FULL-RESOLUTION ADAPTIVE DIFFERENTIAL TOMOGRAPHY

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1. INTRODUCTION

Differential interferometry and 3D SAR tomography are two advanced operation modes of SAR interferometry. The former is a mature interferometric technique, it is based on multiple pass satellite SAR acquisition to accurately measure terrain displacements (scatterer velocity), see e.g. [1,2]. SAR tomography is a more recent interferometric technique, it is based on multibaseline acquisition to produce full 3D imaging for analysis of semitransparent scattering layers or layover areas, see e.g. [3,4]. It is an elevation beamforming technique, and it represents a very promising extension of classical interferometry for topographic mapping. It is still at the experimental stage, yet rapidly developing and raising increasing interest, see e.g. [5,6,7].

Recently, a new interferometric mode crossing the differential SAR interferometry and multibaseline SAR tomography concepts, termed differential SAR tomography or 4D (3D + time) imaging, has been proposed [8]. Its potentials, coming from the joint elevation-velocity resolution capability of multiple layover scatterers, have been demonstrated both theoretically and with real data [6]. Processing is cast in a two-dimensional baseline-time spectral analysis framework, to separate and identify the spatial-temporal harmonics originated by each scattering component. However, because of the very sparse sampling in the baseline-time plane, classical two-dimensional (gapped) Fourier spectral analysis would produce untolerable side- or quasi grating-lobes in the estimated elevation-velocity scattering power distribution [8]; some limited gain is offered by a regularized linear inversion approach [6]. Interestingly, the use of adaptive bidimensional spectral estimation has been shown to allow joint baseline-time processing with significantly reduced sidelobes and also elevation-velocity superresolution, through data-dependent two-dimensional frequency null setting [6,8].

However, this method requires complex multilooking processing for producing the baseline-time correlation estimates on which adaptive processing is based, thus does not produce a range-azimuth full resolution differential tomographic product. While this framework can be well suited for possible applications of differential tomography to natural scenarios like velocity profiling of moving volumetric scatterers, velocity measurement of buried scatterers, and 3D tomography robust to internal motions [9], it may be less satisfactory for applications where full range-azimuth resolution products are more desirable, like e.g. in urban scenarios [5,6].

2. NEW PROCESSING METHOD AND SAMPLE RESULTS

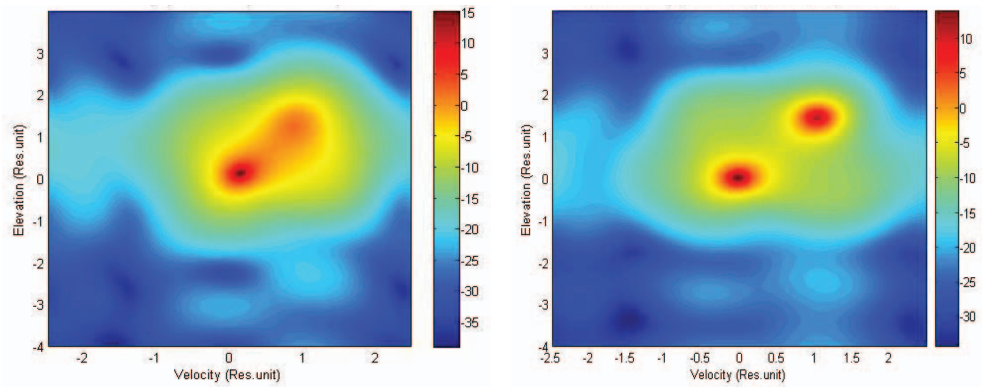
In this work a new single-look adaptive differential tomographic processor is presented, allowing full range-azimuth resolution together with the good elevation-velocity sidelobe and resolution capabilities of the previous multilook adaptive processing.

To derive the baseline-time correlation information for the adaptive processing from the single-look baseline-time data, a two step algorithm is presented. First, a proper knowledge-based interpolator is applied to reconstruct data uniformly sampled along both the baseline and time domain, exploiting a light a-priori information about the multiple moving scatterers scenario. Then, baseline-time multiple lag averaging is applied in place of standard multilooking to estimate the baseline-time correlation, to feed the adaptive differential tomographic processor.

