Classification of Polari Metric SAR (POlSAR) Image Analysis using Decomposition Techniques

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ABSTRACT
The classification of Polarimetric Synthetic Aperture Radar (PolSAR) image using a different decomposition technique has become a very important task after availability of data. In this paper RADARSAT-2 C-band fully polarimetric SAR data is used. This data was in SLC (single look complex) format and was not geocoded. In the present paper different decomposition techniques applied on RADARSAT-2 data for city of British Columbia, Vancouver, Canada and later classified the data using various classification techniques like H-alpha, Wishart H-alpha and Wishart H-A-alpha. The PolSAR classified image analysis is done on the basis of image parameters like Mean, Median, Standard Deviation and Coefficient Variation. From the result, it is observed that the for classification analysis Wishart H-A-alpha classified image is better than H-alpha and Wishart H-alpha classified image.

Keywords
SAR, PolSAR, Decomposition technique, Classification.

1. INTRODUCTION
The SAR is an active remote sensing system, which is used to obtain high resolution images. The SAR has the capacity to penetrate clouds, fog, smoke etc. It also has the capability to sense the object during the day or night. It operates in all-weather conditions, though there is change in environmental changes [1]. In PolSAR application classification is an important task which is the process of assigning a set of given data elements to a given set of classes. Classifying remotely sensed data is very challenging because of many factors, such as the selected study area of remotely sensed data, the complexity of the landscape in the study area, the types of classification techniques in image processing and accuracy assessment.The polarization characteristics of electromagnetic energy recorded by a remote sensing system represent an important variable that can be used in many earth resource investigations [2]. It is possible to selectively send and receive polarized energy using active remote sensing systems which can be in the form of HH, HV, VH, VV polarization. It is also observed that the like-polarization (HH or VV) shows higher reflection and is significantly different from the results observed for cross polarization (VH or HV) [3] [4]. In the present study RADARSAT-2 satellite C-band fine quad polarized dataset for city of British Columbia Vancouver, Canada is used. In this paper decomposition technique used like H-alpha, Wishart H-alpha and Wishart H-A-alpha for classification of PolSAR image. The aim of these techniques to separate the polarimetry measurements from a random media into independent elements which can be associated with the various physical scattering mechanisms occurring on the ground. This paper will provide comparative simulation model results classification of RADARSAT-2 PolSAR image analysis by using above mentioned decomposition techniques in PolSARPro 5.0 and NEST 5.0.16 software. The both software's are freely available on the internet developed by ESA.

2. DECOMPOSITION TECHNIQUE
The available RADARSAT-2 C-Band fully polarimetric data was in SLC format i.e. level 1 which implies that the data was in the form of the scattering matrix for single polarization channel (HH, HV, VH and VV), in terms of the complex scattering coefficient. The data also had speckle noise and was not geocoded. This data was in the slant range format, due to which it was compressed [5]. Therefore, the azimuth and the range direction were different, hence slant range to ground range conversion was performed to equalize these resolutions. This resulted in the creation of an image with square pixels due to equalization of the azimuth and range resolution using multilooking process. This process was carried out to improve the radiometric accuracy of the measurements. Then further processing is carried out using speckle filtering and decomposition techniques. The classification technique used here is based upon polarimetric decomposition classification parameters such as Entropy (H), Anisotropy (A) and Alpha (α). This classification procedure is based on decomposition theorem and the H/A/α set of the coherency matrix [6]. The entropy provides information on the scattering degree of randomness. The alpha parameter indicates the nature of the scattering single or double bounce reflection or scattering over anisotropic media. The anisotropy provides information on the relative importance of secondary mechanisms. This parameter cannot be interpreted separately from the entropy [7]. One of the main advantages of polarimetric radar data analysis is the possibility of separating and identifying contributions from different types of scatteres in the imaged terrain. To do this, the received scattering matrix is analyzed using various techniques to extract information about the scattering processed. These process generally known as target decomposition. There are several types of decomposition techniques performed on the scattering matrix.

3. PolSAR CLASSIFICATION
The classification of PolSAR image is to identify the different spectral classes present in it and their relation to some specific ground cover type. The result of classification done here is based on H-alpha parameters, the Wishart classification based on the Wishart statistics of multilook coherency matrix [8]. In the present work nine classes resulted from the H-alpha and Wishart H-alpha decomposition are used, whereas sixteen classes resulted from the H-A-alpha decomposition as training sets for the initialization of the unsupervised Wishart classifier [9].

