SAR TOMOGRAPHY FOR IMAGING AND MONITORING COMPLEX TARGETS

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Abstract

Differential SAR Interferometry and particularly Persistent Scatterers Interferometry (PSI) have allowed monitoring ground deformations over wide regions at very high accuracy and hence have boosted the application of active microwave remote sensing in many areas of environmental risk monitoring.

The monitoring of urban areas and infrastructures is of key importance for evident reasons of impacts for the security of people, thus requiring advanced analysis carried out at the highest resolution.

Interferometric techniques essentially model the response of stable targets and use the phase information of data acquired in successive passes to determine the target height, and therefore its localization in the 3D space, and its mean deformation velocity, as well as to provide deformation time series. They assume the scattering mechanism to be dominated by a scatterer within each pixel and therefore cannot handle situations where, due to steep ground topography or a high spatial density of scatterers, the signal received in a pixel involves the superposition of responses from multiple scatterers.

3D SAR focusing, also known as SAR Tomography, is an imaging technique that uses multipass data to allow profiling the scattering distribution along the elevation direction and is mainly conceived for applications in cases where the radiation penetrates under the surface, that is on dry ice and, with low frequency (P-Band) systems, in forest areas. Nonetheless, urban areas are characterized by very steep topography variations and represent a complex scenario, where overposition of responses from multiple scatterers in the same image pixel (layover) may occur rather frequently. The analysis of high resolution data from the latest spaceborne X-Band sensors such as TerraSAR-X and COSMO-Skymed, as well as from very high resolution airborne systems seems to point out that the layover phenomenon in urban areas becomes even more relevant due to the fact that the higher the resolution the more evident is the distribution of the layover over the image.

SAR Tomography has been recently applied also spaceborne ERS data and its capability to identify and locate along the elevation direction interfering targets has been also demonstrated for the first time in [1].

In addition to this Differential SAR Tomography, also known as 4D SAR imaging, has been recently proposed as a natural extension of SAR Tomography. It allows focusing the scattering in an elevation–velocity (EV) plane and hence not only to spatially distinguish interfering targets but also measuring their velocities interfering targets. Moreover, based on the application of proper filtering in the elevation/velocity plane, the 4D SAR imaging technique has been shown to be capable of separating also the time series of interfering targets, thus restoring all the options of interferometric techniques to monitor dominant ground scatterers and overcoming some limitations of standard PSI.

At the present status 4D imaging has been only applied to simulated data and very preliminary results have been shown in [2]: here we present the results of an extensive application of the 4D imaging technique to ERS and ENVISAR real data over different urban areas in Italy.

In Sept. 2007 we have submitted a specific proposal for tomography experiments with COSMO/SKYMED data via the announcement of opportunities. Compatibly with the possible availability of data through this project, first results concerning the application of the aforementioned techniques to very high resolution sensors will be shown.

[1] Fornaro, G., Serafino, F., “Imaging of Single and Double Scatterers in Urban Areas via SAR Tomography”, *IEEE Trans. Geosci. Remote Sens.*, Dec 2006, vol. 44, no.12, pp. 3497-3505.

[2] Fornaro, G.; Reale, D.; Serafino, F., "Four-Dimensional SAR Imaging for Height Estimation and Monitoring of Single and Double Scatterers", *IEEE Trans. Geosci. Remote Sens.*, Jan. 2009, vol. 47, no.1, pp. 224-237.