IMPLEMENTATION OF UNSUPERVISED CLASSIFICATION AND COMBINED CLASSIFICATION BASED ON H/q REGION DIVISION AND WISHART CLASSIFIER ON POLARIMETRIC SAR IMAGE

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ABSTRACT*: *Speckles appearing in synthetic aperture radar (SAR) images are generated by the coherent processing of radar signals[1].This paper implements and analyze various types of speckle filtering methods.Based on filtering result, classification of the polarimetric SAR data is done by implementing unsupervised and combined classification.Unsupervised classification uses the backscattering power SPAN combined with H/q plane to obtain the initial cluster centers. Region segmentation is not very much accurate, combined classification is implemented.The combined classification uses H/q plane region division and the maximum likelihood classifier based on the complex Wishart distribution for the polarimetric covariance matrix [2].Experimental results with single look comlex polarimetric data from RISAT-1 demonstrate the effectiveness of these speckle filtering methods. Classification results based on unsupervised and combined classification are demonstrated using RISAT-1 polarimetric SAR data.

Keywords—polarimetric entropy, alpha angle, q parameter, Radar polarimetry, synthetic aperture radar

I: INTRODUCTION

The field of synthetic aperture radar changed dramatically in the early 1980s with the introduction of advance radar techniques, such as Polarimetry and Interferometry. While both of these techniques had been demonstrated much earlier, radar polarimetry only became an operational research tool with the introduction Synthetic Aperture Radar (SAR) system.Radar Polarimetry is the science of acquiring, processing and analyzing the polarization state of an electromagnetic field. Radar polarimetry is concerned with the utilization of polarimetry in radar applications.Polarimetric SAR image is observed to contain granular aspect with random spatial variations known as speckle noise. Speckle corrupts polarimetric information and make region segmentation difficult. Specific procedures are implemented to reduce speckle noise. Thus, speckle filtering is needed at the intial stage of SAR image processing. Unsupervised and combined classification methods are implemented and analyzed to classify the SAR image.

SPECKLE appearing in SAR images causes degradation and makes automatic image segmentation and scene description difficult[3].Boxcar filter of various window size like 5x5,7x7 and lee sigma filter are implemented on polarimetric SAR image to remove the speckle noise. Boxcar filter resulted in blurring of edges and smeared fine features, to overcome the limitations of boxcar filter lee sigma filter[1] is implemented. Region segmentation is implemented and analysed by using unsupervised classification based on H/q plane .In order to increase the accuracy of region segmentation, combined classification using unsupervised classification based on H/q plane and maximum likelihood classifier based on the complex Wishart distribution is implemented to provide better segmentation as compared to unsupervised classification.

II: POLARIMETRIC SAR DATA FORMULATION

Polarimetric radar measures the complex scattering matrix of a medium with quad polarizations[4]. The scattering matrix in linear polarization base can be expressed as

$$S = \begin{bmatrix} S_{hh} & S_{hv} \\ S_{vh} & S_{vv} \end{bmatrix}$$

where Shh is the scattering element of horizontal transmitting and horizontal receiving polarization, and the other three elements are similiarly defined. For the reciprocal backscattering case, Shv=Svh.
The polarimetric scattering information can be represented by Pauli scattering matrix for pixel *i*, is given by

$$k_i = \frac{1}{\sqrt{2}}\begin{bmatrix} S_{HH} + S_{VV} \\ S_{HH} - S_{VV} \\ 2S_{VH} \end{bmatrix} \quad \text{and} \quad T_i = k_i (k_i)^{*T}$$

T*i* is the coherency matrix for the *i*-th pixel.In order to reduce speckle, the data is multilook processed by averaging neighbourhood pixels depending upon the window size. The multilook coherency matrix becomes

$$\langle T_i \rangle - \frac{1}{n}\sum k_i (k_i)^{*T}$$

The coherency matrix is a 3x3 Hermitian matrix, containing complex term.
Speckle is a granular pattern observed on polarimetric SAR image, which degrades the image quality.Speckle filtering can be done using boxcar filter of various sizes and lee filter on the coherency matrix.The boxcar filter is a sliding window filter, which averages the centre pixel of the window. The filtered intensity estimates, X(i , j) , are constructed by computing the sample mean over each pixel neighbourhood, defined by a sliding window of (N w × N w) pixels.

