SHIP DETECTION AND ITS DIMENSION ESTIMATION – AN ANALYSIS BASED ON HYBRID POLARIMETRIC RISAT-1 DATA

Pooja Shah[1], Dr. Tanish Zaveri[1], Dr.Raj Kumar[2], Darshan Patel[1]
[1]Institute of Technology, Nirma University, Ahmedabad
[2]Space Applications Centre, ISRO, Ahmedabad

ABSTRACT

Detection of ship and estimation of its characteristics has its significance in tracking these sea vessels for surveillance. It also has its importance as an ancillary information for marine applications like oil spill detection and its source tracking. This paper aims to explore the strength of hybrid polarimetric information present in RISAT-1 CTLR data through PolSAR pro ver 5.1. RISAT-1 was one of its kind space born SAR which provides CTLR Level-1 data. The processing steps involves generation of covariance matrix and decomposition followed by classification. For decomposition entropy and alpha are obtained for ship detection. H-Alpha Wishart classification is empirically found significant in further enhancing the visibility of ship in ocean. This is required for better accuracy of calculating length and breadth characteristics of ships programmatically.

Index Terms— SAR Polarimetry, H-Alpha Wishart classification, Compact polarimetry

1. INTRODUCTION

Electromagnetic waves are transverse in nature. Thus, they take after property of the heading of motions, which is known as polarization. It has been watched that waves of settled recurrence at a settled area appear as basic geometric shapes like lines, ovals and circles. Each component on the ground scrambles radar vitality in a certain way. Disseminating component describes the dissipating from a given component regarding basic components for which we know the dispersing conduct viz., surface disseminating, dihedral, trihedral, volume dispersing [1]. For the off shore monitoring satellite data can be considered for its effectiveness in reaching remote location and gather surrounding information. Synthetic Aperture Radar is considered to be the finest choice for such applications for remote data gathering with its all weather day and night capability. In this research work the data is retrieved from Indian SAR sensor RISAT-1 which was launched in 2012 by Indian Space Research Organization.

Section 2 elaborates different decomposition techniques used for classification like entropy and alpha which is essential for H-Alpha Wishart classification. Section 3 explains the details of experiments on the ship data of Bombay area which is accompanied by used methodology to detect ship and calculate its characterisitics. Example of a candidate ship is used to explain calculation of length and breadth of ship being carried out. It also gives the specifications of data used in this research. It is followed by a conclusion.

2. BACKGROUND

2.1. Polarimetry and Image Matrix Formation

As mentioned before RISAT-1 is capable of operating in a Circular Transmit and Linear Receive mode, using the same covariance complex matrix can be generated using the mentioned formula:

$$C2 = \begin{bmatrix} < E_{CH}E_{CH}^{*} > & < E_{CH}E_{CV}^{*} > \\ < E_{CV}E_{CH}^{*} > & < E_{CV}E_{CV}^{*} > \end{bmatrix} \quad [2\text{-}7]$$

The system measure complex scattering projection as shown here [2-7]

$$\begin{bmatrix} E_{CH} \\ E_{CV} \end{bmatrix} = \frac{1}{\sqrt{2}} \begin{bmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{bmatrix} \begin{bmatrix} 1 \\ \pm i \end{bmatrix} = \frac{1}{\sqrt{2}} \begin{bmatrix} S_{HH} \pm iS_{HV} \\ S_{VH} \pm iS_{VV} \end{bmatrix}$$

The target vector of CTLR mode is given by the following equation:

$$\vec{K}_{CTLR} = \frac{1}{\sqrt{2}} [S_{HH} - S_{HV} \qquad -iS_{HV} + S_{HH}]$$

2.2 Entropy

Entropy represents randomness of scattering and is computed using equation mentioned below. This is a measure of the dominance of a given scattering mechanism within a resolution cell. Entropy ranges from 0 to 1, where the randomness of a scattering medium from isotropic scattering (H=0) to totally random scattering (H=1). Values in between indicate the degree of dominance of one particular scatterer.

$$H = \sum_{i=1}^{3} -P_i \log_3(P_i) \text{ Where, } P_i = \frac{\lambda_i}{\sum_{j=1}^{3} \lambda_j}$$

