFAR Thresholding in Clutter and Multiple Target Situations", IEEE International conference IEEE 2002.
[4] M. E. Smith,P.K. Varshney, "Intelligent CFAR Processor Based on Data Variability",IEEE International Conference on Advances in Communication and signal processing IEEE 2000
[5] https://en.wikipedia.org/wiki/RADAR.
[6] reference book// Electronic communication system by kennedy.