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Polarimetric Response Graph And To Analyse The Pattern Of Land Use/Land Cover for Bharatpur Region, Rajasthan, India From Radarsat 2 Data (Sar).

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Abstract: *Many Processes have been adapted to analysis SAR data among which target decomposition method have been adopted and cited by many people in their own way .Target decomposition theorems help to determine the various scattering mechanisms involved by expressing average scattering matrix as a sum of independent matrices, each associated with an elementary scattering mechanism. It is also possible to determine the dominant scattering mechanism using target decomposition theorems. Huynen was the first to formalize target decomposition theorems, which have the roots in the work of Chandrashekhar on light scattering by small anisotropic particles*

This project have been carried out on preliminary basis about the need of the target decomposition theorems on the basis of the area and object assumed.Later, on the basis of Pauli decomposition and Cloude Pottier method of decomposition has been adapted for the landuse and land cover analysis for the region of Bharatpur,Rajasthan,India.

Keywords: *Polarimetry, Scattering mechanisms, Target decomposition.*

I. Introduction

The imaging SAR system is an active radar system operating in the microwave region of the electromagnetic spectrum, usually between P-band and Ka-band. It is usually mounted on a moving platform and operates in a side-looking geometry with an illumination perpendicular to the flight line direction. Such a system illuminates the earth's surface with microwave pulses and receives the electromagnetic signal backscattered from the illuminated terrain. The SAR uses signal processing to synthesize a 2-D high spatial resolution image of the earth's surface reflectivity from all the received signals. Such an active operating mode makes this kind of sensors independent of solar illumination and thus allows day and night imaging.

The SAR imaging system is situated at a height H and moves with a velocity V_{SAR}. The antenna is aimed perpendicular to the flight direction, referred to as 'azimuth' . The antenna beam is then directed slant wise toward the ground with angle of incidence theta0. The radial axis or radar-line-of-sight (RLOS) is referred to as slant range. The area covered by the antenna beam in the 'ground range' and azimuth directions is the antenna footprint. The platform moving along the flight direction provides the scanning[1].There are three possible states of polarization that an electromagnetic wave can have. Polarization can be linear, circular or elliptical. The state of polarization describes the oscillation in the plane orthogonal to the direction the wave is propagating in[2].

Many methods to study SAR has been developed one among them is target decomposition method. Target decomposition theorems are aimed at providing such an interpretation based on sensible physical constraints such as average target being invariant to change in wave polarization basis. Target decomposition was first formalized by Huynen but have their roots in the work of Chandrashekhar on light scattering by small anisotropic particles[3].

To get an idea about SAR it is needed to study about Radar system. Radar is an abbreviation for Radio Detection and Ranging. Radar is a device for transmitting the electromagnetic (EM) signals and receiving echoes from the objects of interest (targets) within its volume of coverage. Radar is thus used for remote sensing applications to study target characteristics[4].A method, system or technique, including equipment components, for using beamed, reflected, and timed electromagnetic radiation to detect, locate, and (or) track objects, to measure altitude and to acquire a terrain image. The radio detection instrument consists of a transmitter that sends out high-frequency radio waves and a receiver that picks them up after they have been reflected by an object. Basic building blocks of radar are the transmitter, the antenna (normally used for both transmission and for reception), the receiver, and the data handling equipment. A synthetic aperture radar system, by implication, includes an image processor, even though it may be remotely located in time or space from the radar electronics.

The advantage radar sensors have over other types of sensors is that microwaves can penetrate clouds, most rain storms, and even dry snow[5].

There exist mainly two types of radar systems:
1) Monostatic Radar: The monostatic radar uses the same antenna for both transmission and reception.
2) Bistatic Radar: The bistatic radar is an example of multistatic radar system[6].

