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POLARIMETRIC ANALYSIS OF SYNTHETIC APERTURE RADAR IMAGE USING POLSARPRO DATA PROCESSING AND EDUCATION TOOL

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ABSTRACT

Synthetic Aperture Radar (SAR) gives more resolution than conventional radars. SAR detects and produces the image of the object where conventional radar only detects the object. This paper analyzes the scattering mechanism at tree level of L–band SAR image by using POLSARPRO data processing and education tool. The main view of this paper is creating Pauli color composition of the forest image by using POLSARPRO software which exhibits the characteristics of image as Ground Range and Azimuth in x- direction and y- direction respectively. The Pauli color decomposition technique is used among other coherent color decomposition techniques. The analysis is carried out for finding the characteristics of L – band SAR forest image such as crown, vegetation, Pine Trees and Deciduous.

INDEX TERMS: SAR, POLSARPRO, PAULI COLOR CODE, CROWN, DECIDUOUS, VEGETATION.

1. INTRODUCTION

Antenna aperture gives the capability of extracting the power of the antenna at the receiving side. When the aperture area is large, more power can be received by the antenna at receiving side. The antenna gives more gain when it receives more power. In real time radars large aperture area is not possible due to small length of antenna.

More resolution is not possible with small aperture area of the antenna. In this way the Designing and constructing of radar antenna with small aperture area is needed to produce desirable resolution. Maximum resolution is not possible with small length antennas. Maximum resolution is possible by increasing antenna aperture without increasing antenna length. By using SAR we can achieve maximum resolution with small length antenna. The working principle of SAR is discussed in section 2 accompanied with Polari metric SAR theory.

2. SAR WORKING PRINCIPLE AND POLARIMETRIC SAR

2.1 SAR PRINCIPLE

As discussed in section 1 synthetic aperture radar works with large aperture area. When the aperture area is large it results maximum resolution. In SAR the physical length of the antenna not decides aperture area. In SAR by synthesizing the data from the target we can attain large aperture area.

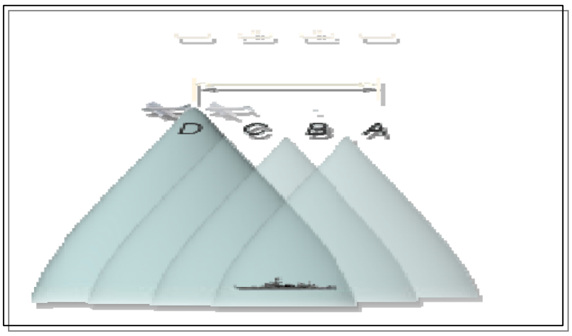


Fig 1: SAR capturing object (ship)

SAR uses one antenna with time – multiplex and antenna changes its geometric positions. As it moves from one position to other, antenna platform also moves [1]. SAR is located on moving objects such as an aircraft or spacecraft and it is originated as an advanced form of side-looking airborne radar (SLAR). As shown in Fig 1 when aircraft or spacecraft moves from position A to D and when ship enters in the antenna beam then the transmitted pulse will be backscattered. The echoes from each transmitted pulse is processed and recorded. As the antenna platform moves forward then all the echoes from the target are recorded during the entire time. The processing and recording data from target will be continued when the target is within the antenna beam. Processing and recording of all the received data forms synthesizing aperture which results maximum resolution [2]. From the recorded data, SAR produces image and this image will be decomposed by different decomposition techniques to analyze. SAR images have wide applications in remote sensing, mapping of the surfaces of both the Earth and other planets, military reconnaissance, measurement of sea state and ocean wave conditions and mineral explorations. The decomposition techniques are discussed in section 3.

2.2 POLARIMETRIC SAR

Polarimetric SAR is the science of acquiring, processing and analyzing the polarization condition of an EM wave. The polarization information in the EM wave backscattered from a given medium is related with target geometrical structure, orientation and geographical properties such as humidity, roughness and conductivity of soils. When EM wave strikes an object it will be reflected back. The SAR Polarimetry theory acquires the characteristics such as reflectivity, shape and orientation of reflecting body from the reflected signal.

Polarimetry deals with the polarized EM wave which propagates through the frequency spectrum in microwave frequency range (300 MHz to 300 GHz) [6] [7] .When EM wave strikes an object, it will be reflected back then the characteristic information about the reflectivity, shape and orientation of the reflecting body can be obtained by implementing polarization control [8] [9].