$$X(i,j) = \frac{1}{(N_w) * (N_w)} \sum_{p=-(N_w/2)}^{(N_w/2} * \sum_{q=-(N_w/2)}^{(N_w/2)} Y_{i+p,j+q}$$

where the subscripts i and j correspond to the considered pixel row and column index respectively.
Smaller the window size higher the preservation of fine details but lesser noise reduction. But as the window size increases, noise reduction increases.
The Lee sigma filter [9], [10] is based on the two-sigma probability of Gaussian distribution and incorporates the speckle multiplicative noise model
z(k, l) = x(k, l)v(k, l)
where z(k, l) is the (k, l)th pixel in intensity or amplitude of a SAR image,
x(k, l) is the reflectance (noise free),
v(k, l) represents speckle noise,
which is characterized by a distribution with E[v(k, l)] = 1 and a standard deviation ηv .

The Lee sigma filter is based on the concept that 95.5% of pixels are distributed within the two sigma range from its mean. For the multiplicative speckle model, the range is (x − 2ηv x, x + 2ηv x).Since the a priori mean x is unknown, it needs to be estimated. The Lee sigma filter assumes x = z, the value of the center pixel, to find the two-sigma ranges. It reduces speckle noise by replacing the center pixel of a scanning window with the average of those pixels within the two-sigma range of the center pixel. Pixels outside the two-sigma range are considered as outliers, and they are not included in computing the sample mean. Consequently, homogeneous areas of high-contrasting distributed scatterers can be separated, and speckle reduction is achieved.

III: SAR DATA CLASSIFICATION

Data classification is an important polarimetric synthetic aperture radar application. Many algorithms have been developed for supervised and unsupervised data classification.Unsupervised classification uses the backscattering power SPAN combined with H/q plane to obtain the initial cluster centers.While in supervised classification, training sets for each class are selected manually based on different decomposition technique.There is high complexity due to the presence of three real and three complex values, this manual technique of selecting training sets results in larger computation time. In order to obtain high accuracy in region segmentation, unsupervised classification based on H/q plane alongwith supervised classification based on wishart classifier is used.

Unsupervised classification, on the other hand, classifies the image automatically by finding clusters based on a certain criterion. In this work, we have used incoherent decomposition based on eigenvalue-eigenvector decomposition. Unsupervised classification is based on H/q plane. The entropy[8] is defined as

$$H = \sum_{i=1}^{3} -P_i \, log_3 P_i$$

where *Pi=eigenvaluei/summation of eigenvalues*

in order to reduce the computation time, alternative parameter to alpha is used. The q parameter have equivalent property to that of alpha angle. The parameter q is given by [12]

$$q = \frac{T_{11}}{span}$$

where T11=first component of the coherency matrix ,span=summation of diagonal terms of <T>

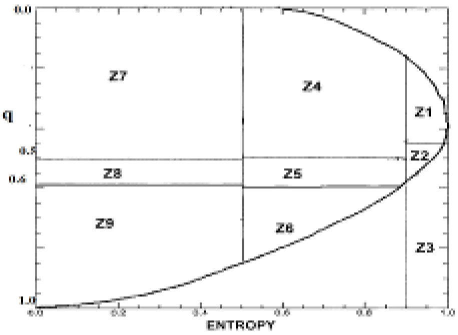


Figure 1. Region division based on H/q plane

Z9,Z6 corresponds to surface scattering,Z8,Z5 and Z2 corresponds to volume scattering and Z7,Z4 and Z1 corresponds to multiple scattering. Surface scattering indicates water, land surface, ice, volume scattering indicates buildings, urban area and multiple scattering indicates heavy vegetation.

In supervised classification, wishart classifier is used. A distance measure between a sample coherency matrix and a cluster mean Vm is determined by using the below formula[8],

$$d(\langle T\rangle|Vm) = ln|Vm| + Tr(Vm^{-1}\langle T\rangle)$$

Distance of every coherency matrix from each class is calculated, the class having least distance, that pixel is considered in that zone. This procedure is repeated till it reaches any of the termination criteria.