It uses two separate antennas for transmission and reception of the electromagnetic waves.An electromagnetic wave transmitted by radar possesses a specific polarization state. In the most commonly used H/V orthogonal polarization basis, polarization state is either horizontal (H) or the vertical (V)[7]. As waves propagate through the medium and as they hit a target, wave polarization state changes. The back scattered waves are then measured at a certain polarization state, for example horizontal or vertical. Depending upon the type of polarization state used for transmission and reception, the polarization mode is defined. For example, in case of the VH mode, transmission is done with the horizontally polarized antenna while reception is done with the vertically polarized antenna. A fully polarimetric system is capable of measuring all the four possible combinations, HH, HV, VH, and VV, of the two polarization states[8].

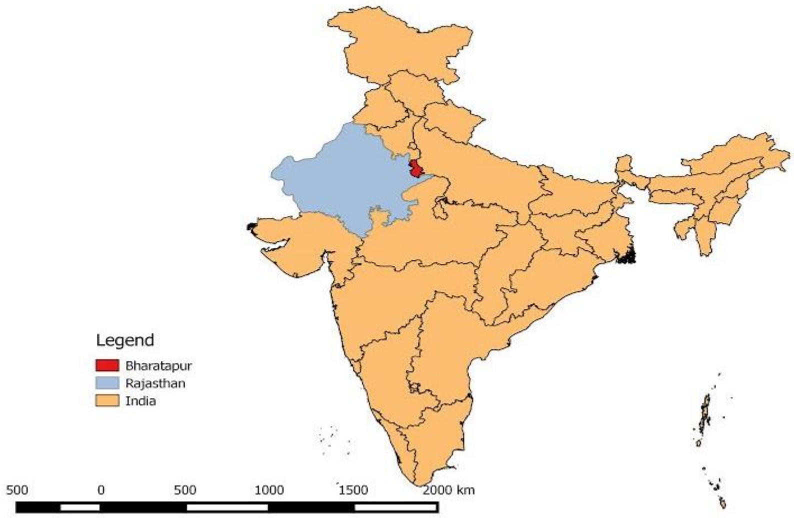
A number of approaches are available for parameter retrieval using SAR polarimetry. Polarization signature is the simplest technique to visualize the scattering mechanisms present in a scene. This can be studied from feature to feature to relate the signatures of known simple targets, making it possible to infer the type of scattering that is taking place. However, when pixels over an area are averaged, the net response contains components from more than one type of scattered and noise as well. At the same time, these scattering components are additive, limiting their use for parameter retrieval. The concept of quadrature-polarization (or full polarization)was introduced to the remote sensing community in the 1980s[9].

Attempts were made to understand the scattering mechanisms present in the polarimetric data. Many procedures have been employed to study polarimetric response from a target. An unsupervized classifier has been developedby Van Zylet al[10]which classify the image pixels to odd-bounce, even-bounce and diffuse using a purely mathematical model. This is achieved by exploiting the difference of scattering behavior in terms of the relative phase changes by 180° for every bounce of simple geometric structures.Application of Freeman Durden decomposition to Polarimetric SAR interferometry by J .David Ballester et al[10]assumes that the interferometric cross-correlation for the linear basis can be decomposed into the three mechanisms considered by the Freeman-Durden approach (i.e. direct, double-bounce and volume scattering mechanisms) even though any other decomposition could be used.The retrieved parameters are defined with magnitude and phase, and hence the power contribution is estimated jointly with the phase center of the scattering mechanism.Therefore, the retrieved magnitudes are also associated with their corresponding interferometric phases which are related to the vertical locations and, actually, the results must be analyzed in terms of the VV and HH interferometric cross-correlations. Indoor and airborne data have been used for testing the procedure. When compared with the original Freeman-Durden decomposition for PolSAR data some new features have been identified in both datasets as a result of the incorporation of the interferometric information.

