REVIEW OF RADAR CONSTANT FALSE ALARM SYSTEMS

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Abstract

A comparative study of two kinds of algorithms; the combination between CFAR in the same family and diverse families. Cell averaged CA-CFAR and Ordered statistics OS-CFAR algorithms have been tested in three radar environments situations, multi targets, close targets and clutter edge. Also, the probability of detection has been evaluated for these algorithms. Based on the three radar field environments, the detection process formed the adaptive threshold required to detect the received radar cell signal. Many algorithms are used to design this adaptive threshold to satisfy a Constant False Alarm Rate (CFAR) according to the detection criteria used in the specified environment, in non-homogenous or homogeneous or multi-target. In this study, the MATLAB 2013 is used to evaluate the performance of different types of CFAR algorithms.

Keywords— Clutter edge, multi targets, Radar, algorithm, CFAR

1. Introduction

The radar receiver works as a superheterodyne-type receiver. The first stage is a low-noise radio frequency (RF) amplifier and the second stage is the mixer stage. The mixer and local oscillator (LO) lower the RF to an intermediate frequency (IF). A typical IF amplifier for an air-surveillance radar might have a center frequency of 30 or 60 MHz and a bandwidth of the order of one megahertz. The IF amplifier should be designed as a matched filter, i.e., its frequency-response function H(f) should maximize the signal-to-mean-noise-power ratio at the output. After maximizing the signal-to-noise ratio in the IF amplifier, the pulse modulation is extracted by the second detector and amplified by the video amplifier to a level where it can be properly displayed. The diagram in Figure 1 is a simplified version that neglects many details. It does not include several devices often found in a radar, such as the automatic frequency control (AFC) or automatic gain control (AGC), the receiver circuits for reducing interference from other radars and unwanted signals, and the circuitry to separate between the moving targets and unwanted stationary objects, such as the moving target indicator (MTI) and constant false alarm rate (CFAR) circuit. In modern radar systems, equipped with automatic detection circuits, the use of CFAR techniques is required to keep false alarms at a suitably low rate in an a-priori unknown, time varying designed for the study of statistical signal detection and parameter estimation. Such concepts require a good knowledge of the fundamental notions on probability, random variables, and stochastic processes. The radar's block diagram is shown in Figure 1. The CFAR circuit lies in the radar receiver part after the analogue-to-digital converter [1].

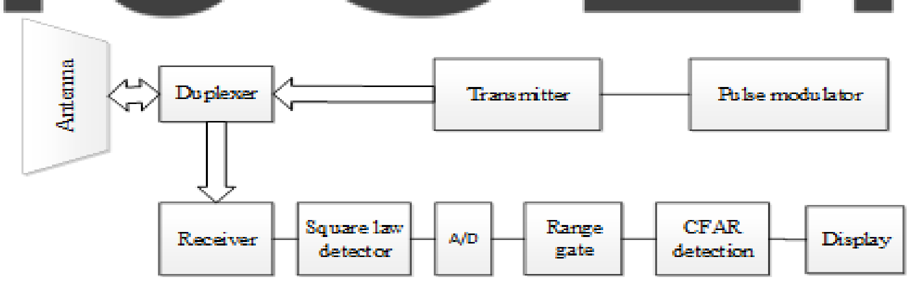

Figure 1: Block diagram of a pulse radar

Many CFARs algorithms has been done to overcome the different return signals in the returns from the tree radar environments situations which are the homogenous environment and the non-homogenous environment (clutter cloud) and the non-uniform(multi-targets) environments as shown in figure 2. The constant false alarm rate (CFAR) detectors are designed to avoid false detection, which could happen when using a fixed detection threshold. CFAR detectors estimate the statistics of the clutter to set a threshold varying adaptively with different background conditions. The adaptive threshold technique assumes that the probability density function of the noise is known except for a few unknown parameters. The surrounding reference cells are then used to estimate the unknown parameters, and the adaptive threshold value will be obtained by observing the noise or background clutter in the existence of the target. The threshold value is adjusted with the measured background. The threshold varies continuously according to the noise or the clutter environment found within a range interval surrounding the range cell under observation [2]. In general, CFAR detectors produce the best performance when the background, such as thermal noise, is uniformly distributed. In practice, however, the received signal could contain unwanted background clutter such as land, rain, or sea clutter. The clutter could appear as a target in some cases, which makes target detection in the presence of background clutter more difficult. Therefore, it is important to understand the characteristics of the background clutter. The statistical model is one of the methods which are required for performance prediction, simulation, and design of the detection process [3].

2. CFAR and Radar environments

The performance of the radar receiver is greatly degraded when there are noise spikes. The goal of the radar receiver is to obtain a constant false alerting rate (CFAR) with the highest possible target detection probability. The echo signal of the targeted target is intercepted by high amplitude signal spikes from interfering targets or undesired echoes (clutter) from the ground, sea, rain, chaff, and other electromagnetic wave reflecting sources. If the false alarm rate has to be reduced, a fixed-threshold detection system cannot be used to detect the targets echo signal from the radar returns in individual range cells since the clutter-plus-noise power is unknown at every given position. Despite the fact that some of these algorithms, such as the greatest of CFAR (GO-CFAR) for clutter cloud problem or ordered statistics (OS-CFAR) algorithms for multi-target environment problems [4], it required more robust algorithm to deal with the multi-targets inside the clutter cloud situation. dependent on the presence of noise. Receiver has to achieve constant false alarm rate (CFAR) and maximum probability of target detection in order to detect. The signal returns from other electromagnetic reflecting sources referred to as interfering targets or unwanted echoes (clutter) from the ground, sea, rain or chaff and another electromagnetic wave reflecting source that interfere with the echo signal of the desired target. Since the clutter-plus-noise power not known at any given location, a fixed-threshold detection scheme cannot apply to detect the targets echo signal from the radar returns in individual range cells if the false alarm rate is to be controlled. An attractive class of schemes can used to overcome the problem of clutter and to maintain the constant false alarm rate (CFAR) processing schemes that set the threshold adaptively based on local information of total noise power.