3. PAULI COLOR CODING

Pauli color coding is coherent color decomposition technique used in synthetic aperture radar Polarimetry. The main objective of coherent color decomposition is expressing measured scattering matrix of radar as a combination of objects. The interpretation of this Pauli coherent decomposition color coding is based on scattering matrix and corresponding scattering coefficients. The Pauli color coding is coding based on a vector representation of linear combinations of scattering matrix [S] elements. The Pauli color decomposition of scattering matrix represents all the Polarimetric information in a single SAR image. The scattering matrix elements can be developed from the data received by the radar due to scattering of EM wave from the target location. In real time applications the scattering matrix measured by the radar corresponds to a complex coherent target. The scattering matrix elements taken from the scattering coefficients, where scattering coefficients are expressed as a function of the intensity of the incident and scattered fields. The scattering coefficients determine the power scattered by targets which are characterized by single or odd bounce. The intensity of scattering coefficients is taken as the combination of HH, VV and HV. H and V represent horizontal polarization and vertical polarization respectively. The resulting Polarimetric intensity can be expressed as the combinations such as HH+VV, HH-VV and HV.

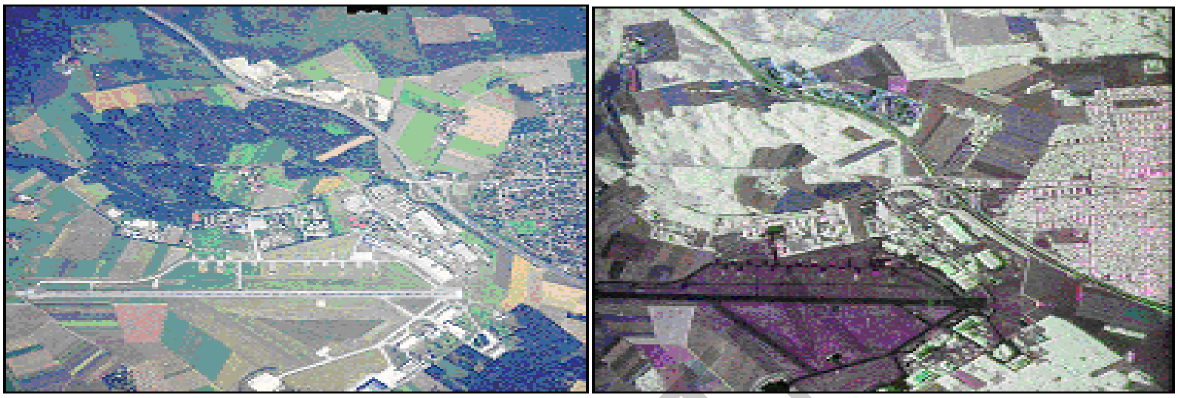


Figure 2: Optical image and Pauli color coded image over oberfaffenhofen (Germany)

In figure 2, 1st image is the optical image and 2nd image is the converted Pauli color code image. The combination of this Polarimetric plays an important role in differentiating ocean surface (or) agricultural areas, forests, vegetation and trees and urban areas which composed with different scenes this process is called "Pauli color coding representation ", this adopted Pauli color coding is the standard for today's POLSAR image display.

The sea appears blue color in image2. This indicates that the first Polarimetric channel HH+VV magnitude is large compared to others. This is characteristic of scattering over a surface. Over forested areas, the green color indicates a dominant HV component it is the characteristic of vegetated zones. Over the built up areas, the dominant colors are white and red. White pixels correspond to equal amplitude over all Polarimetric channels, whereas red indicates that the phase argument of HHVV* is close to π, and denote a wave double bounce reflection. Basically Pauli color code gives color composition to the given SAR image. In this paper this code has been used to find out the crown, vegetation area, pine trees and deciduous and it is discussed in section

6. Pauli color code image gives the graphical representation as Ground Range in x- direction and Azimuth in y-direction.

4. IMAGE ANLAYSIS AND CONSTRUCTION

Image analysis techniques majorly categorized into feature extraction, segmentation and classification technique. In feature extraction spatial feature extraction represents the amplitude. The spatial feature of an image is characterized by its gray levels, joint probability, distribution and spatial distribution. The most useful feature of an object is the amplitude of its physical property such as reflectivity, transimissivity and tristimulus values. In radar images amplitude represents the radar cross-section, which determines the size of the object [10]. The amplitude feature can be extracted by intensity level slicing. Intensity level slicing is the technique which is useful when different features of an image are contained in different gray levels as discussed in section6.