4. TEST SITES AND DATA SOURCES

The study area is located in the city of British Columbia by longitude 122^0 46' to 123^0 21'W & latitude 48^0 55' to 49^0 32' of Vancouver, Canada. This is a coastal seaport city on the mainland of British Columbia, Canada. The Greater Vancouver area of around 2.4 million inhabitants is the third most populous metropolitan area in the country and the most populous in Western Canada. The City of Vancouver encompasses a land area of about 114 square kilometers, giving it a population density of about 5,249 people per square kilometer (13,590 per square mile). The C-band RADARSAT-2 image with the fine quad (HH, HV, VH, VV) polarization having 30 short pulses obtained on 15/04/2008 is used in this study [10].

5. RESULT AND DISCUSSION

The RADARSAT-2 PolSAR image was in SLC format, hence initially it is converted into the ground range using a multilooking process after importing the data in PolSARPro 5.0 software. The figure 1 (a) shows the Pauli RGB image and figure 1 (b) shows Pauli Span image. Using the Pauli decomposition image also called Pauli image can be constructed with the odd bounce, even bounce and 450 tilled even bounce components in red, blue and green colours respectively representing all the polarimetric information of the matrix.

The following figure shows Pauli decomposition, image of RADARSAT-2 data for city of British Columbia Vancouver, Canada,

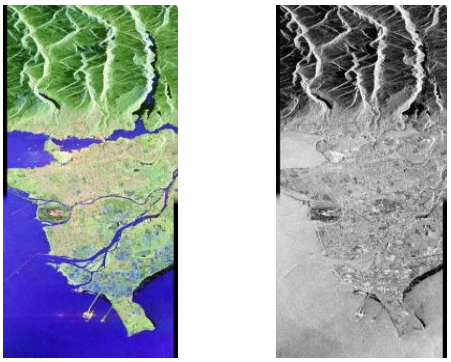


Fig 1: Pauli Decomposition (a) RGB Image (b) Span Image

Next the data filtered with 5x5 window size by using Lee Refined speckle filter, because speckle noise degrades the quality of SAR image. Then H-A-alpha decomposition parameters are generated the Alpha (α), Anisotropy (A) and Entropy (H). The following figures shows H-A-alpha parameters,

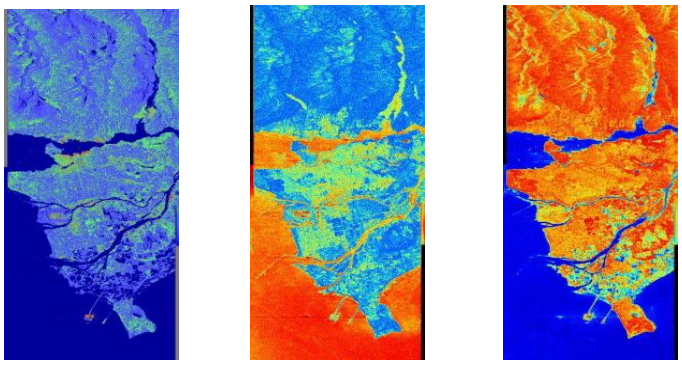
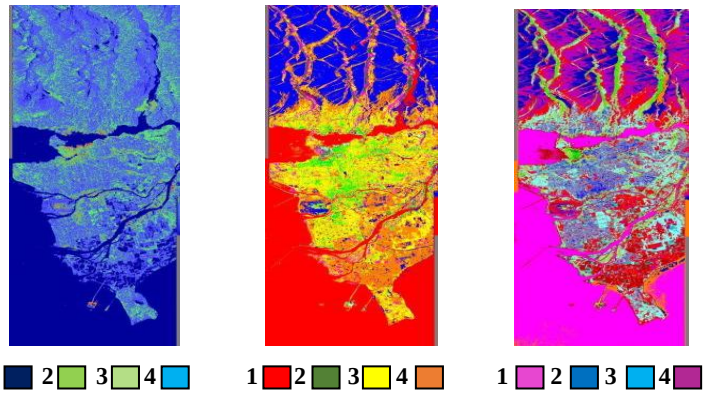


Fig 2: (a) Alpha Image (b) Anisotropy Image (c) Entropy Image

Later, the images are classified using H-alpha, Wishart H-alpha and Wishart H-A-alpha classifier. The results of classified images are shown in the figure 3 (a), 3 (b) and 3 (c) respectively. These classified images further analyze by using NEST software. By comparing the H-alpha and Wishart H-alpha classification images, we observed that though H-alpha and Wishart H-alpha having 9 numbers of classes but Wishart H-alpha shows much more accurate results. Similarly, by comparing results of Wishart H-A-alpha classified image having 16 classes and the results are much better than H-alpha and Wishart H-alpha classified image. The following Table. 1 shows comparison for major 4 classes like water, vegetation, settlement area and open land area of the above mentioned classes.



