AN APPROACH TO SAR TOMOGRAPHY WITH LIMITED NUMBER OF TRACKS

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ABSTRACT

In recent years, unconventional applications ranging from biomass estimation, to the detection and location of targets hidden beneath the foliage or even to the full reconstruction of three-dimensional (3D) SAR images of vegetation have earned an increasing interest for both civil and military purposes.

SAR tomography allows to access such information on the investigated scenario [1]. Building a synthetic aperture perpendicular to the flight direction allows to solve for targets which contribution falls in the same resolution cell of the master image. The tomographic problem can be solved by extending SAR processing or solving the Direction Of Arrivals (DOAs) estimation problem in the height direction [1,2]. Another possibility to face the retrieval of the 3D information consists on inverting the tomographic problem by means of the Singular Value Decomposition (SVD) [3].

More in detail, for a fixed scene, significant additional information becomes mandatory, in which the needed diversity can be obtained by a number of different transmit-receive data sets based on multi-track (mono-static or multistatic) data takes, by a number of frequency-bands or polarizations. As long as the application of interest demands information ranging from qualitative, semi-quantitative, to quantitative, the data collection should be properly conceived to reconstruct, in principle, only the aspects of interest and correspondingly modulate the amount of data to be collected.

Fortunately, in many cases of practical interest, only qualitative, or semi-quantitative, 3D SAR imaging is of interest. Accordingly, the electromagnetic modelling and processing algorithms should be properly fit, to take into account the intrinsic scattering features of soil, vegetation or targets (to be detected and located), to fruitfully exploit the available a priori information, having as aim that of improving the reliability of the results and of reducing the complexity of the acquisition scheme and then meeting the needs of airborne or satellite remote sensing systems [4].

Concerning the design of the transmitting-receiving scheme, depending on the tomographic approach (e.g., monostatic or multistatic), the choice of the number, the positions, the bands and the polarizations becomes, on the one hand, crucial to accurately reconstruct the desired information. On the other hand, such a choice and, in particular, the number and the locations of spatial acquisitions should be the result of a trade-off among accuracy of the 3D SAR image, reliability and computational complexity of the algorithms, which has been a crucial aspect of remote sensing applications since the beginning.

Formally, as long as a linear scattering model of the scenario is employed and the available a priori knowledge is exploited, the reconstruction by a SVD approach should follow a first design stage of the measurements to be performed having the aim of improving as much as possible the ill-conditioning. This can be performed by optimizing the behaviour of the singular values as a function of the parameters defining the acquisition scheme, as it has already been proposed, for electromagnetic applications, in the framework of the sampling in the very near field of a radiator [5] and in the design of Plane Wave Synthesizers [6].

Such a choice allows to synthesize the measurement constellation in a way weakly related to the exploited a priori knowledge about the scenario which, nevertheless, can be subsequently used to improve the reconstructions by a parametric inversion.

In this paper, we present an analysis in which two of the mentioned aspects are examined: the choice of the constellation by singular value optimization and the robust parametric inversion scheme. The work is focused on estimating the vertical complex reflectivity corresponding to vegetated areas with a model based on two distributed sources representing the ground and the canopy contributions, respectively.

The proposed approach has been tested with both simulated and real data acquired by the E-SAR system of the DLR over the area of Dornstetten, Germany in September 2006.

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