POLARIMETRIC SAR TOMOGRAPHY OF NATURAL ENVIRONMENTS USING HYBRID SPECTRAL ESTIMATORS

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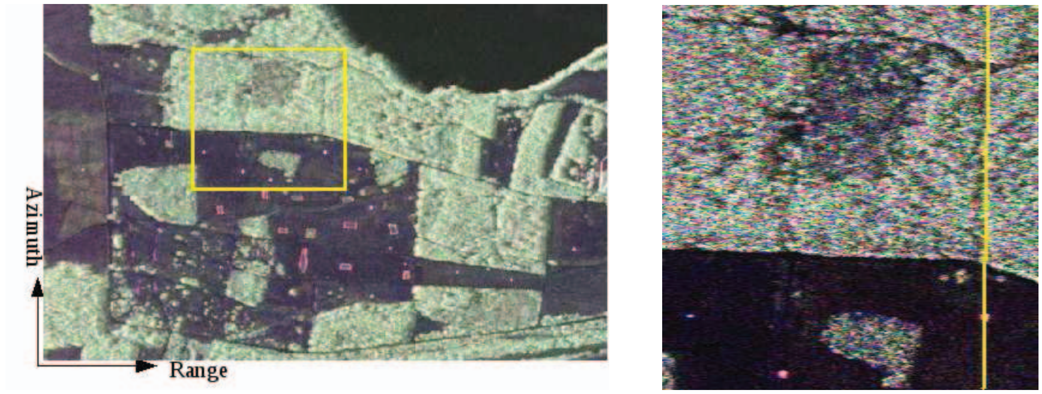
1. INTRODUCTION

SAR tomography is the extension of conventional two-dimensional SAR imaging principle to three dimensions [1]. A real 3D imaging of a scene is achieved by the formation of an additional synthetic aperture in elevation and the coherent combination of images acquired from several parallel flight tracks. This imaging technique allows a direct localization of multiple scattering contributions in a same resolution cell, leading to a refined analysis of volume structures, like forests or dense urban areas.

In order to improve the vertical resolution with respect to classical Fourier-based methods, High-Resolution (HR) approaches are used in this paper to perform SAR tomography. Both nonparametric spectral estimators, like Beamforming and Capon and parametric ones, like MUSIC, Maximum Likelihood, are applied to real data sets and compared in terms of scatterer location accuracy and resolution. It is known that nonparametric approaches are in general more robust to focusing artefacts, whereas parametric approaches are characterized by a better vertical resolution. It has been shown [2], [3] that the performance of these spectral analysis approaches is conditioned by the nature of the scattering response of the observed objects. In the case of objects with a deterministic response embedded in a speckle affected environment, the parameter estimation for this type of scatterers becomes a problem of mixed-spectrum estimation. Localized scatterers generally have a deterministic response with a discrete spectrum, i.e. a single spectral line, whereas natural environments, composed of a large number of elementary scatterers and whose response is affected by speckle, are characterized by a continuous spectrum. Therefore, the usual spectral estimators may reach some limitations due to their lack of adaptation to both the statistical features of the backscattered information and the type of spectrum of the considered media. In order to overcome this problem, a tomographic focusing approach based on hybrid spectral estimators is introduced and extended to the polarimetric case. This tomographic focusing approach can be decomposed into two steps: detection and removal of point-like scatterers responses and analysis of the remaining continuous spectrum for the characterization of the associated natural environment.

2. POINT SCATTERER DETECTION

In this section, we propose to detect and localize point-like scatterers (e.g. calibrators, ground-trunck reflection ...) embedded in a continuous environment (e.g. a forest). The monochromatic discrete components of the spectrum within the 3D resolution cell under consideration are simultaneously detected and estimated by jointly using line spectra estimators and a statistical decision procedure. In order to locate accurately these scatterers, we propose to use parametric approaches, like the weighted subspace fitting (WSF) method, whose extension to the polarimetric case has shown to significantly improve the characterization of complex structures both in terms of resolution and accuracy as in [3].



(a) Test site (b) Test zone

Fig. 1: Polarimetric SAR image (Pauli basis) of the test site

The detected and estimated discrete components are then removed from the global spectrum in order to obtain a residual continuous one, corresponding to the response of the host natural environment.

3. CONTINUOUS SPECTRUM CHARACTERIZATION

We propose here to characterize the continuous spectrum of natural environments (e.g. soil, forests) using robust non-parametric spectral estimators. After removing the polarimetric contribution of potential coherent scatterers from the observed data covariance, non-parametric spectral estimators are applied to the residual covariance matrix and used for characterization purposes.
The removal and estimation operations are implemented under the form of a CLEAN technique [4].

4. TOMOGRAPHY OF NATURAL ENVIRONMENTS

The tomographic analysis of a volumetric forested area and sub-canopy objects is led with diverse spectral estimators, using fully polarimetric L-band airborne data acquired by DLR's E-SAR system over the test site of Dornstetten, Germany. The test site is depicted in **Figure 1(a)**. The tomograms are computed along a constant range line indicated in **Figure1(b)**, that contains some trucks over bare soil areas as well as beneath forested zones considered as deterministic targets. Using the hybrid spectral estimators, the point target feature and forest profile are extracted from the mixted spectrum. These two decoupled extraction permit to better characterize natural environments and potential embedded objects.

References

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