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OS-CFAR Based on Insertion Sorting Algorithm Using Linked-List Structure

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***Abstract*—CFAR is used to detect the target keeping constant false alarm rate. CA-CFAR is simplest method used for target detection but it is not effectively work in non-homogeneous environment. OS-CFAR is effective than CA-CFAR in non-homogeneous environment. It uses sorting algorithm based on rank but this method is highly computational. In this paper, we proposed new method for sorting for OS-CFAR. Anchor based insertion and sorting in Linked-List based structure which represents ordered sequence and Anchors represents featured samples. This scheme reduces computations and this is verified through results.**

***Index Terms*—CFAR, link list, ordered statistics, insertion, sort.**

I. INTRODUCTION

It is crucial to detect targets keeping constant false alarm rate Non-homogeneous or Automotive environment. Since many years, a lot of CFAR detectors, such as CA-CFAR, GO-CFAR, and OS-CFAR introduced to apply the radar system in non-homogeneous environment for multiple target detection and for non-uniform clutters. Amongst them CA-CFAR is the most simplest method based on cell averaging algorithm and having very simple computations, but it has drawback of detection of targets in non-uniform environment and non-uniform clutters. Therefore a new technique OS-CFAR based on sorting algorithm is introduced. It works effectively in automotive environment for multiple target detection.

In OS-CFAR the reference cells (X1 ~ XM) in the sliding reference window are utilized for the figuring of the threshold value, where M is window size. Values taken from the reference window are initially sorted as per expanding size and after that it select the *kth* ordering statistics X(k) and multiply this by a scaling factor. The resulting product is directly used as the adaptive threshold value to detect a target. Entire process gets repeated for N samples.

OS-CFAR I the most effective method in automotive environment amongst all but it suffers high computational problems due to its order statistics and sorting methods. To overcome this computational problem and reduce the required time several algorithms are proposed. Technique is sorting the reference window data only one time instead of sorting for N samples. In this all input data is sorted and then stored in the sorting register along with indexes. After that, these sorting registers values are used in entire process. Therefore, it reduces the computational headache by reusing sorting registers values.

In this method, problem arises when new data gets added in the reference window. As it added, all the values should be sorted again. Therefore all values are shifted from their position to new position. This is shifting problem in this technique.

In this paper, we proposed Anchor-based Insertion Sorting Algorithm for OS-CFAR (ABIS). In this scheme, Linked-List based structure which represents the reference window. It is register which stores the sorted values and it handles all the shifting operations when new data added in the reference window. For old samples, Cell Under Test (CUT), *kth* element Anchors are used to represent. By using this scheme, Anchor-based Insertion Sorting Algorithm reduces computational headache drastically.

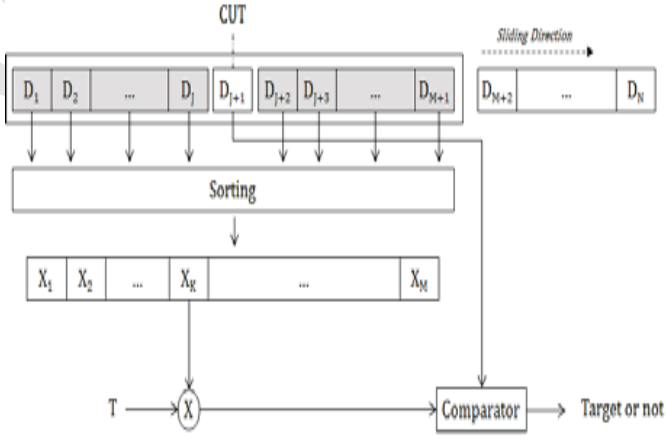

Fig1. Typical OS-CFAR detector

II. RELATED WORK

In this section we analyze some other methods or technique which uses sorting algorithm to reduce computations

[4] Has proposed versatile linear insertion sorting technique which uses linear sorting algorithm which is based on First In First Out (FIFO). In this method, Sorting Basic Cell (SBC) is used as a sorting register which stores the sorted data. When new data comes in reference window it discards the old data and make room for the new incoming data. Some SBC's can shift the old data instead of discarding them. As this method completes this discarding or shifting process in single cycle, it

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reduces computations. Reference [3] Has proposed a New OS-CFAR Detector which uses sorting algorithm with reduced computational overhead. In this scheme, all the input data is sorted single time instead of sorting for each reference window in increasing manner ($X(1) \geq X(2) \geq \ldots \geq X(N)$) and stored in Sorting Register. By obtaining information from positions of sorted data, the corresponding *kth* ordering statistic, $X(k)$ can be obtained.

III. ANCHOR BASED INSERTION SORTING

A. Operations

This technique sorts the reference window data only single time and reuse this ordered reference window many times to reduce computational headache. In ABIS there is Cell Unit List (CUL) which is made up of some Cell Units (CU) . In addition, there is Linked-list based structure to represent Present data and Anchor Unit (AU) to represent old data in the reference window.