Adaptive threshold technique based on the assumption that the probability density function of the noise known except for a few unknown parameters. The surrounding reference cells used to estimate the unknown parameters, and adaptive threshold value will be obtained. From experimental data, the clutter backscattering coefficient (effective echoing area) can be modelled the Rayleigh, exponential, the Weibull distribution or other depending on type of clutter. If the clutter returns are Raleigh envelope distributed, and they assumed identically distributed with the thermal noise, this constitutes the simplest clutter model. Sometimes the environment in which radar operates depends on factors that may yield statistically non-stationary signals with unknown variance at the receiver input. This non- homogeneous environment with clutter edge and non-uniform environments with unwanted multi-interfering targets spikes need robust CFAR algorithm to deal with clutter edge and excise unwanted targets spikes from the background noise estimation to achieve primary wanted targets detection.

Several methods and algorithms used to deal with non-homogeneous and non-uniform environments, Rohling suggested ordered statistics (OS-CFAR) that idea was the beginning of many methods that based on that algorithm [4], such as trimmed mean (TM-CFAR) and censored mean level detector (CMLD-CFAR. The new solution is to examine, the radar environment before applying suitable CFAR circuit established by applying two or more method on the received signal, and developed solution to use combination of CFAR methods together with selection criteria. to choose appropriate method according to the assumed environment such as variable indexed (VI-CFAR) . Few CFAR algorithms consider the worst radar environments with multi target inside the clutter cloud to happen, therefore it required robust algorithm to deal with this situation. It required very complex algorithm for the worst radar environment that need complex hardware with high processing time or may use two stage-censoring algorithm that make it not suitable for real time applications. All of these algorithms may handle this situation with expense of hardware complexity that expense high processing time that make these algorithms unsuitable for radar real time applications. Therefore, new method of maximum spike subtraction method MSS-CFAR was suggested to overcome the problem of non-homogeneous and non-uniform radar environments [2].

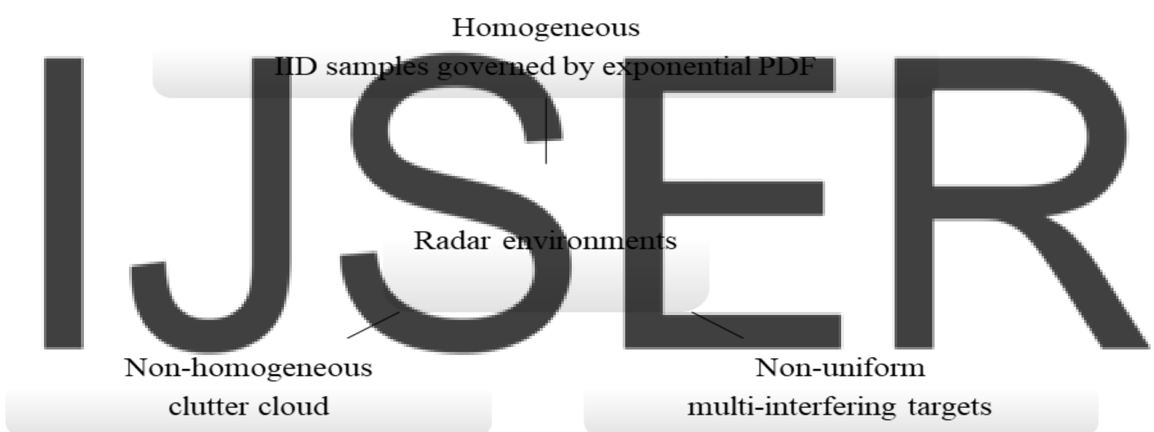

Figure 2: Radar environments

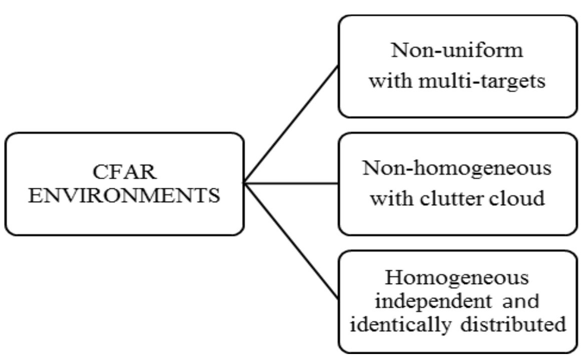

Figure 3:CFAR environments

3. CFAR theory

In a cell-averaging CFAR (CA-FCAR) detector, noise samples are extracted from both the leading and lagging cells around the cell under test (CUT). The noise estimate can be computed as:

$$P_n = \frac{1}{N}\sum_{m=1}^{N} x_m \qquad (1)$$

Where N is the number of training cells and x_m is the sample in each training cell. If x_m happens to be the output of a square-law detector, then P_n represents the estimated noise power. Guard cells are placed adjacent to CUT, both leading and lagging before it. The purpose of these guard cells is to avoid signal components from leaking into the training cell, which could affect the noise estimate [5].