IV: EXPERIMENTAL RESULTS

Speckle filtering is needed to remove speckle from polarimetric SAR image. Speckle filtering is done on RISAT1 polarimetric SAR image and results are shown in figure 1.The speckle reduction can be measured in terms of standard deviation to mean ratio which can be seen in table 1.The reduction of speckle noise is directly proportional to the standard deviation to mean ratio.

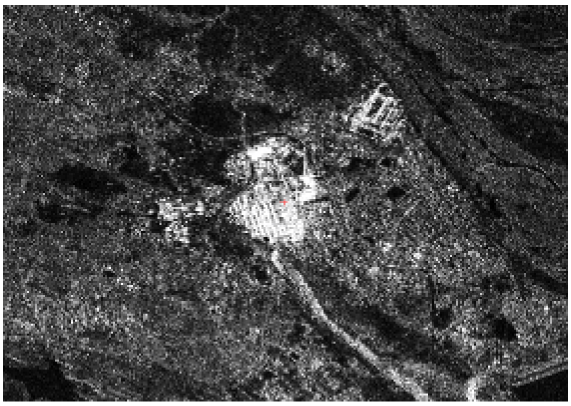


Figure 2.1 Original SAR image

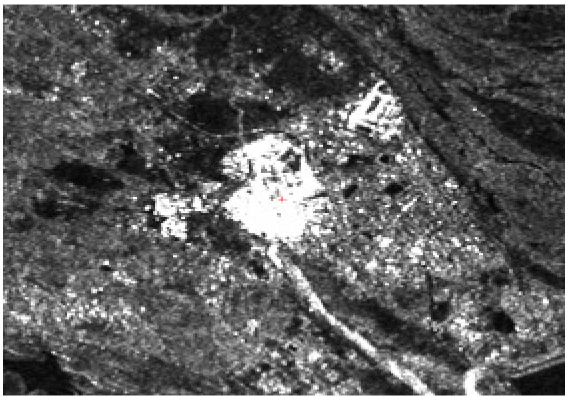


Figure 2.2 Boxcar 5x5 window filtered image

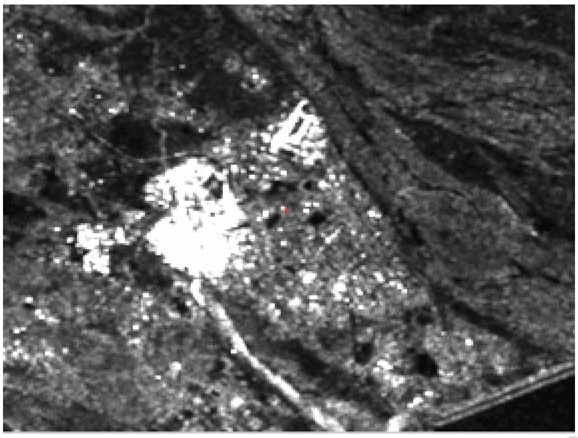


Figure 2.3 Boxcar 7x7 window filtered image

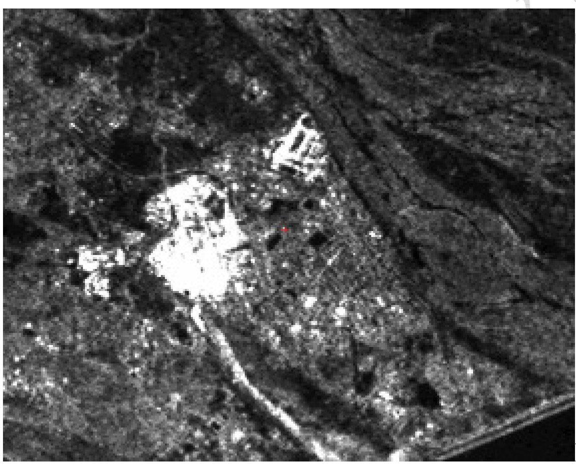


Figure 2.4 lee sigma,3x3 window filtered image

IMAGE	STANDARD DEVIATION	STANDARD DEVIATION TO MEAN RATIO
Original image	11250.719	2.339
5x5 window filtered image	6543.622	1.360
7x7 window filtered image	5724.011	1.185
Lee sigma,3x3	3673.55	1.01