Data Set And Study Area

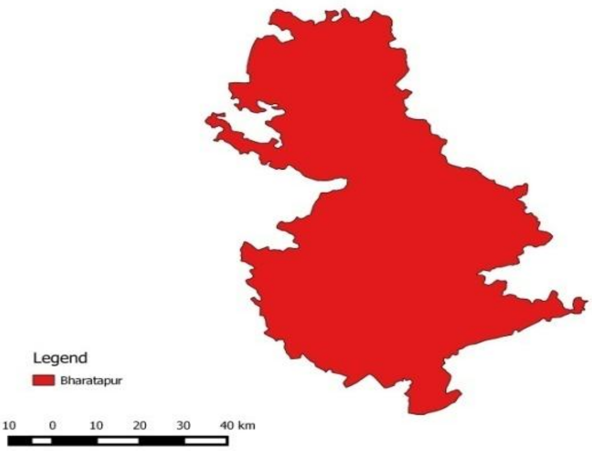
Bharatpur is a city and newly created Municipal Corporation in the Indian state of Rajasthan.District Bharatpur lies on eastern part of Rajasthan located between 26°.22 To 27°.50 northern latitude and 760 .53 To 78°.17 eastern longitudes and on the 100 meters height from mean sea level. According to national resource DOTS the district has a total land area of 507073 hectares which is 1.48% of the total area of Rajasthan State. All around boundaries of the district are as in north it is connected in the district Gurgaon (now,gurugram) of Haryana, in the east with district Mathura and Agra of Utter Pradesh. In the State it is connected with Dholpur and west Alwar and Swai Madhopur.Considering the topography of the district some parts as tehsil Bharatpur and Nadbai are plain in as terrain tehsil Roopwass and Bayana are considerably diversifies by hills. In general the soil is alluvial which is fairly wooded and cultivated; the area surrounded by diversified and detached hill is locally called by name ‘Dang’. Forests exits in considerable size in all the Sub divisions of the district. Keoladeo National Park or Ghana National Park an UNESCO world heritage site also located in Bharatpur[11].

Fig1. India Map showing Rajasthan and Bharatpur



As of 2011 Indian census,Bharatpur district had a population of 25,48,462 of which males are 13,55,726 and females are 11,92,736. Bharatpur has an average literacy rate of 82.13%, higher than the national average of 74.04%; with male literacy of 90.41% and female literacy of 72.80%. The languages commonly spoken in Bharatpur are Hindi, Braj-Bhasha, and English. After the creation of Municipal Corporation and inclusion of new area the current population of City has been estimated to be over 3.2 Lakhs[12].

Fig 2. Map showing Bharatpur



To conduct the further study a processed RADARSAT-II has been taken into consideration. RADARSAT is a Canadian remote sensing Earth observation satellite program overseen by the Canadian Space Agency (CSA). The data used for the analysis is of 2-4 meter resolution and data of October 2008.

II. Methodology

The signals at the output of radar receivers are, by nature, due to a coherent integration of contributions from highly complex scattering mechanisms.Polarimetric target decomposition is a technique that helps in understanding the scattering mechanism that is involved when a target interacts with SAR. This is an added advantage of SAR polarimetry over conventional SAR remote sensing technique [13].

The signals at the output of radar receivers are, by nature, Due to a coherent integration of contributions from highly complex scattering mechanisms. The interaction of the target transforms its polarization depending upon the target characteristics. Hence the polarimetric signature from a target strongly depends upon the actual scattering process. This is the reason why SAR polarimetry has a characteristic property to discriminate different scattering mechanisms that take place when a target interacts with the incoming signals.

This, in turn, leads to possibilities to understand the scattering process which takes place using physical-based scattering models.

