INSTITUTE OF REMOTE SENSING

ANNA UNIVERSITY, CHENNAI - 600 025.

LAB MANUAL

MICROWAVE REMOTE SENSING LABORATORY

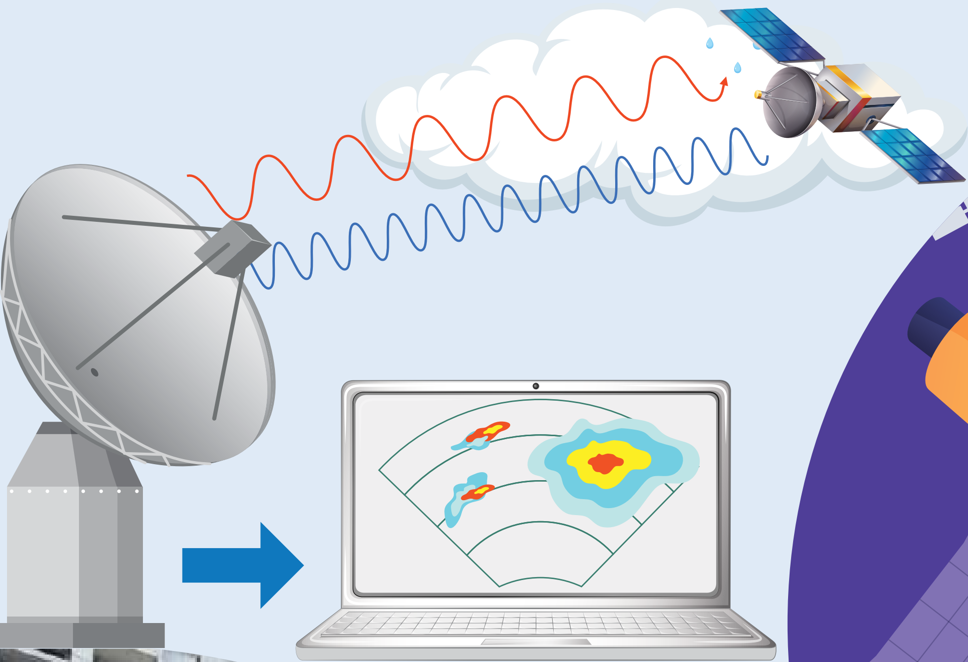


TABLE OF CONTENTS

Expt No. 1	OVERVIEW OF SAR IMAGE PROCESSING SOFTWARE ENVI (4.8) SARSCAPE AND SAR SPECIFICATION ANALYIS	Date of Expt:

AIM:

To read and overview of sar image processing using software ENVI (4.8) SARscape and SAR specification analysis.

PROCEDURE:

- A risat image is given as a working product
- It is a level 2 product and the area has latitude of 36˚
- This image is opened in the ENVI 4.8 software
- First preliminary observations are made by studying its patterns and features are identified.
- Then different features are digitized using R01 statistice result window of different features are opened and its mean values.

INFERENCE:

- During the basic observation, following features ware observed
- Mountain regions were identified by its patterns.
- Road/railways line were identified by smooth straight lines.
- Rivers are identified by its curve lines
- Settlements are identified by its white patches
- The objects which have sharp corners has high reflectance and has low reflection of microwave region.
- On viewing the statistic window, the DN values maximum, minimum and mean constant backscattering value that will be more than this value.

OBSERVATION

Features	**Near range**	**MID range**	**FAR range**
Water body			
Settlement			

RESULT:

Thus the overview of SAR image processing software ENVI (4.8) SARscape AND SAR specification analysis was done.

Expt No. 2	VISUAL IMAGE INTERPRETATION OF SAR IMAGE	Date of Expt:

AIM:

To visually interpret the SAR image.

SOFTWARE USED:

ENVI (4.8) – SARSCAPE

DATA SPECIFICATION:

- RISAT- SAR Data
- It follows- sun synchronous orbit
- Altitude -608 km
- C band with 5.35 GHZ
- Swath width -120 km
- Azimuth resolution -25 m
- Range resolution – 8m
- It follows co and gross polarization.

LAND – MSS DATA

- Sensor –Mss
- Spatial resolution -80m
- Spectral resolution : 0.5-0.6μm, 0.6-0.7μm, 0.8-1.1μm, 0.7-0.8μm
- Radiometric resolution – 6bits
- Temporal resolution – 16-18 days
- Swath width – 185km.

