Deep Learning for SAR Images Restoration

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Abstract : In the context of Synthetic Aperture Radar (SAR) data, polarization is an important source of information for Earth's surface monitoring. SAR Systems are often considered to transmit only one polarization. This constraint leads to either single or dual polarimetric SAR imaging modalities. Single polarimetric systems operate with a fixed single polarization of both transmitted and received electromagnetic (EM) waves, resulting in a single acquisition channel. Dual polarimetric systems, on the other hand, transmit in one fixed polarization and receive in two orthogonal polarizations, resulting in two acquisition channels. Dual polarimetric systems are obviously more informative than single polarimetric systems and are increasingly being used for a variety of remote sensing applications. In dual polarimetric systems, the choice of polarizations for the transmitter and the receiver is open. The choice of circular transmit polarization and coherent dual linear receive polarizations forms a special dual polarimetric system called hybrid polarimetry, which brings the properties of rotational invariance to geometrical orientations of features in the scene and optimizes the design of the radar in terms of reliability, mass, and power constraints. The complete characterization of target scattering, however, requires fully polarimetric data, which can be acquired with systems that transmit two orthogonal polarizations. This adds further complexity to data acquisition and shortens the coverage area or swath of fully polarimetric images compared to the swath of dual or hybrid polarimetric images. The search for solutions to augment dual polarimetric data to full polarimetric data will therefore take advantage of full characterization and exploitation of the backscattered field over a wider coverage with less system complexity. Several methods for reconstructing fully polarimetric images using hybrid polarimetric data can be found in the literature. Although the improvements achieved by the newly investigated and experimented reconstruction techniques are undeniable, the existing methods are, however, mostly based upon model assumptions (especially the assumption of reflectance symmetry), which may limit their reliability and applicability to vegetation and forest scenarios. To overcome the problems of these techniques, this paper proposes a new framework for reconstructing fully polarimetric information from hybrid polarimetric data. The framework uses Deep Learning solutions to augment hybrid polarimetric data without relying on model assumptions. A convolutional neural network (CNN) with a specific architecture and loss function is defined for this augmentation problem by focusing on different scattering properties of the polarimetric data. In particular, the method controls the CNN training process with respect to several characteristic features of polarimetric images defined by the combination of different terms in the cost or loss function. The proposed method is experimentally validated with real data sets and compared with a well-known and standard approach from the literature. From the experiments, the reconstruction performance of the proposed framework is superior to conventional reconstruction methods. The pseudo fully polarimetric data reconstructed by the proposed method also agree well with the actual fully polarimetric images acquired by radar systems, confirming the reliability and efficiency of the proposed method.

Keywords : SAR image, polarimetric SAR image, convolutional neural network, deep learnig, deep neural network
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