The construction of radar image from forest image as follows. During construction of radar image (SAR Image) from the forest image, we have to consider the basic parameters of the forest such as Crown of trees, vegetation and hedge along with pine trees and deciduous trees. During generation of image first the forest scene is generated. By constructing a large scale ground surface and then populating the forest stand area with trees and short vegetation are generated as illustrated in figure 4.

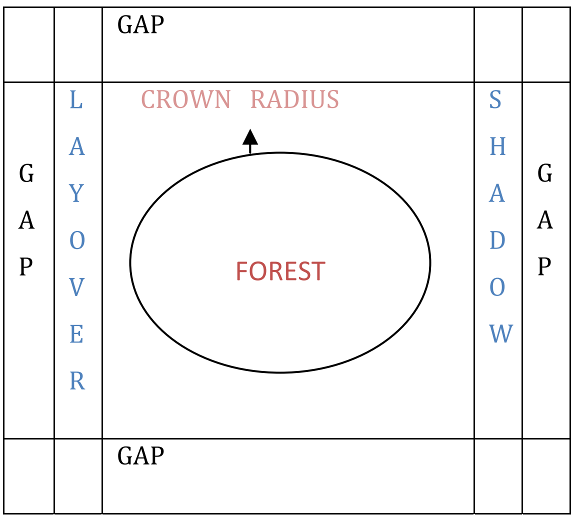
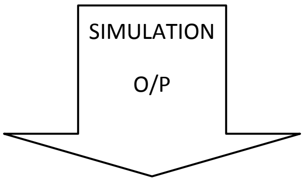


Figure 4: Geometry scene of generating image

Figure 5 : Forest image



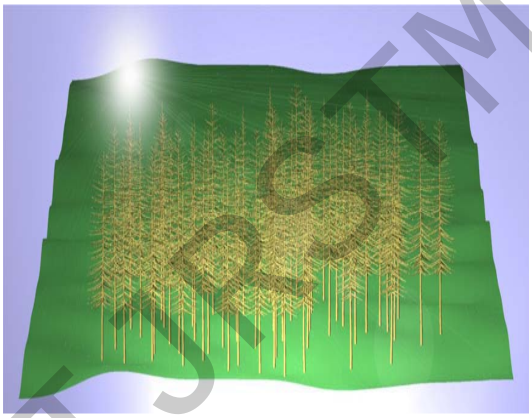


Figure 6: Forest image view from the radar (SAR Image)

From Figure 5 and Figure 6 it can be understood the process of generating radar image as discussed in previous topic. This radar image will be converted into Pauli color code which can be used for analysis and it is discussed in section6.

5. SAR SIMULATION RESULT

In this simulation we have analyzed the forest image by taking L – band SAR forest images by using POLSARPRO Simulator. Before applying the image to simulator the parameters such as tree species, mean height of the stand, stem density and area of the forest stand are to be applied to simulator as user defined parameters. As shown in Table 1 and Table 2 geometric configurations such as Platform Altitude, incidence angle, horizontal base line and vertical base line can be selected by the user. In the same way user can opt geometric configurations and system configurations such as centre frequency.

The result is carried out by considering two cases, 1st case is low forest stand density (trees/Ha) and in 2nd case high forest stand density. When the forest SAR image is applied to POLSARPRO simulator the simulator produces image as fig 6, again this image will be converted into Pauli coherent color decomposition code using POLSAPRO Simulator.

CASE: 1 (LOW FOREST DENSITY)

Table 1: Low forest Density

Geometric Configuration	
Platform Altitude	3680 meters
Incidence Angle	31 degrees
Horizontal Baseline	10.7 meters
Vertical Baseline	- 6.0 meters
System Configuration	
Centre Frequency	1.3 Gigahertz (GHz)
Azimuth Resolution	1.09 meters
Slant Range Resolution	0.56 meters
Ground Surface Configuration	
Surface Properties	3
Ground Moisture Content	5
Ground Azimuth Slope	0.2%
Ground Range Slope	0.2 %
Forest Configuration	
Tree Species	0 HEDGE
Tree Height	10 Meters
Forest Stand Density	362 Stems / Ha
Forest Stand Area	0.7850 Ha
Random Number	888

