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Forest classification using extracted PolSAR features from Compact Polarimetry data

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Abstract

This study investigates the ability of extracted Polarimetric Synthetic Aperture RADAR (PolSAR) features from Compact Polarimetry (CP) data for forest classification. The CP is a new mode that is recently proposed in Dual Polarimetry (DP) imaging system. It has several important advantages in comparison with Full Polarimetry (FP) mode such as reduction ability in complexity, cost, mass, data rate of a SAR system. Two strategies are employed for PolSAR feature extraction. In first strategy, the features are extracted using 2×2 covariance matrices of CP modes simulated by RADARSAT-2 C-band FP mode. In second strategy, they are extracted using 3×3 covariance matrices reconstructed from the CP modes called Pseudo Quad (PQ) modes. In each strategy, the extracted PolSAR features are combined and optimal features are selected by Genetic Algorithm (GA) and then a Support Vector Machine (SVM) classifier is applied. Finally, the results are compared with the FP mode. Results of this study show that the PolSAR features extracted from $\pi/4$ CP mode, as well as combining the PolSAR features extracted from CP or PQ modes provide a better overall accuracy in classification of forest.

Keywords: Compact Polarimetry (CP); CP mode; Pseudo Quad polarimetry (PQ) mode; Forest classification

1. Introduction

Forests are a major natural resource of the Earth and control a wide range of environmental processes such as energy exchange between the land surface and the atmosphere (Jarvis and Dewar, 1993). Therefore, forest classification is essential to manage natural resources and environment, land use plans and land potential. While the weather conditions often limit the use of optical images, Synthetic Aperture RADAR (SAR) images, due to independent of weather conditions and also sensitive to the geometry of both the canopy and branching structure, can be the efficient data for forest mapping applications (Maghsoudi et al., 2012). Particularly, Polarimetric SAR (PolSAR) data has been successfully used in forest classification.

The Full Polarimetry (FP) SAR systems produce the scattering matrix containing the four backscatter measurements at every imaged pixel. This allows much more information to be extracted from targets. The FP mode veritably has proven its increased potential compared to a single or double channel acquisition, but suffer from an increase in the pulse repetition frequency and the data rate over single polarization (Ainsworth et al., 2009). Their imaged swaths are also halved, resulting in reduced coverage and a degraded revisiting time (Dubois-Fernandez et al., 2008). Based on this, the FP mode may be not useful for high scale applications, such as monitoring and controlling of ocean, forest and etc.

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In the standard Dual Polarimetry (DP) SAR systems, versus the FP SAR, one polarization is transmitted, whereas two are coherently received. These DP modes collect only half of the full scattering matrix. This reduces both the data processing requirements and the information content of the polarimetric imagery.

Recently, a growing interest has been raised for the DP SAR system called Compact Polarimetry (CP). It is able to reduce the complexity, cost, mass, and data rate of a SAR system while attempting to maintain many capabilities of a FP system (Boularbah et al., 2012). As with other DP SAR systems, the CP mode transmits one polarization and

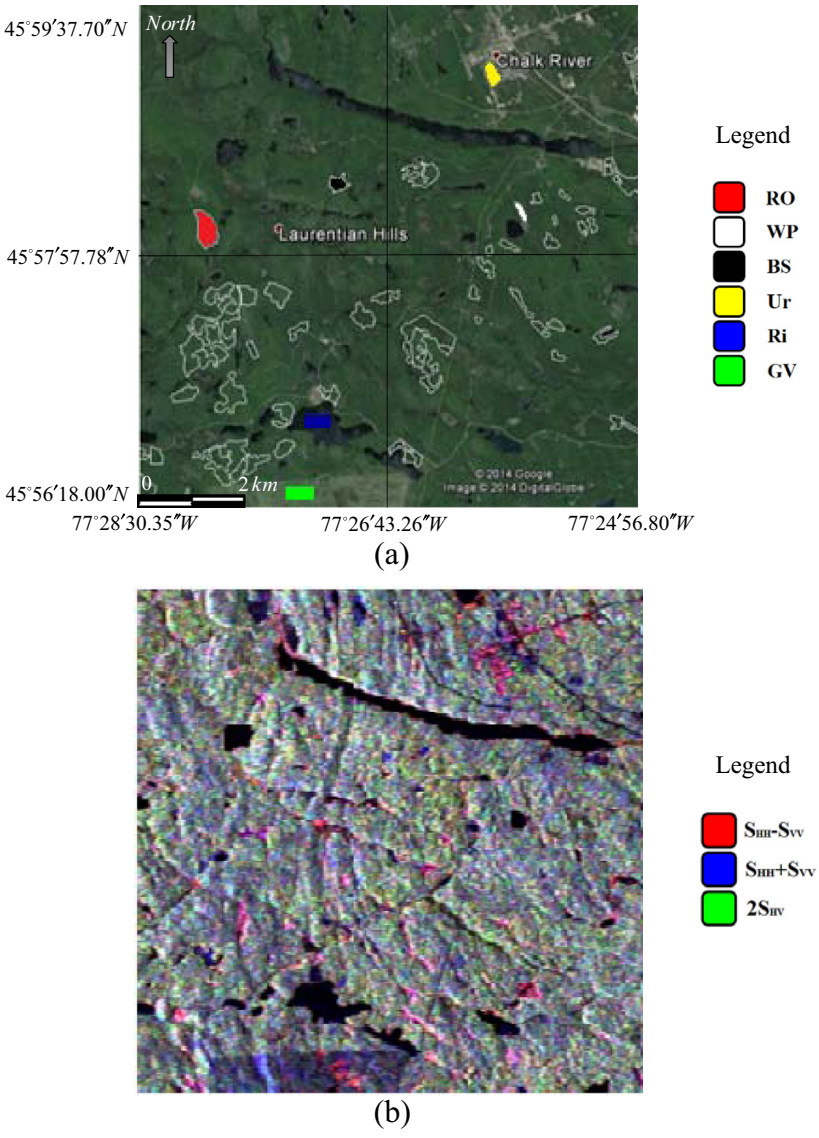

Fig. 1. (a) Reference data polygons of various forest species overlaid on high resolution images, and (b) RADARSAT-2 FP SAR data in Pauli basis. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
List of classes, training and testing sample sizes.

Type	Name	Species	# of training pixels	# of testing pixels
Forest-Hardwood	RO	Red oak	980	772
Forest-Softwood	WP	White pine	305	375
	BP	Black spruce	900	782
Other	Ur	Urban	570	494
	Ri	River	1047	810
	GV	Ground vegetation	978	631