DETECTION OF MARINE VESSELS BASED ON POLARIZATION POWER SCATTERING MATRIX

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ABSTRACT

Satellite images are playing very important role for the coastal security of any country. Independence of Synthetic Aperture Radar (SAR) images from weather and sun illumination helps us in maritime surveillance like an oil spill, to identify the illegal fishery activity and unauthorized marine vessels. Marine vessel detection is like a point target detection in coarse to moderate resolution images. Detection of point targets is adversely affected by speckle noise, thus improvement in the power of point target leads us to reduced number of false alarms. In this paper, an algorithm is presented for marine vessel detection. The algorithm is divided into three parts. First part uses Grave matrix which is a (2*2) Hermitian power matrix, generated by the multiplication of Sinclair matrix and its conjugate. Second part uses discrimination criteria to discriminate between clutter and vessels based on eigenvalue of the Grave matrices. The third part is a post-processing part to fill the gaps and to find the centroid of the vessels. The algorithm has been tested on two full polarization (HH, HV, VH, VV) data sets and promising results are obtained with less number of false alarms. The first data set is AlOS -1 PALSAR L-band data, with size of 498*498 near the coastal region of Singapore. The second data set is of size 472*472, covering coast of Vancouver acquired in C-band by Radarsat-2.

INTRODUCTION

In case of clutter based statistical approach main problem is how to model a clutter to get the desired objects. Statistical approaches are mainly suffering from the two effects, one is capture effect and another one is cluttered effect, these two effects are due to outliers and background intensity transition respectively. It was observed that approximation of echoes depends upon the illuminating area, the less illuminating area is well approximated by Non-Rayleigh distribution and coarse illuminating area can be approximated by Rayleigh distribution [1]. [2] Used, fully polarimetric data (HH,VV, HV,VV) and approximate sea clutter by using multivariate k - distribution. To discriminate target from background clutter, it is required to have some kind of threshold.Some authors used various versions of CFAR like [3],[4],[5] CA-CFAR (working well in homogeneous environment), SO-CFAR, AOS-CFAR respectively. [6] Used variability index CFAR (VI-CFAR) which computes second order statistics from the data in reference window and ratio of means of leading and lagging window. These statistics help to improve the performance of VI-CFAR in homogeneous environment and it assists to perform robustly in non-homogeneous environment like multiple targets and in presence of clutter edge. It combines the best quality of CA-CFAR, GO-CFAR and SO-CFAR.

Marine vessel detection is just like a point target detection. Detection of point target in sea is mainly affected by two things one is speckle noise and another one is Bragg scattering (a scattering occurs at surface of sea due to tides).

These two are mainly responsible for generation of false alarm, so if we improve the power of point target then the detection yields fewer false alarms.

PROPOSED METHOD

By considering all above facts, we came up with an algorithm, the flow diagram of proposed algorithm show in Fig (A)

The Steps involve in the proposed algorithm are given below.

Step 1 By using of Single look complex (SLC) image as input image, we generated Sinclair matrix and its conjugate matrix.

Step 2 Multiplication of Sinclair matrix and its conjugate will lead us towards a scattering power matrix named as Grave (G) matrix.

$$G = S^*S = \begin{bmatrix} |S_{XX}^2| + |S_{XY}^2| & S_{XX}^* S_{XY} + S_{XY}^* S_{YY} \\ S_{XY}^* S_{YY} + S_{YY}^* S_{XY} & |S_{XY}^2| + |S_{YY}^2| \end{bmatrix}$$