Table 1. Comparision of filtered images with original image based on standard deviation to mean ratio

Based on the least value of standard deviation to mean ratio, lee sigma filter must be selected but dark spots are observed in lee sigma filtered image, thus boxcar filter of window size 5x5 is selected for filtering. Unsupervised classification based on H/q plane is done.Combined classification based on H/q plane region division and wishart classifier is implemented on boxcar 5x5 filtered SAR data. The classification result based on unsupervised classification and combined classification can be seen in figure 2.Here, the number of iteration is 6 for wishart classifier method .

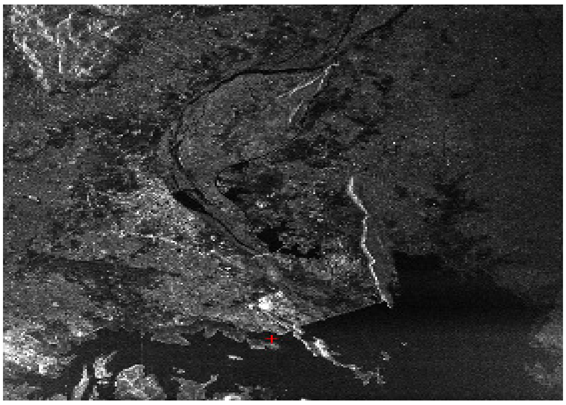


Figure 3.1 SPAN image
SPAN=T11+T22+T33
R=ZONE 9,G=B=ZONE 6

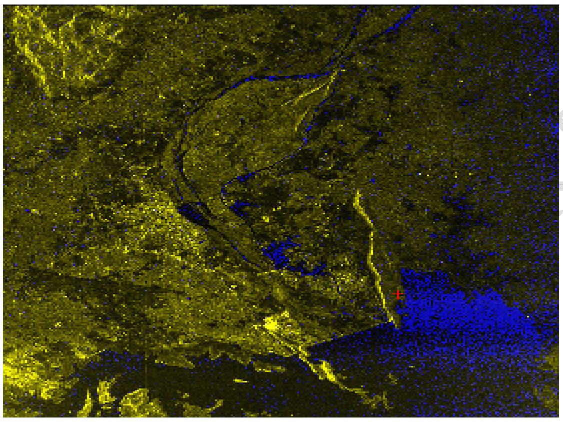
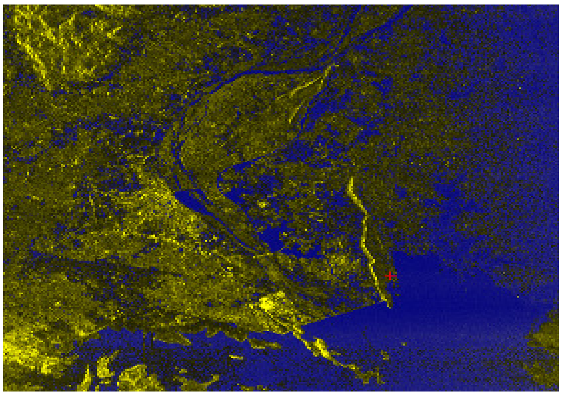


Figure 3.2 Surface scattering region using



R= ZONE 9,G=B=ZONE 6
FIGURE 3.3 Surface scattering region
Using combined classification

V: CONCLUSION

In this paper, we implemented boxcar filter of various window size and lee sigma filter.We observed that speckle noise is reduced, which can be measured by standard deviation to mean ratio .Based on the least value of standard deviation to mean ratio, lee sigma filter must be selected but dark spots are observed in lee sigma filtered image, thus boxcar filter of window size 5x5 is selected for filtering.Combined classification is implemented on boxcar 5x5 filter and we get much better region segmentation as compared to unsupervised classification.Clustering of pixels takes place by wishart classifier method and large area is identified as surface scattering as shown in figure 3.3.Thus, better classification is obtained by combined classification.

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