AN OVERVIEW OF RECENT ADVANCES IN POLARIMETRIC SAR INFORMATION EXTRACTION: ALGORITHMS AND APPLICATIONS

Jong-Sen Lee and Thomas L. Ainsworth
Remote Sensing Division, Naval Research Laboratory, Washington DC 20375, USA
jong_sen_lee@yahoo.com, Ainsworth@nrl.navy.navy.mil

1. INTRODUCTION

Since IGARSS2000 in Hawaii, significant advances in polarimetric SAR (PolSAR) instruments and information extraction technology have been flourished, and PolSAR related research and applications has reached a certain degree of maturity. With the wide availability of PolSAR data from both space borne and airborne SAR systems, especially the three satellites launched in last four years: L-Band ALOS/PALSAR, C-Band RADARSAT-2, and X-Band TerraSAR-X, we are very fortunate to be at the door step of the golden age for developing PolSAR applications for Earth environment, disaster management, crop monitoring, etc. In this review paper, we will present advances in PolSAR information extraction algorithms and applications developed over the last decade.

PolSAR information extraction algorithms can be divided into two categories: generally applicable and application specific algorithms. A few references will be cited in this abstract; a more complete bibliography will be compiled with the presentation.

2. GENERALLY APPLICABLE ALGORITHMS

Algorithms in this category were developed based on radar polarimetry and/or speckle statistics for general applications. Algorithms for PolSAR image enhancement and speckle filtering are also in this category. Due to the page limitation, we will discuss only two out of the six areas.

A. PolSAR Speckle Filtering (Coherent Matrix Estimation)

PolSAR speckle filtering is the technique to reduce the speckle effect inherent in polarimetric covariance or coherency matrix by averaging neighboring pixels adaptively [1]. In recent years, the term "PolSAR speckle filtering" has often been replaced by "coherency matrix estimation" [2]. The approaches have been expanded to include wavelet transform [3]], to take into consideration of scattering mechanisms [5], and other image processing techniques [4]. We believe that PolSAR speckle filtering should emphasize computational efficiency, because of the large dimension of current high-resolution space borne SAR data, typically, of several thousand by several thousand pixels.

B. Target scattering decompositions

Target decomposition is applied to separate polarimetric target signatures into several basic scattering mechanisms. The most frequently applied is the Cloude and Pottier decomposition [6] developed in the 90's. Target decompositions can be divided into coherent and incoherent decompositions. In coherent decomposition, Cameron and Rais [7] examined the range of orientation angle for symmetrical scatterers, and Touzi [12] proposed an alternative alpha angle. For incoherent decomposition, extensions to the scattering model based decomposition by Freeman and Durden [8, 11] have been developed. Yamaguchi et al. [9, 10] proposed a four-component decomposition by adding helix scattering as the fourth component to account for the missing off-diagonal terms of covariance matrix. The main contribution is in the modification of the volume scattering model to include vertical or horizontal oriented volume scatterings.

C. PolSAR Classification

D. Surface Parameter Estimation

E. Orientation Angle Estimation

F. Compact Polarimetry

3. APPLICATION SPECIFIC ALGORITHMS

Many algorithms were developed for specific applications, some algorithms developed for general applications have been applied effectively in parameter extractions. In this category, vegetation/forest parameter estimation has been a hot research topic, and polarimetric SAR interferometry algorithms were specifically developed for this application. We shall restrict our discussion to algorithms based on PolSAR data alone. For example, anisotropy of the Cloude and Pottier decomposition has been found effective for forest height estimation based on P-band PolSAR data [13]. Vegetation scattering modeling [14] has also produced interesting results. Other areas to be considered are Faraday rotation estimation [15] for ionosphere, sea ice detection and classification, and wetland characterization [16] will also be reviewed.

We will illustrate a specific applications employing imagery collected by the new space borne polarimetric SAR systems (L-Band ALOS/PALSAR, C-Band RADARSAT-2, and X-Band TerraSAR-X) and polarimetric airborne SAR data.

4. SUMMARY

During the last decade, very significant advances have been made in polarimetric SAR information extraction technology. In this paper, we intend to provide a detailed review of theory, processing algorithms, and applications. A bibliography will be compiled for easy reference.

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