The CA-CFAR technique is shown in Figure 3.

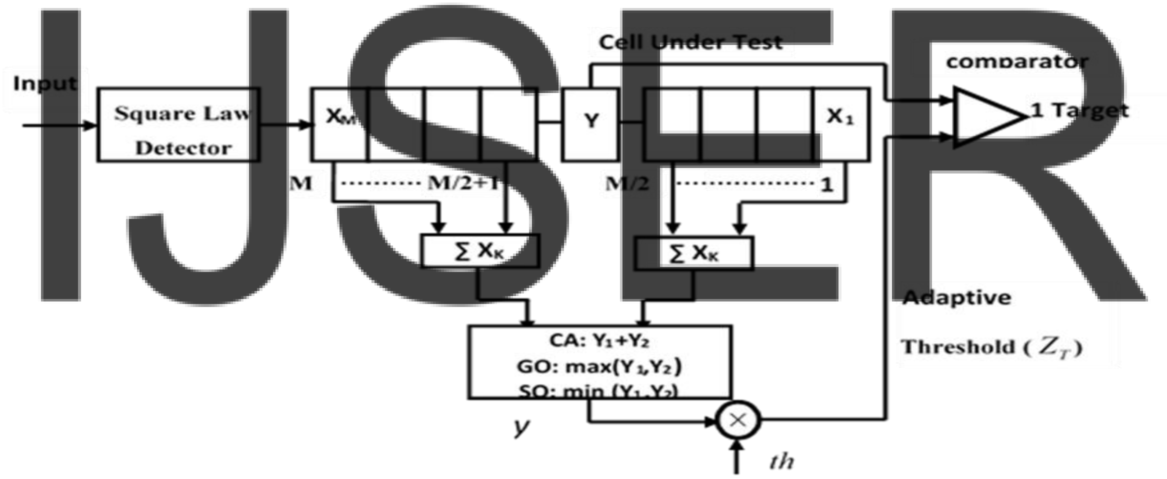

Figure 3: CA-CFAR structure

In an analogue circuit, the samples are obtained from a tapped delay line. However, in new digital circuits, the samples are obtained from shift registers. The cell under test (CUT) is the central cell (test cell). Its immediate neighbours are preferred to be excluded from the averaging process because of the fear of spill-over from CUT. In a basic CA-CFAR, the inputs from the *M* neighbouring cells are averaged, resulting in an estimate of the background noise (interference). The threshold is obtained by multiplying the estimated average by scaling factor α. The input from the cell under test is compared with the adaptive threshold in the same way as it would be compared with the fixed threshold. It is preferred to begin the analysis with the reference channel, which is used to control the adaptive threshold. Assuming the *M* samples of the reference cells are independently distributed and have a Gaussian probability density function, the envelope r of Gaussian noise has a Rayleigh PDF, which is:

$$P(r|A=0) = \frac{r}{\beta^2} exp \frac{-r^2}{2\beta^2} \quad (2)$$

where β^2 is used as the noise RMS value. Then, the envelope is normalised with respect to β^2using the square-law detector transformation:

$$z = \frac{r^2}{2\beta^2}$$

The k^{th} sample of the normalised detected noise has a PDF, given by:

$$P(z_k) = \ exp.(-z_k) \quad (3)$$

The output of the adder *y* will be:

$$y = \sum_{k=1}^{m} z_k \quad (4)$$

In addition, the PDF of *y* will be:

$$p(y) = \frac{y^{m-1}}{(m-1)!} exp(-y) \quad (5)$$

Hence, the threshold will be set at:

$$Z_T = y\frac{\alpha}{M} \quad (6)$$

where *M* is the window size and α is a scaling factor that determines the probability of false alarm. For the sake of simple mathematics, two restrictions will be made. The first restriction involves single-pulse detection, namely, there will be no integration as far as CUT is concerned, and detection is based on a single pulse, which excludes the possibility of Doppler resolution cells since these require several pulses [6]. Second, assuming that the target is a fluctuating target with a Rayleigh PDF, this can be either a Swerling 1 or Swerling 2 target since a single pulse is being dealt with.

Then, the Rayleigh PDF of the amplitude *A* is given as:

$$p(A) = \frac{-A^2}{2{A_0}^2} e^{\frac{A}{{A_0}^2}} \quad (7)$$

where A_0 is the most probable amplitude, which is related to the average signal power:

$$\overline{S} = \frac{1}{2}\overline{A^2} = A_0^2$$

The ratio $\overline{S}/\beta^2$ is the average signal-to-noise ratio:

$$\overline{SNR}=\frac{\overline{S}}{\beta^2} \tag{8}$$

The PDF of the signal-plus-noise normalized sample *z* is given as [13]:

$$p(z) = \frac{1}{1+\overline{SNR}}\, exp\, \frac{-z}{1+\overline{SNR}} \tag{9}$$

where SNR is the signal-to-noise ratio. These terms include another noise, such as interference, which also has a Rayleigh probability density function and is independent of range cell to range cell. When the threshold is fixed at Z_T, the probability of detection will be:

$$P_D\left(\frac{SNR}{Z_T}\right) = \int_{Z_T}^{\infty} P(z)dz = e^{\frac{-Z_T}{1+SNR}} \tag{10}$$