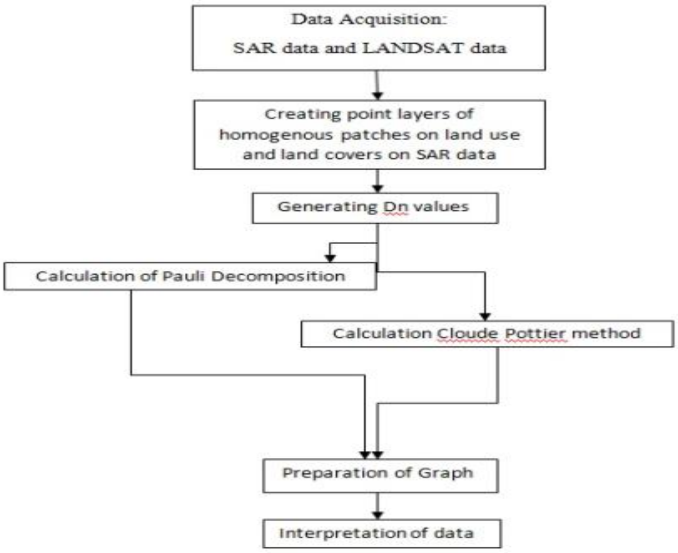


Table 1: Methodology adapted

Polarimetric target decomposition is a technique that helps in understanding the scattering mechanism that is involved when a target interacts with SAR. This is an added advantage of SAR polarimetry over conventional SAR remote sensing technique. Coherent and noncoherent polarimetric target decomposition techniques have been developed.

Initially, the vector point layer had been taken to generate Dn values from the SAR data which is further helpful for the calculation of the power matrix which if further needed the stoke matrix calculation in Cloud Pottier method.

Pauli Decomposition

To analyse the data the Pauli target decomposition theorems have been taken in account,here in Pauli decomposition

Pauli decomposition decomposes S matrix into three scattering mechanisms:

1. Single scattering by plane surface (single or odd bounce scattering),

2. Diplane scattering from corners with a relative orientation of 00 (double or even bounce scattering),

3. Diplane scattering from corners with a relative orientation of 450 (double or even bounce scattering).

The calculation being implemented on spreadsheet. These scattering mechanisms are represented by Pauli matrices. Scattering matrix, S, is represented as the sum of these matrices:

$$S = \begin{bmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{bmatrix} = \frac{a}{\sqrt{2}}\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} + \frac{b}{\sqrt{2}}\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} + \frac{c}{\sqrt{2}}\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix},$$

Where a, b, and c are the all complex parameters given by,

$$a = \frac{S_{HH}+S_{VV}}{\sqrt{2}}$$

$$b = \frac{S_{HH}-S_{VV}}{\sqrt{2}}$$

$$c = \frac{S_{HV}+S_{VH}}{\sqrt{2}}$$

The span, which is a measure of total scattered power, is given by,

$$Span = |S_{HH}|^2 + 2|S_{HV}|^2 + |S_{VV}|^2 = |a|^2 + |b|^2 + |c|^2$$

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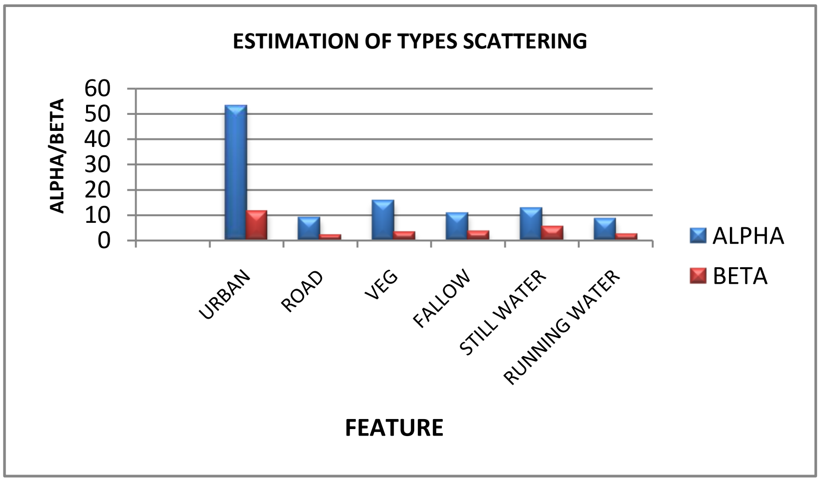
Initially, the vector point layer in had been taken to generate Dn values from the SAR data which is further helpful for the calculation of the power matrix and stoke matrix calculation.

