FOREST – TYPE MAPPING FROM AIRBORNE POLARIMETRIC SAR DATA

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ABSTRACT: Mapping of forest types from satellite data is quite difficult due to poor spatial resolution. This study evaluates the use of polarimetric Airborne Synthetic Aperture Radar (AIRSAR) data to assess forest type distribution within the area of Endau-Rompin in Pahang, Malaysia. Radar backscattering coefficients (σ^0) were evaluated on the L- and P- band for HH, HV and VV polarizations. Statistical evaluation was carried out to determine the Coefficient of Variance (*COV)* and the best combination was determined by calculating the correlation among the bands. The results show that the best band combination for displaying the forest area is band 3 L-HV, band 5 P-HH and band 6 P- VV. Pre-processing was also carried out in terms of both geometric and radiometric correction, which also includes antenna pattern correction. Filtering was carried out using the Lee (5x5) filter, which gave the best *COV*. Masking was also made to exclude other land uses from the forest area. The image was classified by using unsupervised ISODATA technique where five classes of forest have been differentiated from the 10m resolution Airborne SAR data.

1. INTRODUCTION

Satellite remote sensing data using the visible and the infrared wavelengths has been successfully used in various applications related to earth resource studies and monitoring of the environment. Recently, resolution of remote sensing data has been improved in visible images as well as Synthetic Aperture Radar (SAR) images. Polarimetric Airborne Synthetic Aperture Radar (AIRSAR) data that was used are fully polarized C band, L band and P band data. These 3 different wavelengths show their characteristic identity when dealing with forest areas. The C band (5cm) "touches" the canopy of the forest while L band (23cm) and P band (68cm) can penetrate into the forest canopy and return as volume scattering (Grandi, 1994). In this study, the capability of AIRSAR in extracting forest types over the study area was investigated.

2. STUDY SITE

The study site is located in the state of Johor in Malaysia (Figure 1). The natural land is covered by tropical rain forests. From the DEM that has been generated from TOPSAR data, it shows the peak of the mountain is approximately 230m above sea level and is considered as a low land forest. It lies 17 km from Mersing and 22 km from Endau along the Mersing-Endau road.

3. AIRSAR DATA

The AIRSAR data is in 16 – look Strokes matrix format with a pixel spacing of 6.66 m in range and around 8.20 m in azimuth. The incidence angle varies from 20^0 to 60^0. There are 8 bands in this image (Table 1).

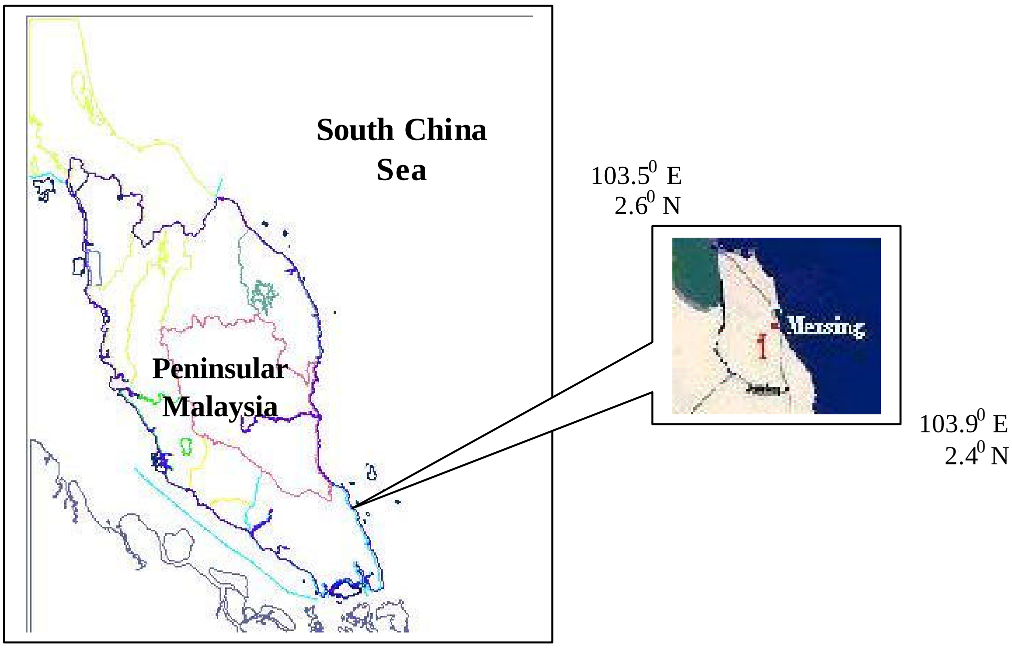

Figure 1: Study area.

Table 1: List of Bands

Band 1	L-HH
Band 2	L-VV
Band 3	L-HV
Band 4	L-TP
Band 5	P-HH
Band 6	P-VV
Band 7	P-HV
Band 8	P-TP

4. DATA PROCESSING

The following processing was carried out on the data (i) conversion of intensity to backscatter coefficient, (ii) geometric correction, (iii) antenna pattern correction, (iv) filtering, (v) region growing and (vi) classification.