However, in a CFAR system, the threshold is a function of the random variable *y*, given in Eq. (2.27). Thus, Eq. (2.32) is only a conditional probability of detection, and the probability of detection will be obtained by averaging Eq. (2.32) over all *y*, as follows:

$$P_D(\overline{SNR}) = \int_{y=0}^{\infty} P_D\left(\frac{\overline{SNR}}{Z_T}\right) P(y)dy \tag{11}$$

Using Eq. (2.26) and Eq. (2.32) in Eq. (2.33) yields a new expression for the probability density function [18]:

$$P_D(SNR,\alpha,M) = \left(1+\frac{\alpha}{M(1+\overline{SNR})}\right)^{-M} \tag{12}$$

The probability of false alarm of CA-CFAR can be obtained from Eq. (2.34) by setting the average $\overline{SNR}$ to zero, thus:

$$P_{fa}(\alpha, M) = \left(1+\frac{\alpha}{M}\right)^{-M} \tag{13}$$

Average Detection Threshold (ADT) is an alternative measure to compute the loss of detection performance in a CFAR processor. The ADT for CA-CFAR is given by:

$$ADT = M.\alpha \tag{14}$$

It is clear that ADT is independent of noise power. From Eq. (2.35), Table 2.2 lists the values of the multiplier factor and ADT for various values of *M* and P_{fa}. This table can be used to find the multiplier factor from *M* and P_{fa} to construct the threshold value by multiplying the multiplier factor with the background noise estimate.

4. Target detection problem

In a radar receiver system, most CFAR processors can maintain a good determination of threshold value with the existence of certain assumptions about the environment. For cell-averaging CFAR (CA-CFAR), the important assumption is that the statistics of the interference at each reference cell are the same as the statistics of the test cell. This situation, called a homogeneous background, is when the reference cells contain independent and identically distributed (IID) observations governed by an exponential distribution. This condition is not met in three common situations:

A) The first problem is the clutter edge when a sudden increase in the background noise level makes two different effects:

If the cell under test is in the clear region, but a group of the reference cells is immersed in the clutter edges, a masking effect will result. The threshold will increase unnecessarily over the target echo signal and CFAR will not detect the target.

If the test cell is immersed in the clutter return but some of the reference cells are in the clear region, then the threshold will detect some noise spikes as targets and the probability of false alarm Pfa will increase.

B) The second problem is the capture effect, which happens when many targets exist in the reference cells for CFAR to detect. The threshold will increase and the probability of detection of the desired target will decrease, and hence CFAR cannot estimate the non-uniform background correctly and may not detect the primary target. The capture effect is known as a compression effect in some references.

C) The third problem is when the interfering targets are so close to each other that the radar resolution cell (range gate) may not be sufficient to separate them. If the targets are close to each other, CFAR may record the strongest one. The consequent masking of one target by the other is called the suppression effect [7].

The problems are stated in Figure 4. Since spikes are the common problem that appears in non-homogeneous and non-uniform radar environments, therefore our main objective will be to reduce the effects of spikes that appear in the three radar environments, as shown in Figure 2. Two classes of adaptive thresholding methods can be recognized:

i. Spatial, in which the threshold level is estimated by using returns from resolution cells which are adjacent to the cell of interest

ii. Temporal, in which use is made of returns gathered from previous scans in the same cell of interest to estimate the threshold value

The classification is motivated by the characterization of interference (in particular, clutter), which allows one to predict performance and then select the adaptive threshold technique. This sets the scene for the next section, which describes the environment in which the radar operates. Most popular temporal CFARs use the clutter-map CFAR technique, in which the reference cells comprise the range-Doppler (RD) cells obtained from all scans up to the current one. This method needs a very huge memory capacity to store the environment information from every radar scan used to estimate the threshold, and it needs very high processing time since we must wait for many radar scans to estimate the threshold for the CFAR circuit. In the clutter-map CFAR detector, a common method is to use a recursive formula, in which the current interference estimate is a weighted sum of the previous estimate and the current scan data. Most of CFAR algorithms consider spatial CFAR, which uses the sliding-window CFAR technique, which slides in the reference cells in the period between two successive radar pulses. For the sliding-window technique, the set of reference cells comprises the neighbouring cells around the test cell in the range-Doppler (RD) map of the current radar scan. Clutter-map CFAR can be combined with the sliding-window CFAR to give a better detection performance, and the spatial CFAR is classified into two groups: standalone CFAR

