MULTIPLE SCATTERERS IDENTIFICATION IN COMPLEX SCENARIOS WITH ADAPTIVE DIFFERENTIAL TOMOGRAPHY

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1. INTRODUCTION AND PROBLEM STATEMENT

Multibaseline synthetic aperture radar interferometry (MB InSAR) employs multiple SAR images with different views for the generation of accurate Digital Elevation Models (DEM). Furthermore, the acquisition of images at different time intervals (multitemporal or multipass SAR) makes possible the precise sensing of the velocity of ground deformations at unprecedented accuracy through differential InSAR-based techniques [1]. Among other applications, InSAR has definitely given to SAR an impressive acceleration in the application to the risk management area.

Standard differential interferometry techniques generally assume specific models for the scattering mechanism, i.e., dominated by a "permanent" scatterer (PS) or distributed on the ground surface [1]. However, when the ground topography is steep enough to generate critical projection of the scatterers in the slant imaging geometry or the imaged area is characterized by a high spatial density of strong scatterers, then the signal received in a pixel may contain the superposition of responses from multiple scatterers (layover). This phenomenon becomes frequent when data are acquired over complex scenarios such as urban areas or large structures and infrastructures. Consequently, accurate scatterer location and deformation velocity determination, as well as the maximization of the number of sensed scatterers are of primary importance to improve the monitoring capabilities over complex structures [2]. Moreover, multiple scatterers separation should become a relevant issue also with data from the new generation of high resolution SAR systems, such as TerraSAR-X, TanDEM-X and COSMO-SkyMed [3].

SAR 3D tomography [4]-[5] is a way of overcoming limitations of standard algorithms for scatterer height determination by achieving focused fully 3D images. In fact, by combining amplitude and phase MB data through elevation beamforming techniques, it is possible to produce a continuous radar reflectivity profile along the height direction and to separate multiple scatterers at different heights in each given range-azimuth cell. Differential interferometry and SAR tomography have been recently fused in the differential SAR tomography processing [6] (tomo-diff), i.e. space-deformation velocity SAR imaging which permits a joint estimation of the height and the deformation velocity of the multiple scatterers in the same cell.

This work focuses on the problem of identification (i.e. detection and heights and deformation velocities estimation) of single and multiple scatterers in MB/multitemporal data in the framework of the differential tomographic imaging. The detection problem, in its more general form including the presence of speckle, long-term temporal decorrelation, and data miscalibrations, may be rather complex. Here, we consider a detection algorithm which combines adaptive beamforming tomography and a complex data domain model fitting, which has been analyzed in [7] in the 3D tomography framework in ideal conditions. This detection algorithm has also been improved to take into account data non-idealities such as residual miscalibrations and non-uniform baseline geometries in [8]. Compared to the detection based on the spatial spectral model fitting described in [9], the proposed technique is also able to detect more than two layover scatterers without increasing the computational burden. Moreover, thanks to the superresolution capabilities of adaptive tomography, it is expected to identify and locate multiple scatterers at height and deformation velocities distances below the respective Rayleigh resolution limit.

2. SCATTERER IDENTIFICATION METHODOLOGY AND SAMPLE RESULTS

Briefly speaking, the hybrid adaptive tomography-complex data domain model fitting works as follows. The adaptive tomo-diff processor [6] is applied to the multilook cell under analysis. Areas with low temporal coherence can be excluded from the analysis. For a hypothesized number of scatterers, their heights and deformation velocities are extracted and used in a model fitting in the data domain for the estimation of the corresponding radar reflectivity. By setting proper thresholds on the respective quality indexes (i.e. the estimated radar reflectivities and the fitting error at each step), the search ends at the highest number of scatterers which satisfies the threshold comparisons. Details of the algorithm will be reported in the full paper.

In this work, scatterer identification will be applied to C-band ERS-1/2 data over the city of Naples; a preliminary sample result is shown in Fig. 1. Here, the estimated deformation velocities of the detected double scatterers are reported, and scatterers locations have been superimposed to the SAR image; the analyzed patch corresponds to an area located around the San Paolo stadium. The large scale velocity behavior of the dominant double scatterers [Fig. 1(b)] agrees with that of the secondary ones [Fig. 1(c)], as it is reasonable to expect. Further results, also with a lower degree of multilook, will be reported in the full paper. Moreover, the achievable performance of tomo-diff in deformation velocity estimation will be discussed by means of the calculation of accuracy Cramér-Rao bounds. Case studies will be found in both the monostatic and forthcoming satellite cluster acquisition systems, such as the DLR TanDEM-X [10] and possibly COSMO-SkyMed, which will allow acquiring simultaneous multibaseline data and frequently repeated in time.

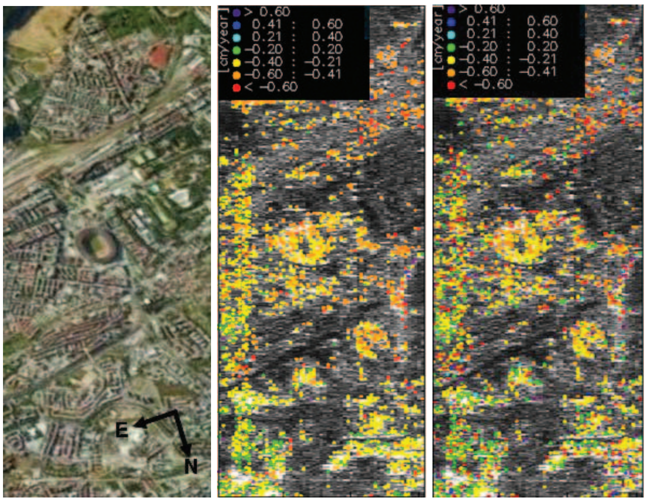

Fig. 1 – First cut result of scatterer identification with ERS-1/2 data over the urban area of Naples around the San Paolo stadium. From left to right: (a) Google image of the analyzed patch; (b)-(c) estimated velocities (coded with colors) of the identified double scatterers (dominant and secondary, respectively) superimposed to the multilook radar image. The authors thank Dr. Fornaro from CNR-IREA for providing the calibrated data set.

3. REFERENCES

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