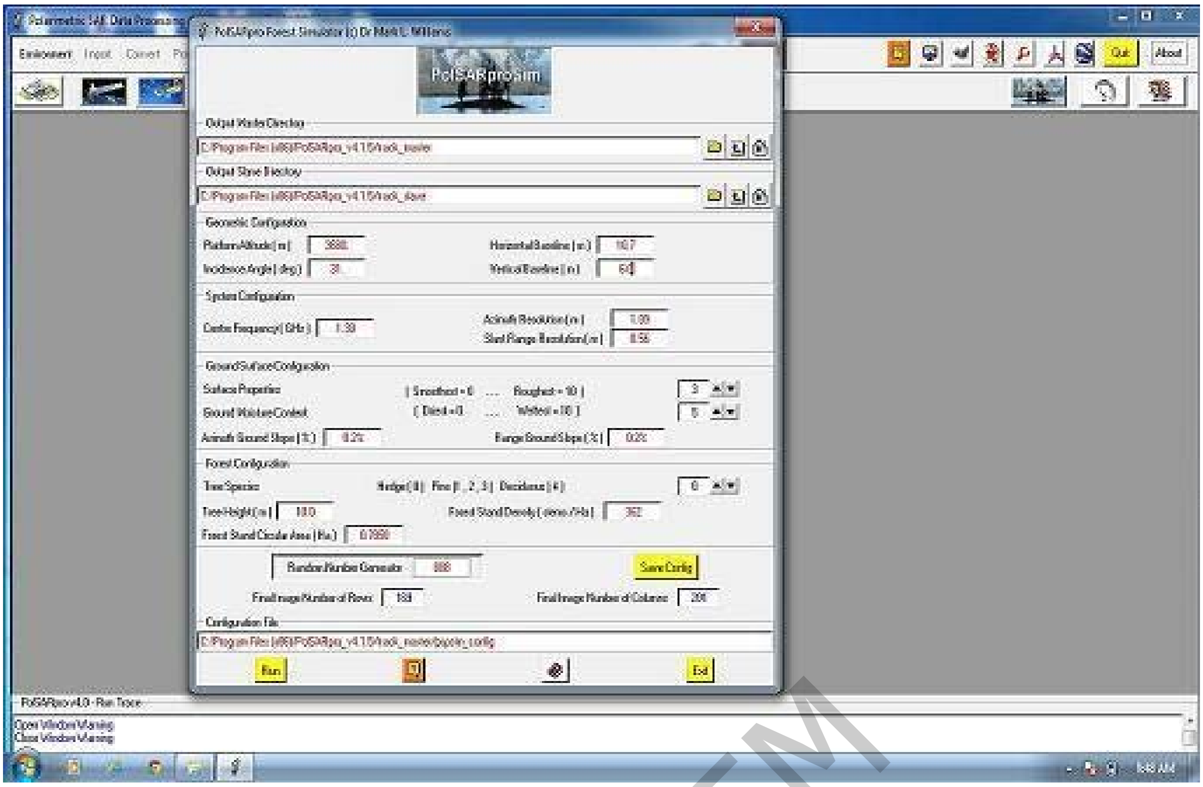


Figure 7: The window shows simulation process

Figure 8: Simulator output image for L – band SAR forest image

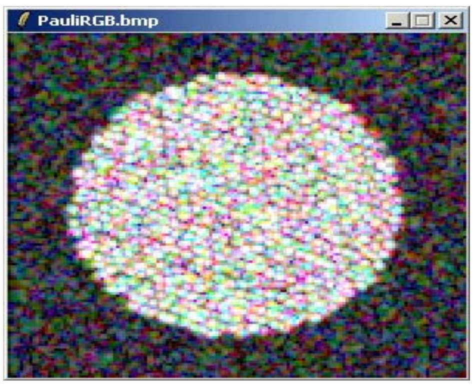


Figure 9: Pauli coherent color coded image

CASE: 2 (VERY HIGH FOREST DENSITY)

Table 2: Very high forest density

Geometric Configuration	
Altitude	3000.0 meters
Incidence Angle	45.0 degrees
Horizontal Baseline	52.5 meters
Vertical Baseline	- 52.5 meters
System Configuration	
Centre Frequency	1.45 Gigahertz (GHz)
Azimuth Resolution	2.5metres
Slant Range Resolution	1.416 meters
Ground Surface Configuration	
Surface Properties	6
Ground Moisture Content	5
Ground Azimuth Slope	0.2 %
Ground Range Slope	0.3 %
Forest Configuration	
Tree Species	4 DECIDIOUS
Tree Height	7.5 Meters
Forest Stand Density	555 Stems / Ha
Forest Stand Area	8.91001 Ha