Figure 4: Problem statement

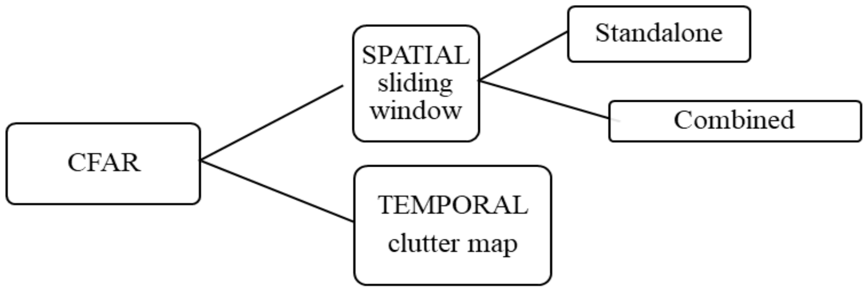

Figure 5: CFAR methods

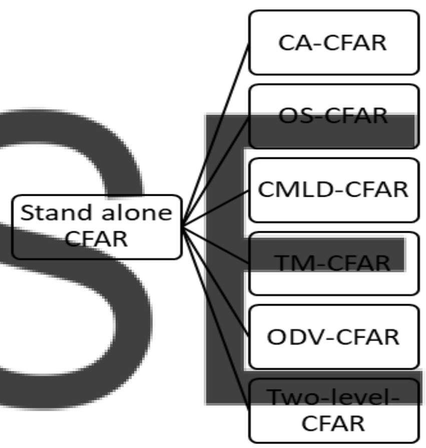

Figure 6:Standalone CFAR types

5. The CFAR threshold estimation

To estimate the mean noise or clutter present in a specific range gate, other local range gates are used. Towards this end, most CFAR algorithms utilize a moving window. There are several components to the CFAR window. CUT is the range gate with which the mean noise or clutter is estimated and with which the threshold is set, while reference cells, or cells near CUT, are used to estimate the mean. Different CFAR algorithms utilize different mathematical estimations and make different decisions. Cell-averaging CFAR, for instance, takes the mean of the reference cells, while ordered-statistics CFAR orders the reference cells from smallest to largest to take the largest kth as the representative of the average noise. The CA-CFAR algorithm runs as follows:

(i) CA-CFAR estimates the unknown background power of the reference cell samples, assuming an independent and identical distribution of samples governed by Rayleigh and exponential PDFs.

(ii) Compute the probability of detection and probability of false alarm.

(iii) Compute the threshold multiplier from the probability of false alarm.

(iv) Multiply the threshold with the samples' power estimation, and the adaptive threshold is produced [3].

6. The CA-CFAR and OS-CFAR algorithms

The reference window is constructed from one sample cell obtained from the analog sampler, which converts the radar range echo signal into digital code. Figure 2 displays the CA-CFAR family. The average of the surrounding reference cells is used to estimate the background noise. If the summation of the leading reference window samples is greater than the summation of the lagging reference window samples, the greatest of GO-CFAR is constructed. If the smaller value is selected between them, the smallest of SO-CFAR is constructed.

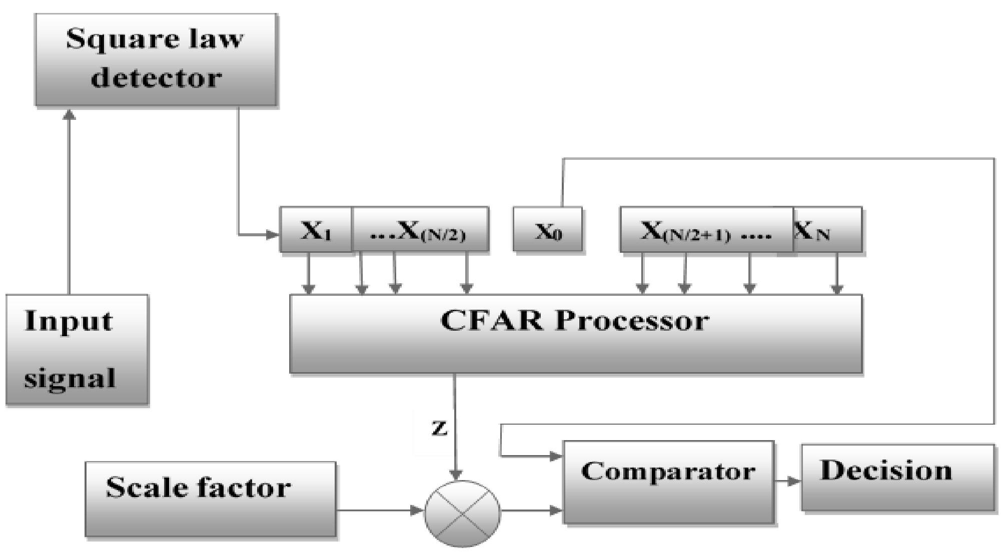

Figure 7:CFAR processor block diagram

The ordered statistics OS-CFAR algorithm is proposed for multitarget problems and requires prior knowledge of the expected number of targets. The algorithm consists of three steps: sorting the reference cells, estimating the interference power based on the kth sample in the ordered sequence, and choosing the appropriate rank for the OS-CFAR family to function properly. If the sorting process is performed separately for the leading and lagging windows, as shown in figure 3. The greater value between leading and lagging is selected to construct the OSGO-CFAR, while the smaller value is chosen to construct the OSSO-CFAR. [4].

