Spatially Adaptive Analysis and Segmentation of Polari-metric SAR Data

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Abstract

In recent years, Polarimetric Synthetic Aperture Radar (PolSAR) has been one of the most important instruments for earth observation, and is increasingly used in various remote sensing applications. Statistical modelling and scattering analysis are two main ways for PolSAR data interpretation, and have been intensively investigated in the past two decades. Moreover, spatial analysis was applied in the analysis of PolSAR data and found to be beneficial to achieve more accurate interpretation results. This thesis focuses on extracting typical spatial information, i.e., edges and regions by exploring the statistical characteristics of PolSAR data. The existing spatial analysing methods are mainly based on the complex Wishart distribution, which well characterizes the inherent statistical features in homogeneous areas. However, the non-Gaussian models can give better representation of the PolSAR statistics, and therefore have the potential to improve the performance of spatial analysis, especially in heterogeneous areas. In addition, the traditional fixed-shape windows cannot accurately estimate the distribution parameter in some complicated areas, leading to the loss of the refined spatial details. Furthermore, many of the existing methods are not spatially adaptive so that the obtained results are promising in some areas whereas unsatisfactory in other areas. Therefore, this thesis is dedicated to extracting spatial information by applying the non-Gaussian statistical models and spatially adaptive strategies. The specific objectives of the thesis include: (1) to develop reliable edge detection method, (2) to develop spatially adaptive superpixel generation method, and (3) to investigate a new framework of region-based segmentation. Automatic edge detection plays a fundamental role in spatial analysis, whereas the performance of classical PolSAR edge detection methods is limited by the fixed-shape windows. Paper 1 investigates an enhanced edge detection method using the proposed directional span-driven adaptive (DSDA) window. The DSDA window has variable sizes and flexible shapes, and can overcome the limitation of fixed-shape windows by adaptively selecting homogeneous samples. The spherically invariant random vector (SIRV) product model is adopted to characterize the PolSAR data, and a span ratio is combined with the SIRV distance to highlight the dissimilarity measure. The experimental results demonstrated that the proposed method can detect not only the obvious edges, but also the tiny and inconspicuous edges in heterogeneous areas. Edge detection and region segmentation are two important aspects of spatial analysis. As to the region segmentation, paper 2 presents an adaptive PolSAR superpixel generation method based on the simple linear iterative clustering (SLIC) framework. In the k-means clustering procedure, multiple cues including polarimetric, spatial, and texture information are considered to measure the distance. Since the constant weighting factor which balances the spectral similarity and spatial proximity may cause over- or under-superpixel
segmentation in different areas, the proposed method sets the factor adaptively based on the homogeneity analysis. Then, in heterogeneous areas, the spectral similarity is more significant than the spatial constraint, generating superpixels which better preserved local details and refined structures. Paper 3 investigates another PolSAR superpixel generation method, which is achieved from the global optimization aspect, using the entropy rate method. The distance between neighbouring pixels is calculated based on their corresponding DSDA regions. In addition, the SIRV distance and the Wishart distance are combined together. Therefore, the proposed method makes good use of the entropy rate framework, and also incorporates the merits of the SIRV distance and the Wishart distance. The superpixels are generated in a homogeneity-adaptive manner, resulting in smooth representation of the land covers in homogeneous areas, and well preserved details in heterogeneous areas.

**Key Words**
Polarimetric SAR, Spatially adaptive, Edge detection, Spherically invariant random vector (SIRV), Superpixel, Simple linear iterative clustering (SLIC), Entropy rate, Segmentation