G = Grave polarization coherent power matrix

S = Sinclair matrix

S^* = Conjugate of Sinclair matrix

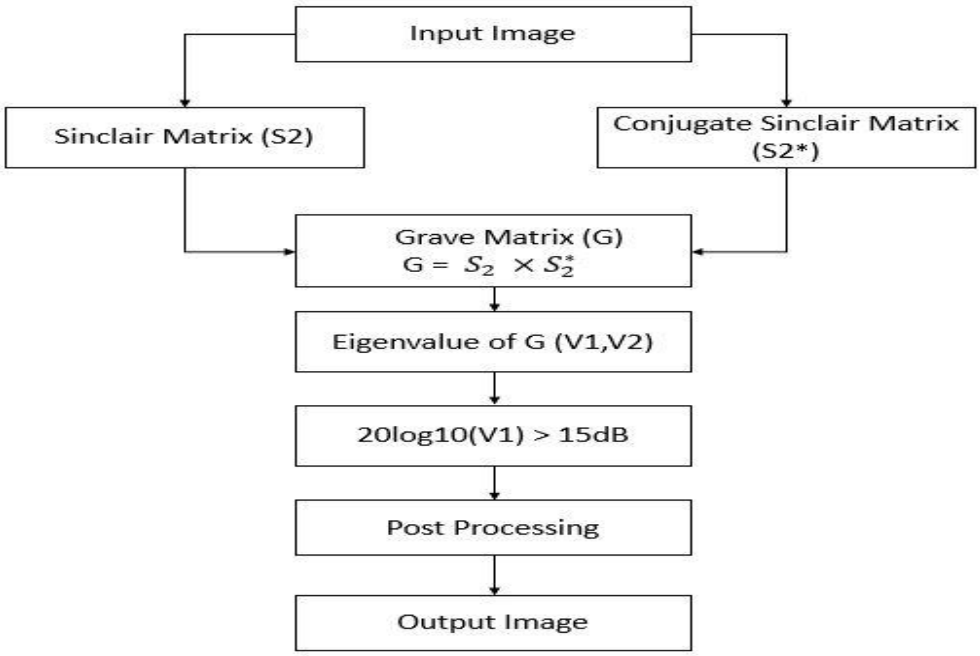
Step 3 Grave matrix which is a (2*2) Hermitian power matrix, having Eigenvalue greater than or equal to zero.

Eigenvalues of Grave matrix can be calculated by following way –

$$V_{1,2} = \frac{Tr(G) \pm \sqrt{Tr(G)^2 - 4\,|G|}}{2} \qquad with\, V_1 \geq V_2$$

Step 4 Here we are considering a threshold to discriminate vessels from clutter. In which, if the power of target is greater than the 15 dB we are considering it as vessels and if not then its clutter. So it will lead us towards better detection of Vessel (point target) in the sea without specifically eliminating the speckle noise.

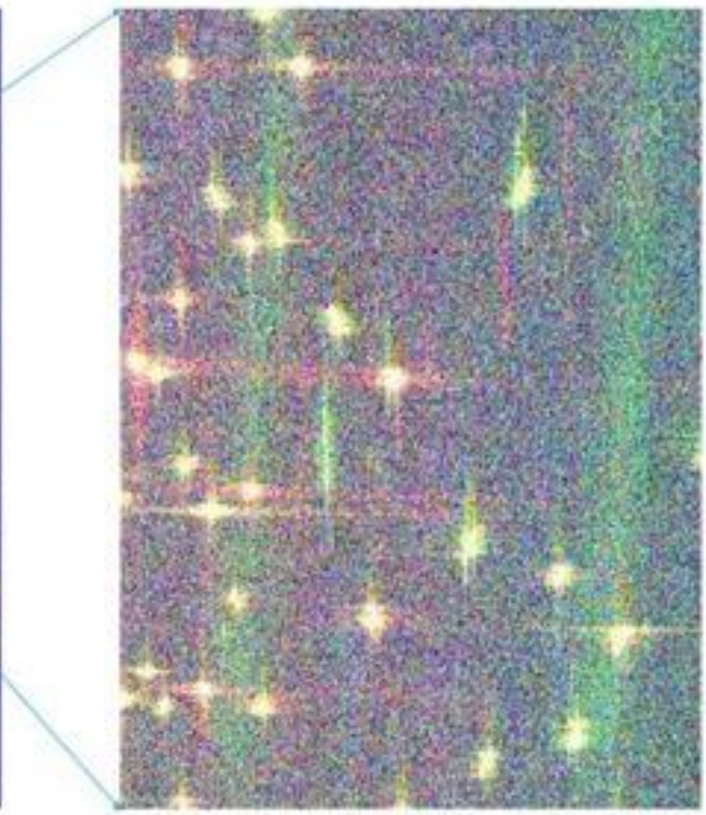
Step 5 The post processing part is divided into two subparts. The first subpart includes morphological operation dilation, which is used to fill the gaps and connect the disconnected parts. Second subpart used a criteria which are not only distinguishing between small and big vessels, but it will helpful to count and mark the centroid of vessels. Criteria that we used to discriminate small and big vessels is eccentricity, if the eccentricity is greater than 0.8 then we consider it as a big vessels otherwise it's a small vessel.