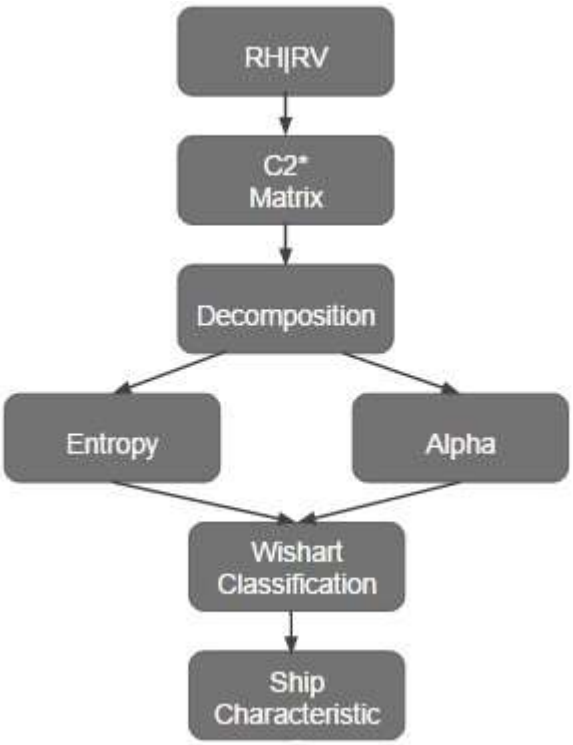

Figure 1: Flow chart of used methodology

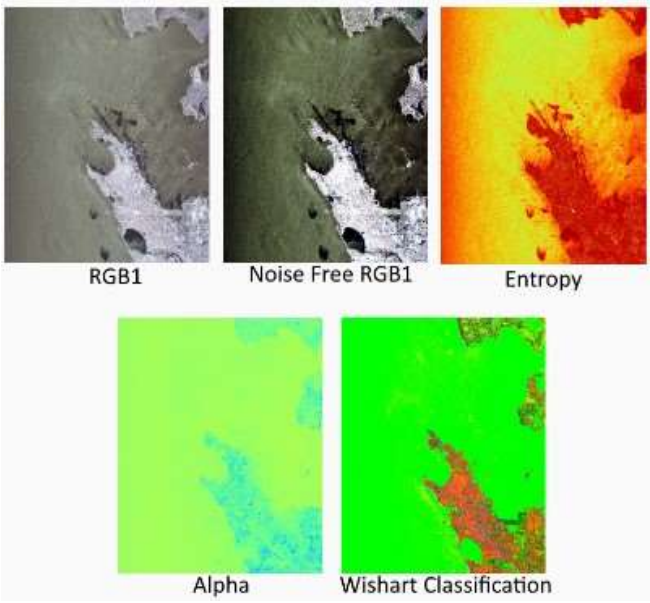

Figure 2: Preprocessing, Decomposition and Classification of Mumbai area

2.3. Alpha

If the Entropy is close to 0, the alpha angle provides the nature or type of the dominant scattering mechanism for that resolution cell. For example it will identify if the scattering is volume, surface or double bounce. Alpha is calculated based on equation:

$$\alpha = \frac{\lambda_1}{\sum_{j=1}^{3}\lambda_j}\cos^{-1}(v^1{}_1) + \frac{\lambda_2}{\sum_{j=1}^{3}\lambda_j}\cos^{-1}(v^1{}_2) + \frac{\lambda_3}{\sum_{j=1}^{3}\lambda_j}\cos^{-1}(v^1{}_3)$$

3. EXPERIMENT

3.1 Flow Chart

RISAT-1 FRS-1 data consists of RH and RV image, which consists of complex numbers. Now, using the same complex number image, separating its real and imaginary value, c2 matrix is generated. * indicates it is speckled image. Entropy, Alpha and Anisotropy are calculated. These three comes under decomposition of polarimetric SAR images. Other decomposition of compact polarimetry like m-chi, m-delta are available, but after practically working on many SAR images, entropy and alpha works best for target ships. Before this, many ship detection algorithms paper are available, but characteristics of ship is less explored topic. Figure 1 shows methodology used in this paper for ship characteristic.

3.2 Data source and decompositions

RISAT-1 FRS-1 data with right circular transmit and linear recieve of Mumbai area as mentioned in Table 1. Figure 2 shows RGB(with and without speckle filtering), Entropy, Alpha and Wishart classification .The swath of data taken is 32.13 kilometer along azimuth direction and 23.98 kilometer along range direction. Figure 2 contains various decomposition and classification as per used methodology explained in flow chart.

The small portion of a single SAR image of RISAT-1 is highlighted as shown in Figure 3, which shows number ships to work upon. To separate ship and water can be done by measuring reflection by ships, which is bright spot on surface of ocean. When boundaries of ship, manually of programmatically, is to be drawn then H-Alpha Wishart classification comes into picture, where ships are outlined easily as shown in Figure 4. First step is to outline with as ship with a rectangle and then calculating the contributing pixel along azimuth and range directions.

Taking an example of ship shown in Figure 4. Table 2 represents details of the ship taken as example.