SAR IMAGE

FEATURES	NEAR REGION	MID REGION	FAR REGION
VEGETATION			
POND			
WATER			
SETTLEMENT			

LANDSAT IMAGE

FEATURES	BAND 3			BAND 4		
	FAR	MID	NEAR	FAR	MID	NEAR
VEGETATION						
WATER						
POND						
SETTLEMENT						

OVERVIEW

SAR image is black and white in nature. In order to identify the different feature in given image, the landsat data of some area is used for interpret different feature. The brightness of radar image is depends on entry return back from target on the feature. The following factor is control the brightness

a) Surface roughness
b) Radar reviewing and surface geomentry relationship
c) Moisture content and electrical properties of target.

In ladsat data features can be identified by using the following elements.

1. Tone 2. Shape 3. Size 4. Pattern 5. Texture 6. Shadow 7. Association 8. Colour

NECESSITY

It is necessary to check the thematic accuracy of given image pre-processing (Radiometric & Geometric correction, change direction analysis etc.). This feature is checked with field vegetation for reducing error.

PROCEDURE

The image interpretation is done using ENVI 4.8 SARSCAPE software

- Open ENVI 4.8 software
- Load SAR data & Landsat data
- Tool
- ROI
- Export R01 TO EVF
- Load RO1 on SAR image

- Statistics
- Note down the avg. back scattering value

GRAPH

The graph is drawn between region (x –axis) and mean back scattering value of different feature (y-axis) it shows how the same feature (water bodies, vegetation and mountain)will appear in SAR image and its mean back scatting value.

RESULT

Thus the given SAR & Landsat data is visually interpreted.

Expt No. 3	SAR IMAGE FUSION	Date of Expt:

AIM

To obtain high resolution multi spectral image by combining spectral characteristics of low resolution image of high resolution PAN.

- The standard merging method of image fusion are based on red-green-blue to intensity – hue- saturation (IHS) transformation.
- Principle component transformation
- Intensity modulation

  Intensity of band modulated and fused

  - Colour normalized transformation.

TRANSFORMATION

The image must either be geo referenced or have the same image dimension. ENVI uses the following image sharpening techniques for spectral

- A Gram–Schmidt transform
- A principal components
- A color normal
- ENVI uses the following image sharpening techniques for bye- scaled RGB imagery
- HSV transform
- A column normalization

USING HSV SHARPENNING

HSV sharpening to transform an RGB image to HSV color space, replace the value band with high- resolution image, automatically resample the hue and saturation bands to the high resolution pixel size using a nearest neighbor, bilinear, or convolutions technique. The output RGB image will have the pixel size if the input high resolution data.

USING COLOUR NORMALIZED (BROVEY) SHARPRNING

Used to sharpen multi spectral data using high spatial resolution data. The row spatial resolution spectral data bonds to use to simulate the panchromatic band must fall in the range of the high spatial resolution panchromatic band.

USING PC SPECTRAL SHARPENING

- Performing a PC transformation on the multi-spectral data.
- Replacing pc band with the high resolution band and scaling the high resolution band to match information occurs.
- Performing an inverse transformation.
- The multi-spectral data to the high resolution pixel.

PROCEDURE

- Map
- Registration
- Select GCP image to image
- Select points and add points then save GCP to ASCII
- Wrap file, input land sat transform
- Image sharpening

INFERENCE

Some features are very clear in the SAR imagery because of the cloud penetration character of the microwave remote sensing. Some features in the optical data is easily identified because of the visible color. By fusing the two imageries, the advantage of the two imageries is combined and the visual interpretation becomes easy. The coordinate system of the warped image is transformed to match the high-resolution coordinate system of the base image. In this process, the UTM projection of the LANDSAT imagery is converted to the polyconic projection of the SHR imagery to achieve high-resolution results.

RESULT

Thus the high resolution imagery is obtained by combining the low resolution imagery with the high resolution imagery.

Expt No. 4	PRE-PROCESSING OF SAR IMAGERY	Date of Expt:

AIM

To preprocess the given SAR imagery by using ENVI 4.8.

SOFTWARE USED

ENVI 4.8 Software

DATA USED

SATELLITE: ALOS PALSER.

BAND: L-BAND.