4.1 Conversion of intensity to backscatter coefficient

The raw image is in the form of intensity (I) ranging from 0 to 1. For forest study, the image is converted into decibel (dB). It represents radar backscattering properties at small and compressed dynamic range. The intensity image is converted to backscattering coefficient by using the equation (Wu, 1987):

$$dB = 10 \, Log_{10} \, (I)$$

where I = Intensity

4.2 Geocoding

The raw image is based on Universal Transverse Mercator (UTM) projection. Geometric correction was carried out to fit the image according to the Rectified Skew Orthomorphic (RSO) projection. Initially, the image is geocoded using four corner coordinates, which are provided in the TOPSAR header file. The image is geocoded again using a topographic map of 1:25,000 scale (Figure 2). Eleven ground control points were selected which produce a RMS error of 0.21 pixels.

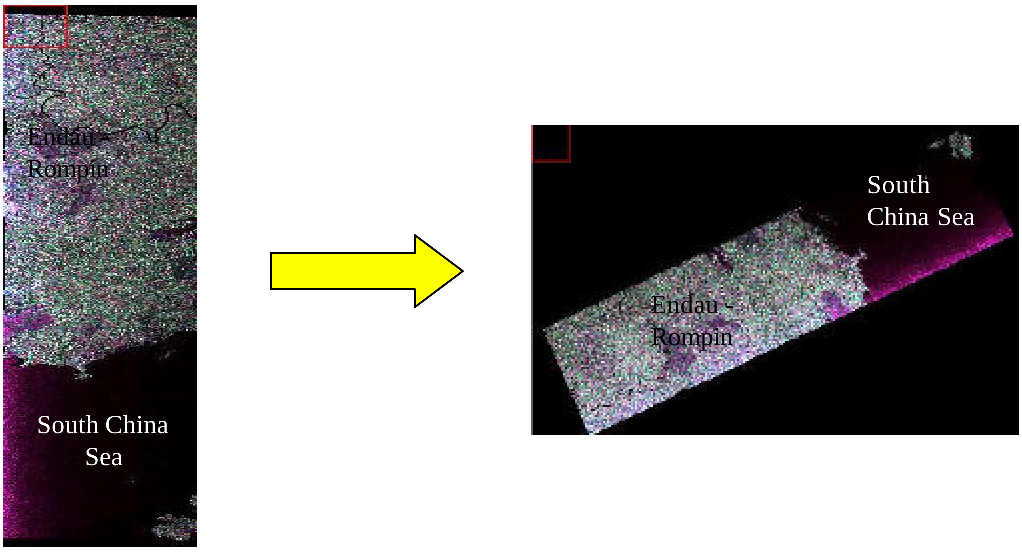

Figure 2. Image before geocoding (left) and after geocoding (right).

4.3 Antenna pattern correction

The brightness of the image is affected by the antenna gain variation where the near range will receive maximum power while the far range will receive minimum power. This effect produces an image that varies in intensity (tone) along the range direction across the image. The antenna pattern effect is expressed as the energy returned to the radar and decreases dramatically as the range distance increases. Antenna pattern correction is applied to produce an uniform average brightness across the imaged swath.

4.4 Filtering

Speckle noise is the main problem in SAR image interpretation and will affect the accuracy of the classification. The noise appears when the signal is converted to image. In this study, various filters have been used to determine which filter gives the best result of minimizing the effect of noise by calculating Coefficient of Variation (COV). COV value is obtained by dividing the mean of digital numbers by the standard deviation (Table 2). From the study, the LEE 5x5 filter gives the best result compared to other filtering techniques. The LEE 5x5 filter successfully minimized the multiplicative noise in the image (Figure 3). A good adaptive filter will minimize the variation of the standard deviation over the mean of the image (Wakabayashi, 1996).

4.5 Region growing

The Gunung Arong forest reserve is surrounded by peat swamp forest. Although the forested area can be located visually, but for accuracy purposes, the forested area is located by using region-growing technique. This technique will automatically locate the forested area by considering the variation of standard deviation. When it " grows", it will look for neighbouring pixels that have similar characteristics with the training pixels and then make a record of that similar pixel so that it is included as the forest pixel (Figure 4). In this case, the standard deviation that has been used to discriminate the forested area is 0.75 using 4 neighbouring pixels.

Figure 3. Image before filtering (left) and after filtering (right).