1. Water 2. Vegetation 3. Settlement 4. Open Land

Fig 3: (a) H Alpha Classification (9 Class) (b) Wishart H Alpha Classification (9 Class) (c) Wishart H A Alpha Classification (16 Class)

Table 1: Classification of RADARSAT-2 PolSAR Image

Class	Types of Classification		
	H Alpha*	Wishart H Alpha	Wishart H A Alpha
Water	35.683	31.137	27.520
Vegetation	2.753	1.584	1.810
Settlement	14.281	18.677	12.008
Open Land	44.162	20.950	11.852

* All values are in %

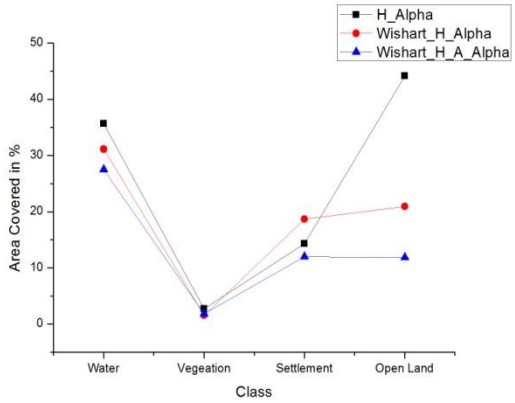


Fig 4: Comparative Graph for Classification of RADARSAT-2 SAR Image

From the above graph it is observed that the Wishart H-A-alpha having lower values in all the classes as compared to the H-alpha and Wishart H-A-alpha classification.The statistics of the classified SAR images are generated by NEST software and with the help of this the classified image parameters like Mean, Median, Standard Deviation, and Coefficient Variation are shown in following Table. 2.

Table 2: SAR Image Parameter for different classification

SAR Image Parameter	Types of Classification		
	H Alpha	Wishart H Alpha	Wishart H A Alpha
Mean	6.6814	5.1177	9.1718
Median	5.9961	4.9922	10.9902
Standard Deviation	1.9723	2.0409	3.8417
Coefficient Variation	0.5146	0.6938	0.7249

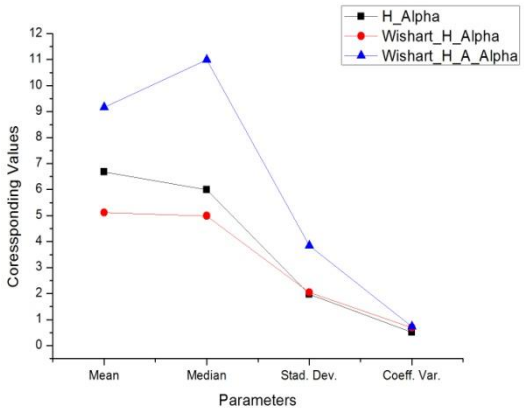


Fig 5: Comparative Graph for Classification Parameters

The graph shows that the though H-alpha and Wishart H-alpha having same classes, but values Mean and Median of Wishart H-alpha are lower than H-alpha classified image. But all parameters having larger values in Wishart H-A-alpha as compare to H-alpha and Wishart H-alpha classified image.

6. CONCLUSION

The classification of PolSAR RADARSAT-2 fine quad polarized SLC data by using different decomposition techniques in PolSARpro software was successfully done in this work. The decomposition techniques were used for generating the alpha, anisotropy and entropy. Then by combining these parameters, the H-alpha, Wishart H-alpha and Wishart H-A-alpha techniques are used for classification. The classification results are compared and for analysis NEST software was used. The more accuracy and large number of classes was found in Wishart H-A-alpha classified image also the image parameters like Mean, Median, Standard Deviation and Coefficient Variation found to be larger values than other two classifications. Hence, from all these studies it is concluded that the classification accuracy is better in Wishart H-A-alpha classification. In future the classification used in this paper can be further applied to the other microwave L, C, X band polarimetric SAR dataset like TerraSAR-X, SIR-C, ALOS PALSAR etc.

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