WAVELENGTH: 23.5cm

GEOREFERENCING

Data is georeferenced if it is associated with some position on the earth's surface by using a spatial reference system. This can be achieved by using Coordinates.

DATA PRODUCTS

Level 0: Raw imagery

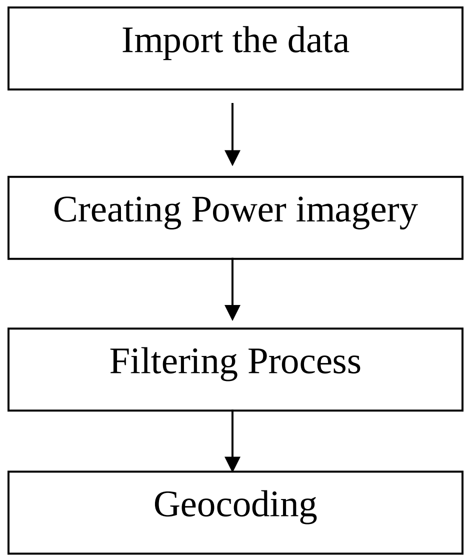
Level 1: Geotagged product that contain all level 0 data appended Calibration and navigation data.

Level 2: Georeferenced product that derived from the Level1 product by applying the sensor calibration, atmospheric correction and the algorithms specific for each kind of geophysical value.

Level3: Composite images of derived variables resampled onto Standard map base and averaged over a certain time period.

PROCEDURE

The georeferencing process is done by the following methodology



MULTILOOKING IMAGERY/POWER IMAGERY

The Single look imagery is converted to multi-looking imagery to reduce the speckle noise in the data. The multi-look data on a disk can be represented as number of looks, number of Lines, sample, azimuth or range resolution.

FILTERING

Filtering is used to enhance images by removing certain spatial frequencies. Spatial frequency describes the variation in brightness.

LEE FILTER

This filter is used to smooth noisy data that have an intensity related to the image scene and that also have an additive and multiplicative component lee filtering is the standard deviation based filters that filters data based on statistics Calculated within individual filter windows.

FROST

The frost filter is an exponentially damped circularly symmetric filter that uses local Statistics. Use this filters to reduce speckle while preserving Edges in radar images.

MEAN/ MODE / MEDIAN

The Mean/Mode/Median filtering is used to reduce the speckle in the radar imageries. The mean filter is the mean based filter that filters data based on statistics calculated within individual filter windows. The mode and Median are also based on the mode and median respectively.

INFERENCE

The imagery was raw data, to make this as useful data we need to preprocess it. The raw images uses SLC product. It have Speckle by changing it as a multilook image reduce speckle. The imagery will be power imagery. By using suitable filters we can enhance the image and it can be georeferenced and resampled.

FILTERING METHODS

Mean/Mode / Median

Azimuth: 3

Range: 3

Edge preserving smoothing

Azimuth: 5 Directionality no: 12

Range: 5 Iteration no: 2

Frost/Lee/Refined lee

Azimuth: 4 Equivalent no. of look = -1.0000

Range: 4

Anisotropic nonlinear diffusion

Gaussian Blur Kernel variance =0.5

Window size = 50

Anisotropy = 0.50

Global interest = 1

Anisotropic nonlinear diffusion interest = 0

Non-linear Iteration = 1

RESULT

Thus, the pre-processing of SAR imagery was done and the image is enhanced & georeferenced.

Expt No. 5	GEOCODING WITH DEM & HEADER EXTRACTION OF SAR IMAGE	Date of Expt:

AIM

To geocode the given SAR image using DEM details and to get the extraction details of the header file of the SAR imagery.

SOFTWARE USED

For geocoding SAR image = ENVI (4:8) - SARSCAPE.

For header file extraction = Best Software.

DATA SPECIFICATIONS

DATA USED- ALOS PALSAR

Orbit - Sun Synchronous orbit

Altitude - 681.65 km

Swath width - 70km

Bit Quantization - 5 bit

Ground resolution - 9m x 10m Reoccurrence cycle - 46 days

OVERVIEW

The given ALOSPAR SAR image, originally in its raw SLC (Single Look Complex) format, is first imported and converted to an MLC (Multi Look Complex) format to reduce noise. Next, a suitable filtering technique is applied to minimize speckle. The image is then geocoded using DEM data. The best available software is utilized to extract the header file, which contains the metadata of the image.