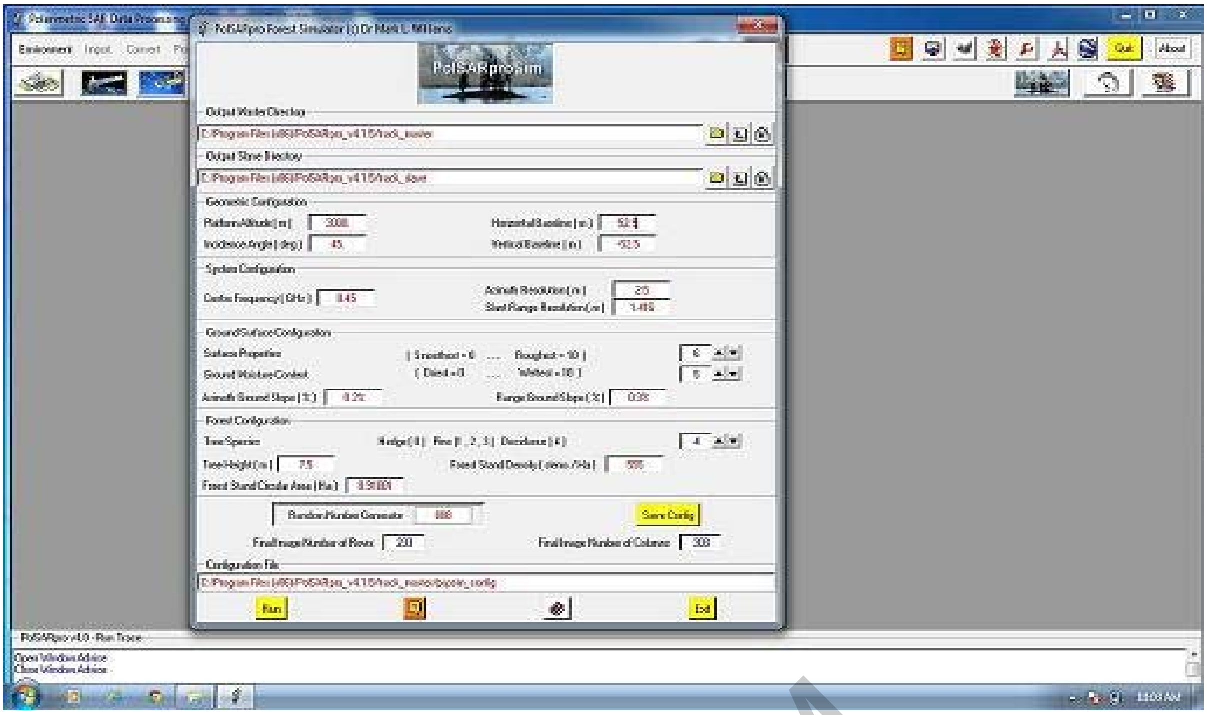


Figure 10: The window shows simulation process

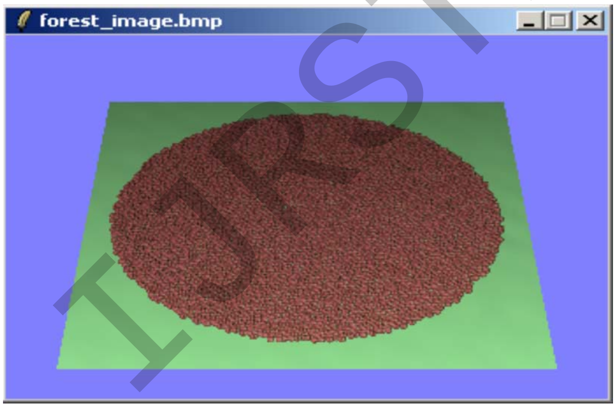


Fig11: Simulator output image for L – band SAR forest image

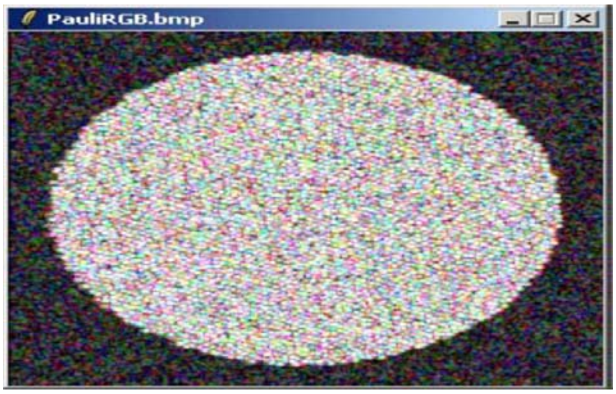


Figure 12: Pauli coherent color coded image

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6. DISCUSSION ABOUT THE RESULT