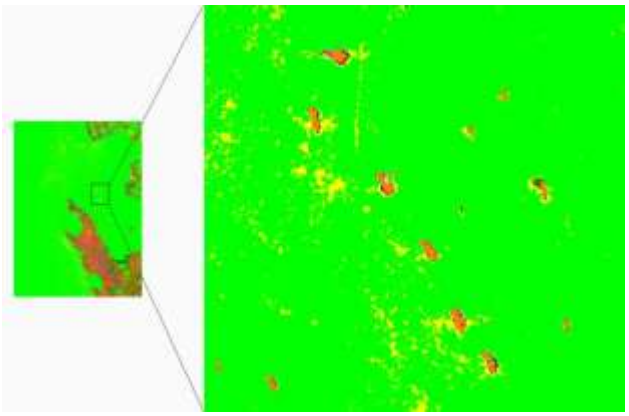

Figure 3: Highlighting Ships presence

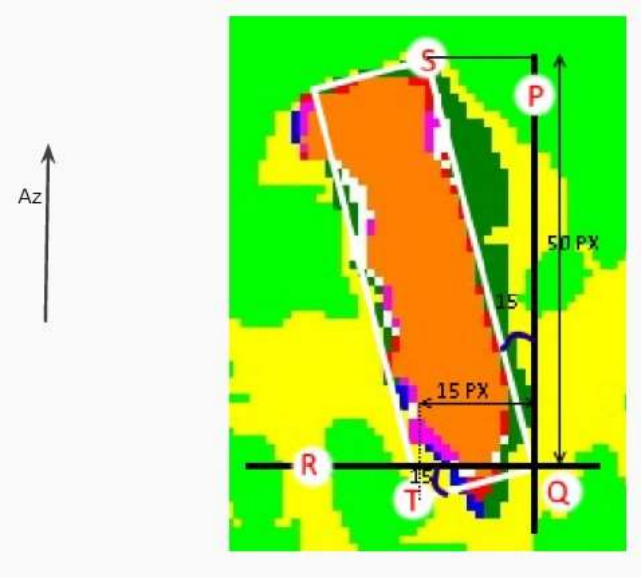

Figure 4: Measuring contributing pixels of candidate ship along azimuth and range direction.

Site Name	**Bombay**
Lat/Long.	18.91 / 72.81
Date of Pass	21 Feb 2014
Polarisation	RH / RV
Satellite Altitude (km)	541.994
Image Heading Angle (degrees)	348.511
Image Format	CEOS
Incident Angle (degrees)	25.45

Table 1: Data Specifications

Using calculations shown in Table 2, length and breadth of ship can be calculated as shown here:

Length = (Number of pixels representing Azimuth direction of whole SAR image)*(Pixel Azimuth Cover)/***cos***(PQS)

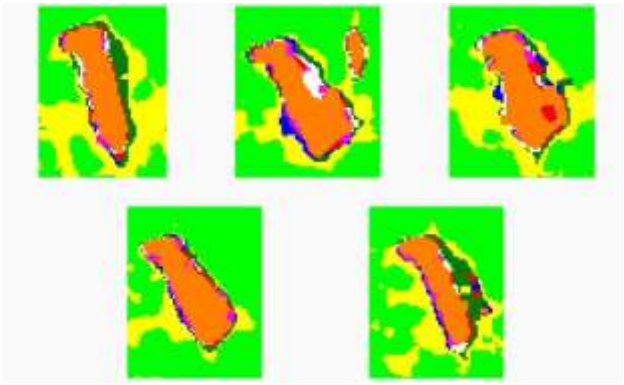

Figure 5: ROI of different ships

Breadth = (Number of pixels representing Range direction of whole SAR image)*(Pixel Range Cover)/***cos***(RQT)

Azimuth Cover	32.13 KM
Range cover	23.98 KM
Number of pixels representing azimuth direction of whole SAR image (**A**)	7812
Number of pixels representing range direction of whole SAR image (**B**)	5776
Each pixel along azimuth direction coverage in meter. (**C**)	4.11 m
Each pixel along range direction coverage in meter. (**D**)	4.15 m

Table 2: Details of SAR image

Height of ships can also be calculated using shadow of the ships, but it comes with certain limitations. Similar type of analyzing can be done on other ships as well. Figure 5 shows the ROIs of different shapes.

4. CONCLUSION

Using above proposed method, ships tracking using SAR polarimetry images can be made easy. RISAT-1 SAR images are less explored, using these type of novelty approaches to track ship and its location. Wishart classification is best tool to detect as well as identify ships, detection can also be made possible by calculating ratio of length to breadth of ships.

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