The calculation of power matrix is:

$$\{P_{\psi\chi}\} = \left\{ \begin{bmatrix} 1 \\ \cos 2\chi \cos 2\psi \\ \cos 2\chi \sin 2\psi \\ \sin 2\chi \end{bmatrix}_R^T \begin{bmatrix} \frac{1}{2}\left(|S_{xx}|^2 + |S_{xy}|^2 + |S_{yx}|^2 + |S_{yy}|^2\right) & \frac{1}{2}\left(|S_{xx}|^2 - |S_{xy}|^2 + |S_{yx}|^2 - |S_{yy}|^2\right) & \mathrm{Re}\left(S_{xx}S_{xy}^* + S_{yx}S_{yy}^*\right) & \mathrm{Im}\left(S_{xx}S_{xy}^* + S_{yx}S_{yy}^*\right) \\ \frac{1}{2}\left(|S_{xx}|^2 + |S_{xy}|^2 - |S_{yx}|^2 - |S_{yy}|^2\right) & \frac{1}{2}\left(|S_{xx}|^2 - |S_{xy}|^2 - |S_{yx}|^2 + |S_{yy}|^2\right) & \mathrm{Re}\left(S_{xx}S_{xy}^* - S_{yx}S_{yy}^*\right) & \mathrm{Im}\left(S_{xx}S_{xy}^* - S_{yx}S_{yy}^*\right) \\ \mathrm{Re}\left(S_{xx}S_{yx}^* + S_{xy}S_{yy}^*\right) & \mathrm{Re}\left(S_{xx}S_{yx}^* - S_{xy}S_{yy}^*\right) & \mathrm{Re}\left(S_{xx}S_{yy}^* + S_{xy}^*S_{yx}\right) & \mathrm{Im}\left(S_{xx}S_{yy}^* + S_{xy}^*S_{yx}\right) \\ \mathrm{Im}\left(S_{xx}S_{xy}^* + S_{xy}S_{yy}^*\right) & \mathrm{Im}\left(S_{xx}S_{yx}^* - S_{xy}S_{yy}^*\right) & \mathrm{Im}\left(S_{xx}S_{yy}^* + S_{xy}^*S_{yx}^*\right) & \mathrm{Re}\left(S_{xx}S_{yy}^* - S_{xy}S_{yx}^*\right) \end{bmatrix} \begin{bmatrix} 1 \\ \cos 2\chi \cos 2\psi \\ \cos 2\chi \sin 2\psi \\ \sin 2\chi \end{bmatrix}_T \Bigg|_{\psi=0^\circ}^{180^\circ} \Bigg|_{\chi=-45^\circ}^{45^\circ} \right\}$$

S here denotes Sigma Nought, S_{xx}can be taken as S_{HH}, S_{XY} as $S_{HV,}S_{YX}$as $S_{VH,}S_{YY}$ as S_{VV}. Here Re represents the real or the magnitude value of SAR data and Img represents Phase value of the data.Cos and Sin here used for computing target vectors.

The above calculation being implemented on spreadsheet and 4*4 matrix being created and the average of the spreadsheet has been calculated and plotted as follows:



FEATURE	SPAN	ALPHA	BETA	GAMMA
URBAN	2.62	0.92	0.20	0.08
ROAD	0.43	0.16	0.04	0.09
VEG	0.64	0.27	0.06	0.02
FALLOW	0.52	0.18	0.06	0.00
STILL WATER	0.70	0.22	0.10	0.02
RUNNING WATER	0.38	0.14	0.04	0.02

Table 2: Average calculated for the different feature extracted from Pauli decomposition

Fig 3: Graph showing the calculation of different feature in Pauli decomposition.