PROCEDURE FOR GEOCODING WITH DEM

Import SLC Data

↓

Conversion to Power Imagery

↓

Filtering Power Imagery

↓

Geocoding with DEM Data

PROCEDURE FOR HEADER EXTRACTION

Open Best Software

↓

Select data import & quick look

↓

Give necessary details in header analysis

↓

Geocoding with DEM Data

INFERENCE

The ALOSPAR SAR image which was initially in single looking compiles imagery is converted to multi-looking imagery format.

Speckles in the image was removed by one of the filtering technique and finally geocoded with DEM data.

The header file which contains the meta data of the image is also extracted.

OBSERVATION

Product type: PRI	Data format: CEOS
Source: ERS-2	Facility id: PGS
Record name: Text record.	
1. Record Sequence number	
2. Scene identification	Orbit 62558
Scene id	Date 8/4/2007
9:53:09	
3. Product type specifier	Product; ERS-2 SAR, SIL
4. Location and date/time	Generated at UK-PAF
of product location & creation	06/April / 2009 11:34:22
5. Scene location	frame 2752
	Lat: 42:39
	Long: 12:99
	Record name: Data Set Summary record
1. Scene reference number	orbit -62558
	frame -2752
2. Scene Centre Home (UTC)	2001040 8095318690

	YYY-M-DD-hh-mm-s-st
3. Processed Scene Centre geodetic	42.3893166
	longitude (degree)+ve N - ve S
4. Processed Scene centre geodetic	12.9907627
	longitude (degree) – ve w
5. Ellipsoid designator	WGS 84
6. Ellipsoid semi major axis	63781370000
7. Ellipsoid Semi minor axis	6 356 752 3000
8. Earth mass time gravitational Constant	3.9860044
9. Scene Centre line number	00014812
10. Scene centre pixel number	002496
11. Number of SAR Channels	0001
12. Sensor platform mission identifier	ERS-2
13. Sensor ID and mode of operation for this channel	SAR-C-HR-IM-VV
14. Orbit number	62558
15. Sensor platform geodetic latitude at nadir coordinate Sensor plat geodetic long	-999.999 +ve for N
16. Sensor platform geodetic longitude at nadir coordinate Sensor plat geodetic long	-999.999 -ve for W
17. Sensor clock angle	90
18. Incidence angle.	23. 232

19. Radar frequency	5.300
20. Radar wavelength	0.0566660
21. No.of. Looks in azimuth	1.0000
22. No. of looks in range	1.0000
23. Range Pulse length	37.1200000
24. Satellite clock time (UTC)	2007040509384288
25. Product type specifier	SAR SINGLE Look
26. Nominal resolution in range is	10 complex image
27. Nominal resolution in azimuth	5
28. Line spacing	3.9769638
29. Pixel spacing	7.9048901
30. Processing system identifier name	PGS- Ees

RESULT

Thus, the geocoding with DEM & header extraction of SAR image was done.

Expt No. 6	PRE-PROCESSING OF POLARIMETRIC SAR IMAGERY	Date of Expt:

AIM

To preprocess the given polarimetric SAR Imagery.

SOFTWARE USED

POLSARPRO V.40

DATA SPECIFICATIONS

RADARSAT-2 Spatial resolution: 1m * 3m.

Active antenna C band, Centre frequency: 5.405 GHZ.

Polarization: HH, VV, HV, VH.

Altitude: 798 km.

Inclination: 98.6 degree.

Duration of one orbit. 100.7 min.

Descending node: 6hrs, Ascending node: 18hrs.

Sun Synchronous: 14 orbits/day.

OVERVIEW

Polarimetric SAR image has to be pre-processed for Speckle reduction to use it effectively. The polarimetric SAR image used in the present exercise is ALOSPALSAR of level 1.5 and level 1.1. These images are of Quad pol type and JAXA CEOS format.

ISOLATED SECTION

When the distance between the target interest is lesser than the radar cross section it is called Isolated section.

INDEPENDENT SECTION

When the distance between the target of interest is more than the radar Cross section it is called independent section.