Cell contains information data in it, ABIS takes these value in reference window which is shown in Fig. as grey colored and then sort out this data in CUL which does not contain CUT (Cell Under test). CUT is nothing but the any one CU from (M +1) CUs present in CUT. M is reference window size which contains data. During sorting position of CU's is not changed and CU assigns their previous and next index values in CUT. CU consist of four parts, sampled value of data, its index value and previous and next values index of CU's and these indices are *idx(prev) and idx(next).* if *Cui* is CU of *CUj* 's next order , *Cui.idx(next)* is assigned to *j* and *CUj.idx(prev)* is assigned to *i*. Here, for CUT indices are not defined because CUT is not included in this CUL. In Fig.3 basic Link-list based structure is shown which contains input samples, CUT and ordered sequence. Therefore the ordered sequence is ($XU(1) \leq XU(2) \leq \cdots \leq XU(M)$) like this and from this sequence we can obtain the *kth* ordered CU.

In Fig.3, AU are Anchor Units used to identify featured CUs. There are 5 AUs in the reference window which denotes 2 right hand side CUs such as right head and right tail CU, left Hand side CUs such as left head and left tail CU and CUT in sub-reference window. In ordered sequence also contains 3 AUs, one is used to denote smallest value in ordered sequence, one is used to denote largest value and remaining is used to represent CU of *kth* order.

When sliding window operation is executed then old samples of previous reference window should be eliminated and with the use of Right Head and Left anchors they can be retrieved easily. During sliding window *idx(next)* value is assigned to neighboring CUs of old CUs. After sliding two new CUs are added, their values are replaced with the values of Left Head and Right Head. In such way all the data is Sorted, Inserted and replaced by Anchors. This is the Insertion Sorting Algorithm for ABIS.

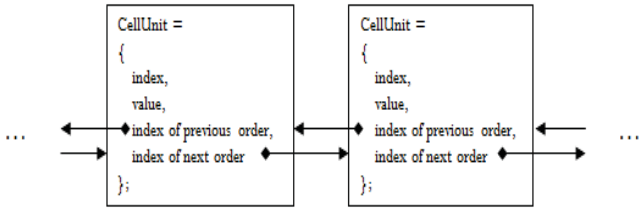

Fig2. Structure of Cell Unit

IV. PERFORMANCE EVALUATION

The ABIS technique we implemented and the new OS-CFAR detector which uses quick sort algorithm. For this, first we generated Transmitted pulse and Received signal added with noise. We analyzed the performance of these techniques by varying the number of input samples and the reference window size.

V. RESULS AND ANALYSIS

By varying the reference window size, we measured the performance of both the techniques which showed in Fig.4. From results we observed that, the total processing time required for ABIS is much smaller than OS-CFAR although it uses quick sort algorithm because, every time new samples in the reference gets copied for sorting in this technique but in ABIS, it uses the previously ordered sequence which is stored in CUL.

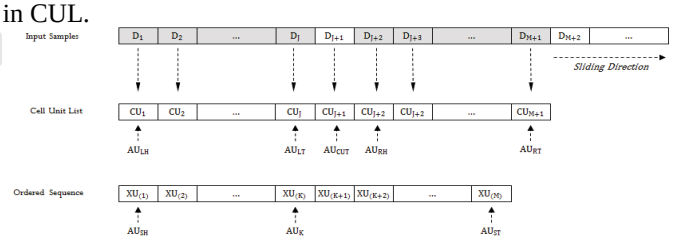

Fig3. ABIS Structure

We varied the window size M here, we observed that, when the window size is small, the performance of both the technique is nearly same because data is in small size and for CUL management Au is required. So, both techniques are same for small data. But if we increase the window size, the ABIS's consuming time not much increases but for OS-CFAR it increases drastically.

In rundown, ABIS demonstrates the execution enhancements of 40%-50% as far as processing time.

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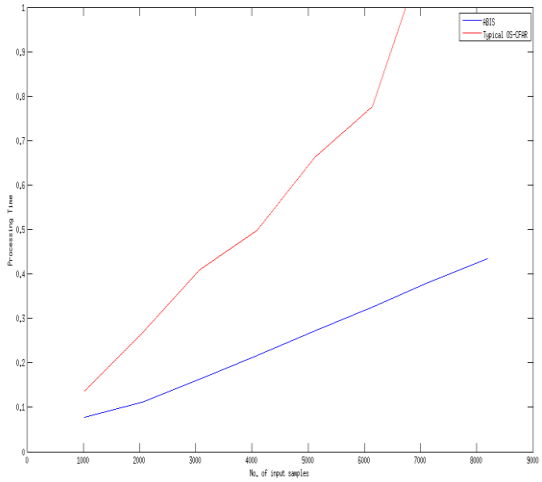

Fig4. Simulated Result

VI. CONCLUSION

In this paper, we introduced technique of Anchor Based Insertion Sorting Algorithm based on Linked-List structure. It uses Anchors and CUL for Cells and required samples which performs insertion sorting method using previously ordered statistics to reduce computations and processing time.

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