Further alpha and beta i.e. scattering and incidence angle of the feature class has been taken and implemented graphically.

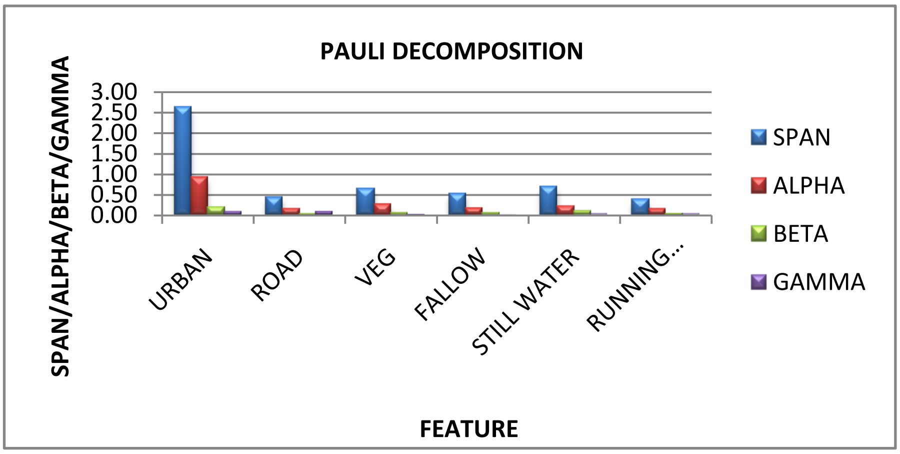


Table 3: scattering and incidence angle in pauli decomposition

FEATURE	ALPHA	BETA
URBAN	52.98305527	11.34128085
ROAD	8.881738241	2.16697345
VEG	15.47503196	3.261007025
FALLOW	10.58271536	3.325236373
STILL WATER	12.71977799	5.52087982
RUNNING WATER	8.290337645	2.438583657

Fig 4: Graph showing the estimation of types of scattering

Interpretation Of The Pauli Decomposition

The interpretation of the Pauli decomposition must be done according to the matrices .The matrix S corresponds to the scattering matrix of a sphere, a plate. In general, $a/\sqrt{2}$is referred to single- or odd-bounce scattering.Thus, the complex coefficient a, represents the contribution of S to the final measured scattering matrix[14]. In particular, the intensity of this coefficient, i.e., $|a|^2$, determines the power scattered by targets characterized by single- or odd-bounce. The second matrix, $b/\sqrt{2}$ represents the scattering mechanism of a dihedral oriented at 0 degrees. In general, this component indicates a scattering mechanism characterized by double or even-bounce, since the polarization of the returned wave is mirrored respect to the one of the incident wave. Consequently, b stands for the complex coefficient of this scattering mechanism and 2 b represents the scattered power by this type of targets. Finally, the third matrix corresponds to the scattering mechanism of a diplane oriented at 45 degrees. As it can be observed in $c/\sqrt{2}$,and considering that this matrix is expressed in the linear orthogonal basis (H,V), the target returns a wave with a polarization orthogonal to the one of the incident wave. From a qualitative point of view, the scattering mechanism represented by c is referred to those scattererswhich are able to return the orthogonal polarization. The coefficient c represents the contribution of $a/\sqrt{2}$ to Swhereas $|c|^2$ stands for the scattered power by this type of scatterers.

The Pauli decomposition of the scattering matrix is often employed to represent all the polarimetric information in a single SAR image[15]. The polarimetric information of [S] could be represented by the combination of the intensities $|S_{HH}|^2$ $|S_{VV}|^2$ and $2|S_{HV}|^2$ in a single RGB image, i.e., every of the previous intensities coded as a color channel. An RGB image can be formed with the intensities $|a|^2$, $|b|^2$ and $|c|^{2.}$

Cloude Pottier Decomposition

Cloude-Pottier's method is presently the most used method for decomposition of natural extended target scattering. The characteristic decomposition of the Hermitian target coherency matrix allowed Cloude and Pottier to derive key parameters, such as the scattering type alpha and the entropy H, which have become standard tools for target scattering classification and for geophysical parameter extraction from polarimetric synthetic aperture (SAR) data[16].