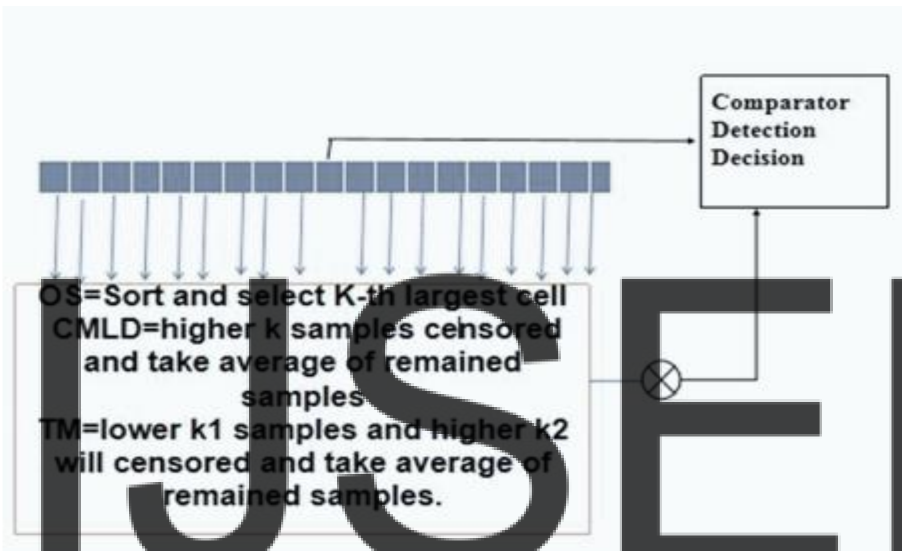

Figure 8:The development of OS-CFAR-based processors

7. Essential factors in MATLAB simulation process

To test these methods, the radar environments will be created with models, and each algorithm was applied separately to these models to examine the behavior of each of them in the worst radar environment and other environments. There are four factors of special importance when dealing with CFAR algorithms, as shown in Figure 3.5, which are the size of the window (M), multi-interfering targets, the closely spaced targets, and the clutter cloud length

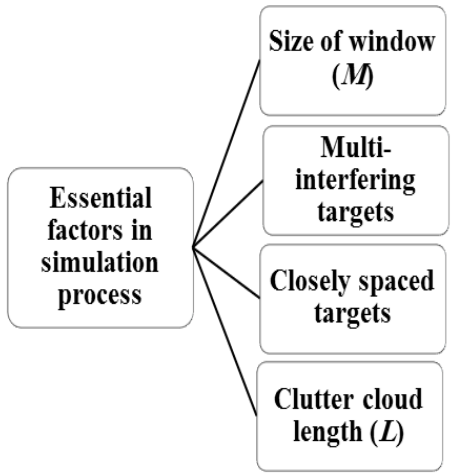

Figure 9: Essential factors in the simulation process

i. Closely spaced targets

Closely spaced targets are a special case from multi-interfering targets when the interfering targets lie close to each other in the reference window causing the capture effect when the CFAR detects only the strongest target and may not detect the small targets. And there are many solutions proposed to detect the closely spaced targets by using the ordered statistics modified method and if the numbers of targets are known, CMLD-CFAR could be used and excision-CFAR also can be used and multi-step-CFAR and finally, the new method of fusion CFAR detectors suggested in 2016 and feedback concept in 2017 to solve the problem. And if the closely spaced targets were so close to each other that they exist in the same range gate, then the radar cannot see the targets and record the strongest one only, this situation is called the suppression effect.

ii. Windows size (M)

The size of the window (M) is the number of cells that are used to estimate the background noise. Also, this window moves like a sliding window during the time between pulses to maintain the adaptive threshold. When M is increased, the CFAR loss in a stationary noise background monotonically decreases, together with an increase in hardware complexity. Also, with increasing M, an inevitable violation will occur in the inherent assumption that the noise samples are identically distributed over the reference window, which is used to estimate the noise in the cell under test. Therefore, in a non-homogeneous environment, the CFAR penalty sometimes increases more with larger *M*. Also, the likelihood that an interfering target or a 'spiky' clutter return could enter the reference window will be larger for larger M [2].

i. Multi interfering targets

The multi-interfering target is essential factors in the MATLAB simulation process because when the interfering target lies within the reference cells with the primary target, the threshold raises, and the detection of the primary target is degraded.

ii. Clutter cloud length (L)

The statistical model with uniform clutter background that originally is exclusively used for the development of CFAR procedures has lost its predominance since it is a rather true approximation only for one of the numerous different clutter situations occurring in practice. A single model cannot describe the real radar environment, yet the consideration of a larger number of different situations might be confusing. For these reasons, in the following, four different signal situations are selected [3]. The ratio of M/L is very important, as when it is greater than two, the response will be worse. When the clutter cloud is within the reference window, the threshold value will rise and the probability of detection is degraded. The larger length of the clutter cloud means more cells in the clutter cloud region. The other situation is when a clutter cloud with high power gives the probability of some small targets immersing in that cloud. The last situation with special importance happens when the clutter cloud merges with multi-targets and the detection problem becomes more complicated; multi-targets cantering in the clutter cloud is the worst radar environment.

8. Common factors for simulation

First of all, the size of the window must be the same for all families to give them equal opportunity for competition with each other, also, the size of the window should be suitable for them, therefore, it is chosen to be M=32, but in chapter 5 for circuit implementation purpose the smaller size of the window is taken. The second important common factor is how to choose the value of the probability of false alarm P_{fa}. There are three common values for P_{fa} , 10^{-4}, 10^{-6} and 10^{-8}. Therefore, the most suitable and usually used for research purpose is the mid-value $P_{fa} = 10^{-6}$.