(A) Flow Diagram

RESULT AND DISCUSSION

Alos-PalSAR-1

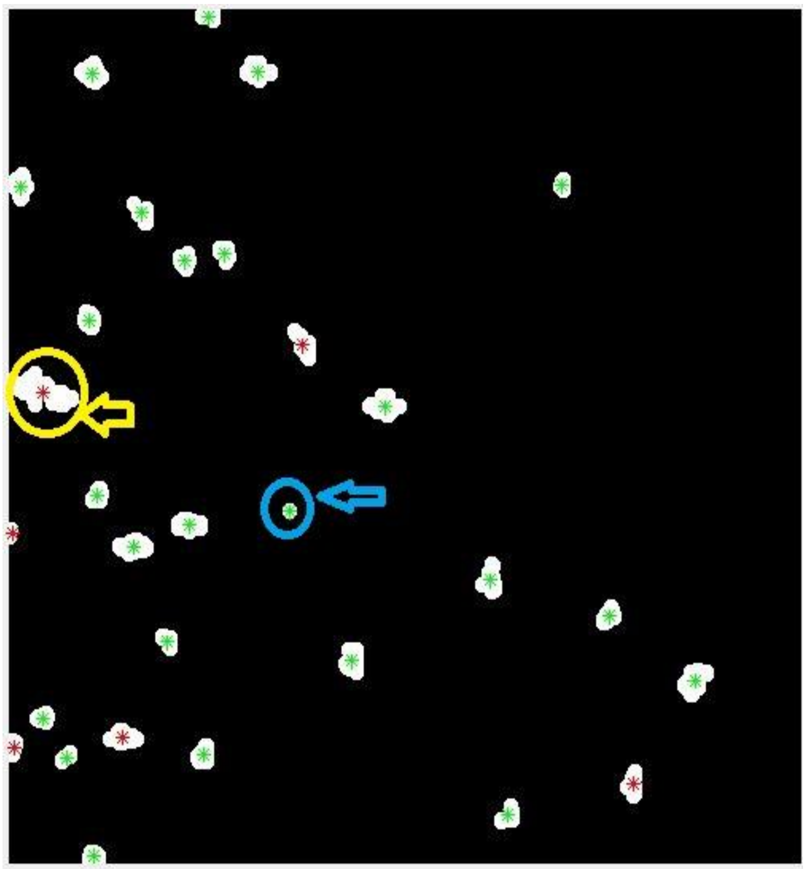
(B) Pauli RGB (C) Study Area 498 * 498

Table 1

Parameters	Values
Band	L
Polarization	Quad
Data Format	BSQ
Azimuth Looks	6
Range Looks	1
Pass	Ascending
Far Look angle (Degrees)	21.5
Incidence angle (Degrees)	23.97
Range Pixel Spacing (m)	3.56123
Azimuth Pixel Spacing(m)	9.368514
Data Site	Coastal area in Singapore
Study Area size	498 * 498

Table 2

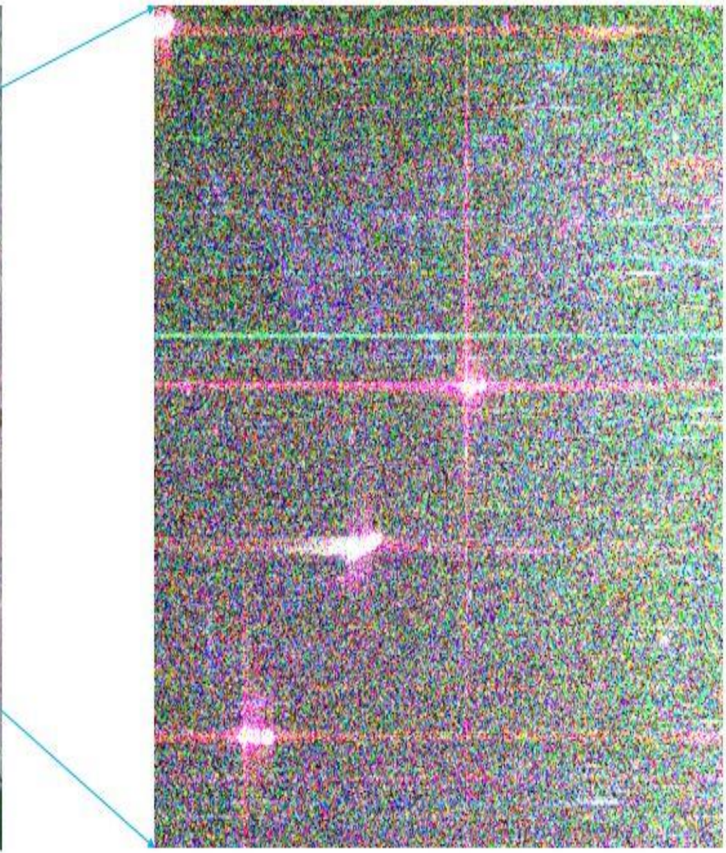
Parameter	Number of Vessels
Total Vessels	30
Small Vessels Detected	23
Big Vessels Detected	6
Total Vessels Detected	30
False Alarm	2