Simulated results are reported in the full paper for different baseline-time acquisition patterns, both monostatic and multistatic [10], various motion conditions and signal parameters of multiple layover scatterers, and different a-priori information and other processing parameters, showing that the new single-look adaptive differential tomographic processor is promising. Comparison with gapped Fourier processing is also made. As a sample, Fig.1 reports an elevation-deformation velocity power distribution estimate (dB) for two compact and electrically stable layover scatterers spaced 1.5 height

Rayleigh resolution units, one moving with SNR=12 dB and one steady with SNR=15 dB, ideal calibration, 6 monostatic acquisitions with non uniform baselines values (a), and 6 non uniform multistatic acquisitions with 3 channels each for a total of 18 acquisitions (b).

It is apparent how the new method can offer both low elevation-velocity sidelobes and superresolution starting from the single-look non uniform data. This paves the way to extend the application range and performance of the original differential tomography concept in [8]. First preliminary real data tests of the new method will be also shown in the full paper.



(a) (b)

Fig. 1 –Example of single-look adaptive differential tomography simulated result, monostatic (a), and multistatic (b).

The author thanks Mr. Nannipieri for his help with software coding and running.

REFERENCES

[1] A. Ferretti, C., Prati, F. Rocca, “Nonlinear subsidence rate estimation using the permanent scatterers in differential SAR interferometry”, *IEEE Trans. Geosci. and Remote Sens.*, vol. 38 (5), pp. 2202-2212, 2000.

[2] P. Berardino, G. Fornaro, R. Lanari, E. Sansosti, “A new algorithm for surface deformation monitoring based on small baseline differential SAR interferograms,” *IEEE Trans. Geosci. and Remote Sens.*, vol. 40 (11), pp. 2375-2383, Nov. 2002.

[3] A. Reigber, A. Moreira, “First Demonstration of Airborne SAR Tomography using Multibaseline L-band Data,” *IEEE Trans. on Geosci. and Remote Sensing*, vol. 38 (5), pp. 2142-2152, Sept. 2000.

[4] F. Lombardini, A. Reigber, “Adaptive Spectral Estimators for Multibaseline SAR Tomography with Airborne L-Band Data”, *Proc. 2003 IEEE Int. Geosci. and Remote Sensing Symp.*, Tolouse, France, July 2003.

[5] A. Ferretti, M. Bianchi, C. Prati, F. Rocca, “Higher-Order Permanent Scatterers Analyis”, *EURASIP Journal on Applied Signal Processing*, Vol. 2005, No. 20, December 2005.

[6] M. Costantini, G. Fornaro, F. Lombardini, M. Pardini, F. Serafino, F. Soldovieri, “Multidimensional SAR Imaging: Studies in the Framework of LIMES Project,” *ESA FRINGE 2007 Workshop*, ESA-ESRIN, Frascati, Italy, Nov. 2007, http://earth.esa.int/workshops/fringe2007/programme.html.

[7] R. Bamler, M. Eineder, “The Pyramids of Gizeh Seen by TerraSAR-X – A Prime Example for Unexpected Scattering Mechanism in SAR”, *IEEE Geosci. and Remote Sensing Letters*, vol. 5 (3), pp. 468-470, July 2008.

[8] F. Lombardini, “Differential Tomography: a New Framework for SAR Interferometry,” *IEEE Trans. on Geosci. and Remote Sensing*, vol. 43 (1), January 2005, pp. 37-44.

[9] F. Lombardini, “New Potentials of Differential SAR Tomography: Volumetric Differential Interferometry and Robust DEM Generation,” *Proc. 2007 IEEE Int. Geosci. and Remote Sensing Symp.*, Barcelona, Spain, July 2007.

[10] G. Krieger, A.Moreira, H. Fiedler, I. Hajnsek, M. Werner, M. Younis, M. Zink, “TanDEM-X: A Satellite Formation for High-Resolution SAR Interferometry”, *IEEE Trans. on Geosci. and Remote Sens.*, vol. 45 (11), pp. 3317-3341, 2007.