Table 2: Statistical details of unfiltered image (left) and Lee filtered image (right)

Bands	Mean	Std Dev	COV
Band 1	-10.243473	11.118441	0.9213
Band 2	-10.195885	10.832705	0.9412
Band 3	-17.260886	12.696562	1.3595
Band 4	-11.962812	11.051064	1.0825
Band 5	-8.640384	11.215838	0.7703
Band 6	-9.546126	11.036947	0.8649
Band 7	-16.358134	11.976386	1.3658
Band 8	-10.764494	11.048330	0.9743

Bands	Mean	Std Dev	COV
Band 1	-10.230362	10.543162	0.97033
Band 2	-10.183194	10.241094	0.99434
Band 3	-17.250143	12.186924	1.41546
Band 4	-11.951987	10.514146	1.13675
Band 5	-8.623541	10.601191	0.81347
Band 6	-9.531320	10.401710	0.91631
Band 7	-16.347613	11.371149	1.43764
Band 8	-10.753491	10.507019	1.02345

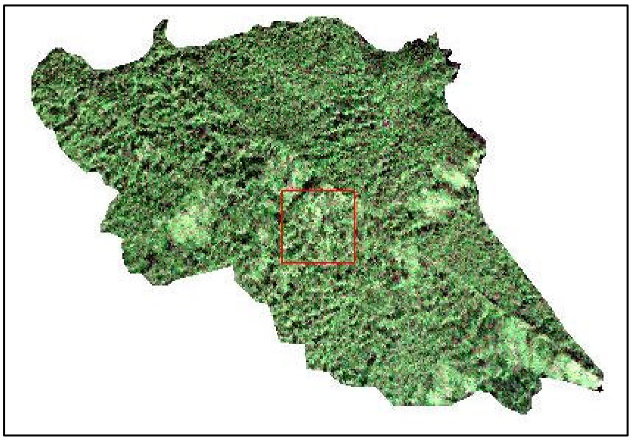

Figure 4. Study area located using region growing technique.

4.6 Visual analysis

As only three bands can be displayed at the same time, determination of maximum information image was done by calculating correlation among the bands (Table 3).

Table 3: Correlation Matrix of Image

Bands	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8
1	1.000000							
2	0.972571	1.000000						
3	0.932214	0.909219	1.000000					
4	0.991419	0.989309	0.948103	1.000000				
5	0.938259	0.929964	0.860979	0.935636	1.000000			
6	0.934612	0.937650	0.848549	0.937468	0.948108	1.000000		
7	0.937738	0.924716	0.927659	0.947036	0.920948	0.915518	1.000000	
8	0.956111	0.952273	0.886287	0.958726	0.985648	0.981367	0.951774	1.0000

The 3 bands with least correlation were displayed, in this case, band 3 L-HV, band 5 P-HH and band 6 P-VV.

4.7 Classification

An unsupervised classification using ISODATA technique was carried out. At least 5 classes of forest types can be identified using the ISODATA technique (Figure 5).

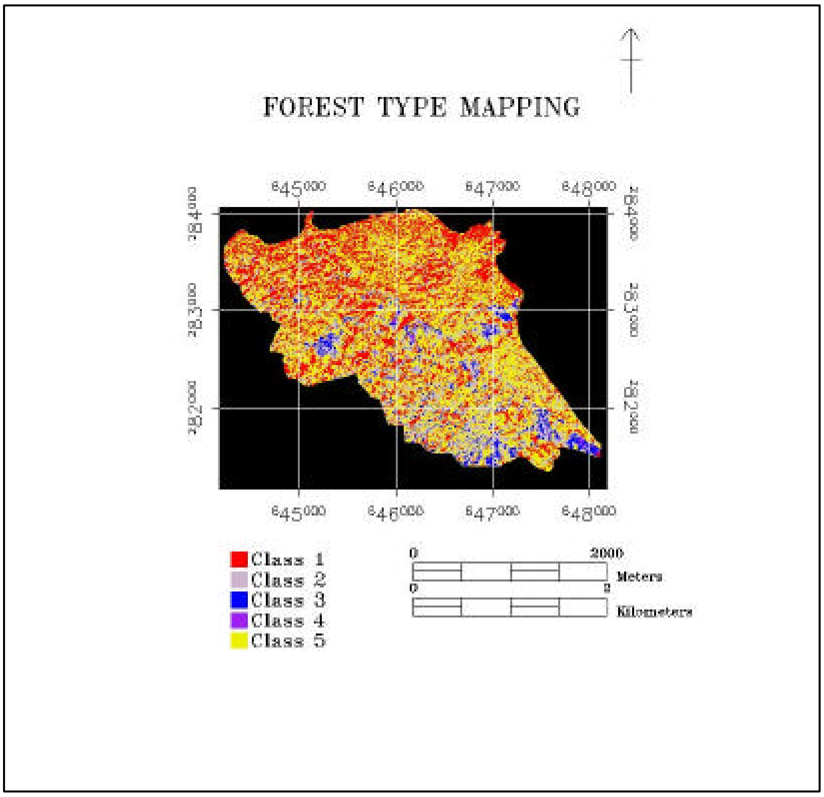

Figure 5. Map of forest types from ISODATA classification technique.

Due to lack of ground truth data, analysis on the accuracy of the classification could not be done. Further work will be carried out to identify the forest types and to estimate tree density from ground truthing work.

5. CONCLUSION

Although ground truth is not available, the polarimetric SAR has proved to be successful in differentiating forest types in forested areas. Further work will be carried out to identify the forest types and to estimate the tree density.

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