To represent the coherent single scattering assigned to each target coherency eigen vector, Cloude and Pottier introduced the so called alpha beta model. The most used parameters is a alpha, which when combined with the Cloude entropy H, leds to the most popular approach entropy/alpha for target scattering classification.

Beta has been used for target tilt angle measurement.In most of the applications that involve Cloude-pottier target scattering decomposition, the target phase angles have been ignored and their physical meaning is still not well understood.

From the CloudePottier Decomposition method the scattering, mechanism or the alpha are being classified into a range confide with entropy range where alpha has been divided on the range of 0-40 degree i, e surface scattering 40-50 degree volume scattering and 50-90 degree is multiple scattering and entropy had been ranged between 0-1 where, 0-0.5 is low entropy, 0.5-0.8 is medium entropy and 0.8-1 is high entropy. On the basis of Cloude Pottier method the following graph has been plotted after the calculation of entropy and alpha for the feature of road, still water, running water, vegetation, and fallowland and urban.

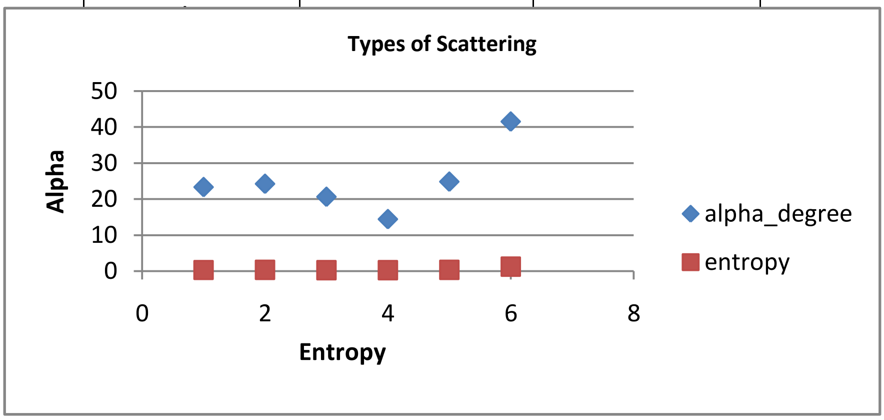
The result shown that all the feature are coming under surface scattering except urban which is giving a volume scattering. The entropy of all features showing the result of low entropy except urban feature which is coming under zone 3 i.e Branch/Crown structure and high entropy. The result of urban feature of having high backscatter value and high entropy value is due to the man made structure which is mainly of vertical structure results in double bounce of the EM waves.

Table 4: Table showing average for the each feature class

Further the average for the each feature class has been calculated and scatter plot has been graphed:

Feature	alpha	entropy
road	23.34598349	0.276971627
still water	24.25661022	0.309378605
running water	20.65027877	0.219623183
fallow land	14.44044134	0.211437389
vegetation	24.85488315	0.339779696

Fig 5: Graph showing the average of entropy and alpha



Interpretation Of The Cloude Pottier Method

In 1997, Cloude and Pottier have proposed a method of the extraction of mean diffusion based on eigen values/eigen vectors decomposition of the coherence matrix[17].Based on this idea they defined a set of parameters and called entropy and anisotropy parameters and alpha and beta angles. The need of these parameters to identify objects in polarimetric radar images is used for classification of fully polarimetric SAR data. For the Cloude Pottier method of classification the type of scattering for an object is classified in terms of coherent and incoherent object. In incoherent object it can be classified that pure target are basically identified. By pure targets we can mean to say manmade objects for which we can identify the object easily by its scattering type and its orientation. On the basis of alpha we can say as above classified that if the object ranges between 40-49 degree said to be volume scattering. Here from the above graph I have taken out the average for all the feature class and plotted in terms of alpha and entropy. On the basis of the plotted graph we can say Urban has a double bounce and volume scattering.