9. The testing models

The CFAR algorithm is tested by testing model that constructed from Multi targets that have different magnitudes and to make detection Procedure more complicated from the other models the multi-target is merged with clutter cloud and there is also closely separated targets which are located in different places. For more details there are 20dB at 40^{th} and 50 dB at 50^{th} and 30 dB at 45^{th} and 55^{th} cell positions from 100th to 200th cell clutter cloud which is centered by five closely Targets (2-30dB, 2-40dB, 70dB) respectively, and there is one target 40 dB Magnitude at 230^{th} cell centered between two targets with 20dB magnitude locations 225^{th} and 235^{th} cell respectively, as shown in Figure (5).

The CFAR algorithms deal with four situations, multi target, clutter cloud, multi target merged with clutter, multi-targets located inside clutter. In this model three regions shown: Closely separated multi targets merged with noise, multi targets cantered in clutter cloud representing the worst radar environments [2].

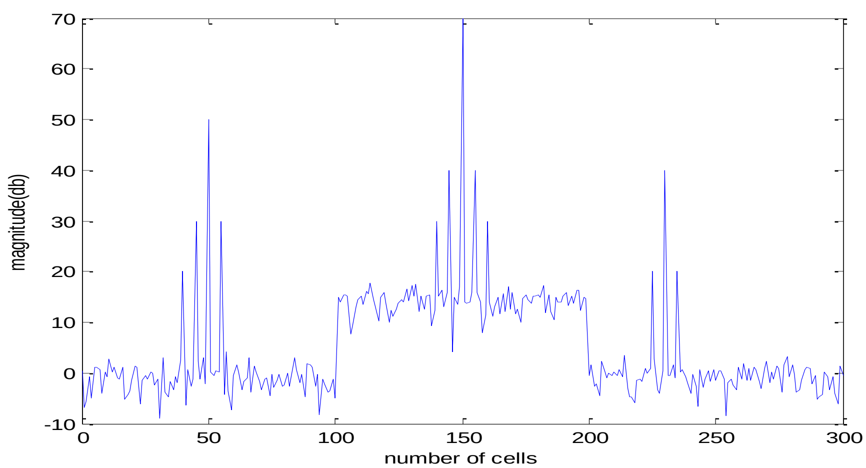

Figure 10: the test model

10. comparison

The CA-CFAR family showed poor response to the three models. Since the CA-CFAR family uses very simple hardware, it needs a very short processing time compared with the other methods. However, when there are several closely spaced targets causing non-uniform environments, the performance of the CA-CFAR family is degraded.

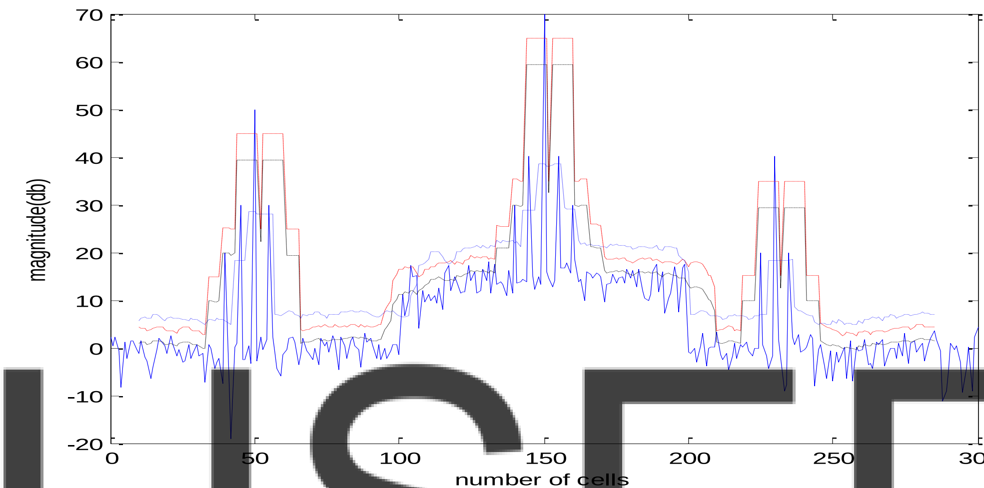

Figure 11: CA-CFAR Family with M=16, P_{fa} $=10^{-6}$ applied to the testing model

Meanwhile, the OS-CFAR family needs prior knowledge of the number of interfering targets. Although this family shows robust performance in non-uniform environments with closely spaced multi-targets, it handles the clutter cloud that causes non-homogeneous environments and showed good response even with the clutter cloud's existence, except OSSO-CFAR that fall in clutter. Although OSGO-CFAR has half the processing time of OS-CFAR, it still uses the sorting circuit, which has a high processing time and complicated hardware, while also needing prior knowledge of the number of interfering targets.