POLARIMETRIC DECOMPOSITION

The principle behind this technique is that a polarimetric response can be characterised by a combination of idealised scatterers i.e., as a combination of diplane, a sphere and a helix. In physical - based approach it is characterised by dihedral (double bounce), spherical scattering and depolarised signal

Corresponding to volume Scattering. This decomposition is of two types

i)Coherent Decomposition

ii)Incoherent Decomposition

COHERENT DECOMPOSITION

The objective of the coherent decomposition is to express the measured Scattering matrix by the radar [s] as the Combination of the Scattering response of simple objects (or) Canonical objects (or) pure targets

$$[S] = \sum_{i=1}^{R} C_i [S]_i$$

where C_i indicates weight $[S]_i$ & $[S_i]$ indicates the response of pure targets or manmade objects one example of coherent decomposition is the pauli decomposition technique.

Pauli Decomposition

It express the measured scattering matrix [s] in terms of pauli- basis i.e.,

$$[S] = \begin{bmatrix} S_{hh} & S_{hv} \\ S_{vh} & S_{vv} \end{bmatrix} = \alpha[S]_a + \beta[S]_b + \gamma[S]_c$$

Where $[S]_a = 1/\sqrt{2} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, $[S]_b = 1/\sqrt{2} \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$, $[S]_c = 1/\sqrt{2} \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$

& $\alpha = (S_{hh} + S_{vv})/\sqrt{2}$, $\beta = (S_{hh} - S_{vv})/\sqrt{2}$, $\gamma = \sqrt{2}\, S_{vv}$

[Considering monostatic systems Configuration]

Incoherent Decomposition

Distributed scatters (or) natural objects can be Characterised Statistically only with presence of noise. To analyse the Blatter and to reduce speckle second order polarimetric descriptors like covariance < $[C_3]$> <$[T_3]$> and coherence <$[T_3]$> are used. Freeman, Huymen and eigen Vector coherence <$[T_3]$> are used and decomposition techniques are discussed below

Freeman decomposition

This models the Covariance matrix as the Contribution of 3 scattering mechanism

1.Volume scattering where Canopy scatter with randomly oriented dipoles is modelled.

2. Double bounce scattering modelled by a dihedral corner reflector.

3. Surface or Single bounce scattering modelled by Bragg surface scatter.

Huymen Decomposition

Huymen decomposition consideres the concept of "wave dichotony" exporting to the study of distributed Scatters. The Covariance matrix is

$<[T_3]> = <[T_o]> + <[T_N]$ where $[T_o]$ refer to pure target and $[T_N]$ where refer to N-target and it corresponds to distributed target.

Eigen Vector- Eigen value-based Decomposition

This is based on Eigen decomposition of where matrix <$[T_3]$>. According to eigen decomposition theorem, the 3x3 hormetian matrix <$[T_3]$> can be decomposed as $<[T_3]> = [U_3] [\varepsilon_3] [U_3]^{-1}$

$$[\varepsilon_3] = \begin{pmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda_3 \end{pmatrix} \quad \text{(Eigen Values)}$$

& $[U_3] = [\,U_1 \;\; U_2 \;\; U_3]$ Eigen Vectors.

To Simplify 3 Secondary parameters are defined for <$[T_3]$>

Entropy: (H) It determines randomness of scattering process which can be also interpreted as the degree of statistical disorder

When h = 0 indicates pure target

h = 1 indicates distributed target

h>0.7 Indicates the presence of more noise hence anisotropy is suggested.

Anisotropy: It is Complementary to entropy. It measures the relative importance of second and third eigen values of eigen vector.

Mean alpha angle (α): This is related with Scattering process

α = 0 - single bounce by rough Surface

α = 1/4 - volume scattering

α = 1/2 - Double bounce scattering

The different polarimetric data formats.

The (2x2) Sinclair [S_2] used for coherent polarimetric representation and monostatic configuration.

The 3x3 Coherency [T_3] or covariance [C_3] matrices used for incoherent polarimetric representation of second order monostatic matrix elements.

The 4x4 coherency [T_4] or covariance [C_4] matrices used for incoherent polarimetric representation of bistatic scattering matrix.

The 2x2 complex covariance [C_2] matrices used for incoherent polarimetric representation of second order statistics of two scattering matrix elements.

Huymen decomposition values varies from – 26.33 to 5.41 Road Can be identified only pure pixel can be easily identified.