Urban can be assumed to have back scattering value for its creation of manmade structure and double bounce due to its inclination of the object from the ground creates an angle for the EM wave to bounce the object once on the surface again interacting with the object before receiving by the antenna.While the other target classified here as surface scattering due to its Incoherent nature and distributed object type. Like in water the Bragg scattering is happening which can be assumed for the smooth surface and for vegetation less scattering happening due high observance of the trees from the nature.

III. Disscussion

Though the study has been done in a preliminary basis. To validate the model for both the target decomposition method adopted,viz, Pauli decomposition and CloudePottier method of target decomposition we need to run model to find out the actual differentiation of the LU/LC pattern from both the model.But from the calculation it can be concluded that both result for feature classes is same like for urban the scattering value for both the model is high and further the model has been rechecked and found the calculation to be correct.Therefore the calculation for the classification LU/LC is correct more than 91%. For further validation the programmed has to be run in the format from where visual interpretation can be easily done.

On the basis of calculation in target decomposition SAR has been classified. In Pauli decomposition the classification is being done on the basis of the calculation of SPAN value. Further, Cloude Pottier method has also been used for the differentiation of the scattering process and graph has been plotted in accordance with entropy and alpha As, the image processing for SAR is purely depends preliminary on equations therefore one has to be very careful initially taking the ROIs. Suggested a detail analysis of the study area need to done to understand the feature carefully and only after SAR image could be efficiently processed.

IV. Conclusion

The study had been done to show the differentiation between the various target decomposition techniques and their uses according the need of test site. People have further processed the calculation and range it according to their own convenience for the study of their own feature. Later Pauli decomposition has been cited to calculate SPAN feature of the given area where the result range for different classes are due to their feature and related to their backscatter values. Again Cloude Pottier method had been applied for the same ROI and found the scattering value for urban feature is high as in Pauli decomposition method. Which if further studied can give a result which is further easy to understood and interpret the region visually.

Reference

[1]. Sen. John and Pottier Eric, Polarimetric Radar Imaging: From Basics to Application,5-7.
[2]. Cloude Robert Shane and Pottier Eric, A review of target decomposition theorems in Radar polarimetry,IEEE Transactions on Geoscience and Remote Sensing,34,2,1996
[3]. A.Farina,Introduction to Radar Signal & Data Processing: The Opportunity,NATO,063bis
[4]. European Space agency,ASAR User Guide,Glossary.
[5]. Burkholder.R. J etal.Comparision of Monostatic and Biastatic Radar Images.
[6]. Olivié J. D, H-α decomposition and unsupervised Wishart
[7]. classification for dual-polarized polarimetric SAR data.
[8]. Krogager E, Advances of Techniques for Utilizing Polarimetric
[9]. Features of Radar Targets.
[10]. Shell J.R II Polarimetric remote sensing in the visible to near infra red
[11]. Ballester .J.D et al.Applying the Freeman Durden decomposition concept to polarimetric SAR interferometry, IEEE,vol8,Jan 2010.
[12]. MSME-Development Institute,Brief Industrial Profile of Bharatpur.
[13]. Bharatpur, Wikipedia
[14]. Krogager. E et al.Potential of Coherent decompositions in SAR polarimetry and interferomtery.
[15]. M. Ouarzeddine et al. Classification Of Polarimetric Sar Images Based On Scattering Mechanisms.ISPRS,XXXVI.
[16]. Ridha Touzi, Target Scattering Decomposition in Terms of Roll-Invariant Target Parameters,IEEE,vol-45,Jan 2007
[17]. Hasan K.M et al. Analytical Computation of the Eigenvalues and Eigenvectors in DT-MRI,Journal of Magnetic Resonance.41-47(152),2001.