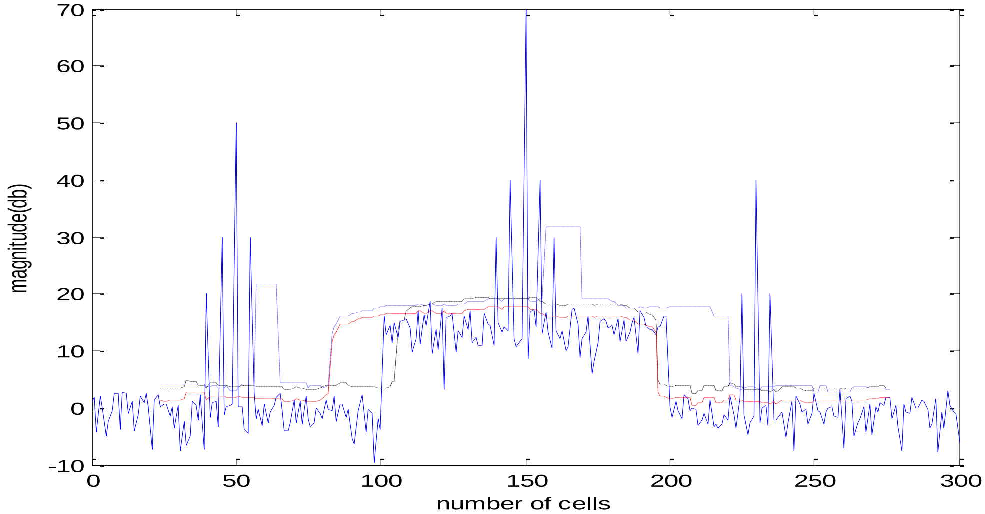

Figure 12: OS –CFAR family applied to test model, M=48, P_{fa} $=10^{-6}$

When applied to the three models, the OS-CFAR family behaved much better in the clutter-edge and multi-target environment than the CA-CFAR family, especially OS-CFAR. OS-CFAR needs very high processing time and because of the process of sorting the samples, it is very hard to be implemented in an electronic circuit. Even though OSGO-CFAR needs only half the processing time of OS-CFAR, the same hardware complexity as OS-CFAR's sorting circuit is used.

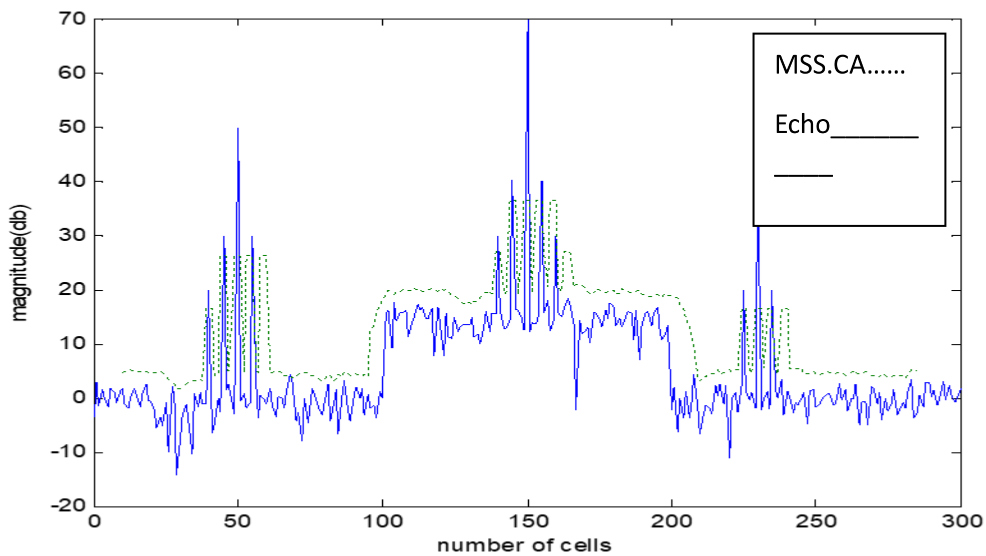

Figure 13: MSS- CA-CFAR response to test model, M=16, P_{fa} $=10^{-6}$

11. Conclusion

Several CFAR processors that showed robust performance in non-homogeneous and non-uniform radar environments were studied in the literature review chapter. The common gap in these algorithms is that they underestimate the amount of processing time, the hardware stages, and the components required to implement different processing algorithms. Also, an evaluation of different processing algorithms concerning different parameters, such as processing time, hardware complexity, and performances in non-uniform and non-homogeneous radar environments introduced in the literature review chapter confirms that gap.

A new algorithm, MSS-CFAR that needs no prior knowledge of the number of interfering targets was analysed in MATLAB simulations before implementing it in the FPGA schematic circuit. The most important feature of MSS-CA-CFAR is that it can adapt and work in all radar environments effectively with processing time suitable for radar real-time application, and it does not need complicated hardware, while OS-CFAR can be used only with nonuniform and nonhomogeneous environments, also OS-CFAR needs prior knowledge of the number of interfering targets, and used samples ranking and sorting that needs very high processing time comparing with MSS-CFAR [2].

12. Future works

The first suggestion is to use the MSS-CA-CFAR in-car anti-collision system since it has a low processing time, it can show high sensitivity to car movements, MSS-CA- CFAR detectors can be employed by radar sensor systems, and also using it can construct high-performance radar system for automated driving, and can be used in a new car auto driver system as a censer for the surrounding object movements. Also, the new CFAR method can be used to develop a real-time seismic detection system [2]. Since MSS-CFAR has low processing, therefore can use in the real-time anti-jamming system [63]. In new moving targets indicator MTI and moving targets detector MTD systems, MSS-CFAR will be very effective [8].

Other suggestions are to use a neural network as a switching circuit between CFAR methods to improve CFAR performance in the nonhomogeneous environment [2] or use this method with a support vector machine as intelligent CFAR [2], also in the military can be used for a real-time decision making in war environment. MSS-CFAR can used also to construct new VI-CFAR that is used in marines and the ground-penetrating radar, by replacing the CA-CFAR family with MSS-CFAR family and suitable for real-time track the high-speed targets in multi-static radar that used to construct the wireless sensor network [2][6].

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