(D) ALOS PALSAR 1 Output Image

RadarSat-2

(G) Pauli RGB



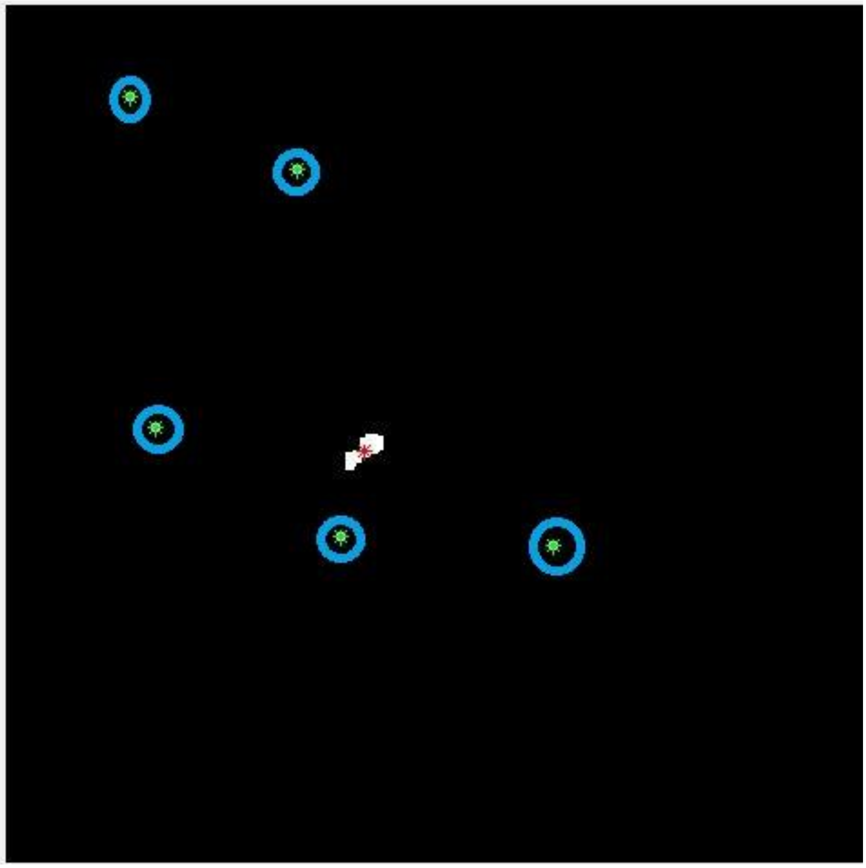
(H) Study Area 472 * 472

Table 3

Parameters	Values
Band	C
Polarization	Fine Quad
Azimuth Looks	1
Range Looks	1
Pass	Descending
Range Pixel Spacing (m)	4.7330
Azimuth Pixel Spacing(m)	4.8716
PRF (MHz)	2737
Data Site	Vancouver Data

Table 4

Parameter	Number of Vessels
Total Vessels	4
Small Vessels Detected	0
Big Vessels Detected	1
Total Vessels Detected	1
Total vessels Undetected	3
False Alarm	5



(I) RADARSAT-2 Output Image

ALOS PALSAR-1 PauliRGB image and study area having size of 498*498 pixels are shown in Fig (B) and Fig (C). Fig (G) and Fig (H) are showing RADARSAT-2 PauliRGB image and its study area having size of 472*472 pixels. Table 1, Table 3 contains information regarding to data type. Table 2, Table 4 is shown about the how many total vessels are present in the image, how many detected and how many false alarm generated by the proposed algorithm for ALOS PALSAR-1 and RADARSAT-2 data respectively. Fig (D) show output of the algorithm, which is able to detect 23 smaller vessels and 6 big vessels applied on ALOS PALSAR-1 data. Apart from this, algorithm generated two false alarms. The first one is a wrong vessel and the other one is two vessels are merged (due to less space between them) into one vessel shown in blue and yellow circle respectively Fig (I) shows the output of RADARSAT-2 in which algorithm were able to detect only 1 big vessels out of 4 vessels and shows 5 false alarms indicated by a blue circle.

CONCLUSION

Detection of marine vessels (point target) in the presence of speckle noise is a challenging task. In this paper proposed algorithm is used to detect target using a scattering power matrix which is generated by multiplication of sinclair matrix and its conjugate. Algorithm is tested on two different data sets one is ALOS PALSAR-1 having study area is 498*498 and other one is RADARSAT-2 having study area 472*472 pixels. Proposed algorithm is working well in L band with less no of false alarm as compared to C band.

Acknowledgement –

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