The result in section5 gives conversion of forest image into SAR image and Pauli color code image. Generation and construction of radar image is discussed in section4. The radar image gives Ground Range in x- direction and Azimuth in y- direction. It gives forest density in centre of the scene in a circle manner.

CASE 1: When the forest stand area is 0.7850 Ha, forest stand density is 362 stems / Ha, tree height is 10 meters and there is no hedge then the resulting radar image is illustrated in Fig8. By using this user defined parameters the image was generated and from this image we can conclude that platform altitude is 3680 meters, where platform is generated with green color, but crown density is very low which is indicated in red accent 2 color. Figure 8 shows the Pauli color code image is generated by using POLSARPRO software tool. As discussed in section 3 Living Crowns are represented as Red color, deciduous is represented in gray color, short vegetation represented as shadow and pine trees represented as overlap. By observing Fig9 red color pixels are very less which indicates that the crown density is low.

CASE 2: When the forest density is 8.91001 Ha, forest stand density is 555 stems / Ha, tree height is 7.5 meters and there is hedge with 4 deciduous then the resulting radar image is illustrated in Fig11. By using this user defined parameters the image was generated and from this image we can conclude that platform altitude is 3000 meters where platform is generated with green color, but crown density is very high compared with Fig8 which is indicated in red accent 2 color.

The generation of Pauli color code image by using POLSARPRO software tool is shown in Fig12. As discussed in section 3 Living Crowns are represented as Red color, deciduous is represented in gray color, short vegetation represented as shadow and pine trees represented as overlap. Fig12 shows red color pixels are more which indicates that the crown density is high and the observed shadow indicates the deciduous.

7. CONCLUSION

The features of forest image such as crown, hedge, deciduous and shadow have been studied from scattering mechanism at tree level. All parameters analyzed in this paper are regarding tree properties. The comparison of results shows high forest stand density exhibits more crown density and low forest density exhibits low crown density. Finally we can conclude that all the consequences of the analysis presented in this paper are regarding tree properties.

REFERENCES

1. Introduction to Radar Systems by Merrill, I, skolnik 2nd edition published by Tata Mcgraw Hill Education Private Limited.

2. Synthetic Aperture Radar Fundementals and image processing by Roberto. Harger, EEE department, university of marylandcollege park, MD20742.

3. Principles of SAR by samuelw. mccandless, Jr and Christopher p. jackson

4. Earth.esa.int/polsarpro.

5. Polsarpro Education Tool Tutorial Notes.

6. Boerner, W-M, H. Mott, E. Lüneburg, C. Livingston, B. Brisco, R. J. Brown and J. S. Paterson with contributions by S.R. Cloude, E. Krogager, J. S. Lee, D. L. Schuler, J. J. van Zyl, D. Randall P. Budkewitsch and E. Pottier, "Polarimetry in Radar Remote Sensing".

7. Boerner, W-M, S.R. Cloude, and A. Moreira, 2002, "User collision in sharing of electromagnetic spectrum: Frequency allocation, RF interference reduction and RF security threat mitigation in radio propagation and passive and active remote sensing", URSI-F Open Symp., Sess. 3AP-1, 2002 Feb.

8. Poelman, A.J. and J.R.F. Guy, 1985, "Polarization information utilization in primary radar"; in Boerner,W-M. Etc al. (eds), 1985, "Inverse Methods in Electromagnetic Imaging", Proceedings of the NATO-Advanced Research Workshop, (18-24 Sept. 1983, Bad Windsheim, FR Germany).

9. Poelman, A.J. and K.J. Hilgers, 1988, "Effectiveness of multi-notch logic-product polarization Filters for countering rain clutter", in Proceedings of the NATO Advanced Research Workshop on Direct and inverse methods in Radar Polarimetry.

10. Fundamentals of Digital Image Processing by Anil K. Jain.