Freeman decomposition values varies from -24-13 to 4.60. It is based on scattering single bounce, double bounce volume bounce

Single bounce α=0

Double bounce $\alpha = \frac{\pi}{2}$ corner reflection (settlement)

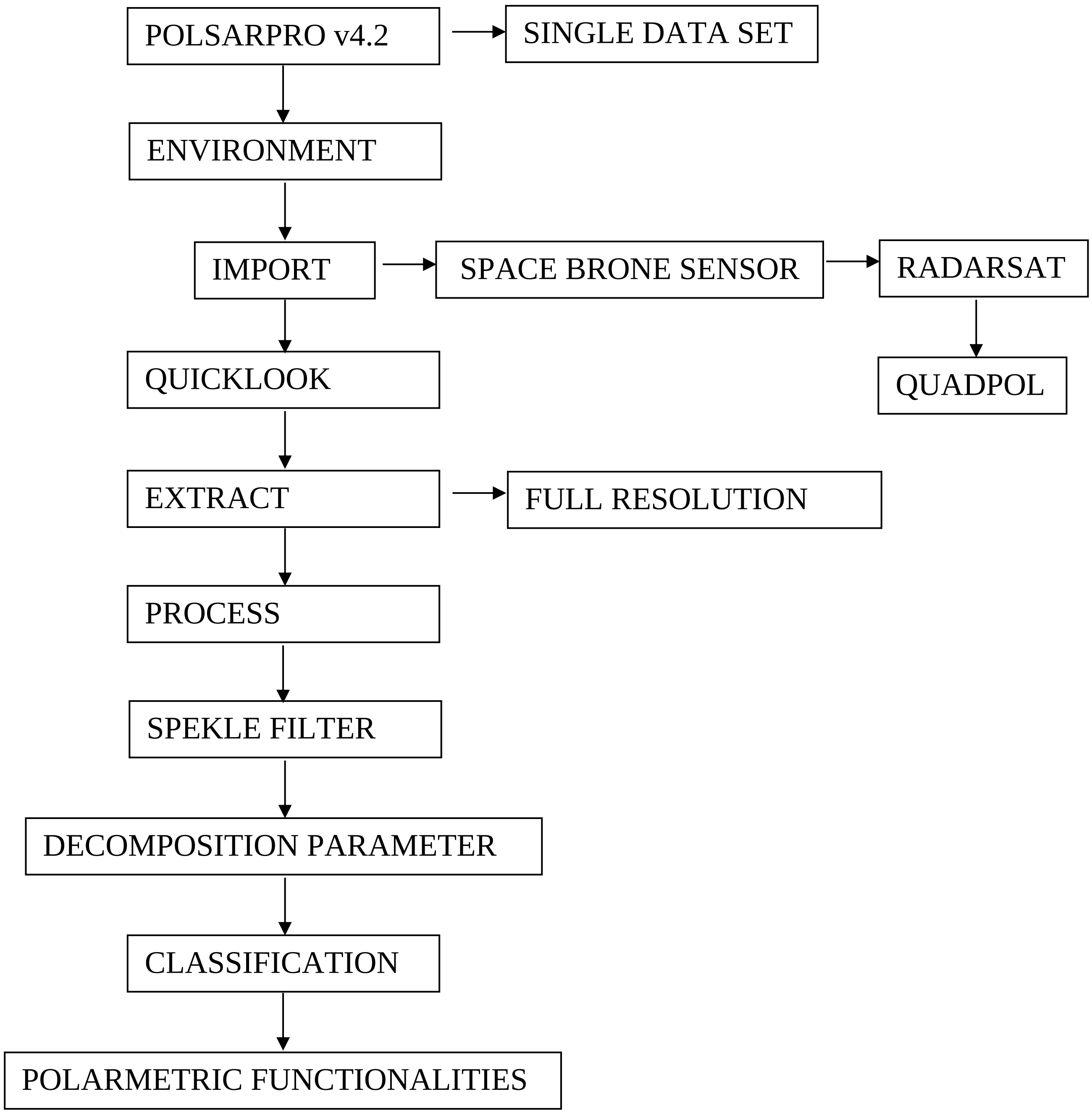
volume bounce $\alpha = \frac{\pi}{4}$ (Forest)

Entropy value varies from 0 to 1 and this above 0.7 means anisotropy is used to enhance it.

Supervised classification, supervisor will give the class here we gave 3 classes.

In unsupervised classification, it classify as 8 classes.

PROCEDURE



RESULT

Thus, the preprocessing of polarimetric SAR image was done.