EXPERIMENTAL RESULTS WITH BISTATIC SAR TOMOGRAPHY

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Abstract

During the last decades, Synthetic Aperture Radar (SAR) has become an important tool for Earth Observation. Of the many techniques that have arisen using SAR, one of the most popular is SAR interferometry (InSAR). InSAR is a well-known technique for measuring topography. It consists of using two different SAR images acquired from slightly different looking angles. For each resolution cell of the SAR image, InSAR retrieves the height of the mean or dominant scattering center. Furthermore, it is impossible to determine the heights of different scattering centers located within a given resolution cell if only two SAR images are used.

Multibaseline (MB) techniques have appeared as a natural evolution of InSAR. They are based on using more than two images, acquired from slightly different positions, of the scene. Applying tomographic techniques to a MB data set, it is possible to retrieve for each resolution cell the distribution of backscattered power as function of height above ground. Scattering at different heights within the same azimuth-range cell can be due to the penetration of the radiation through different scattering layers or because the ground topography is steep enough to generate critical projection of the scatterers in the slant imaging geometry. Recently, the MB technique was studied using monostatic spaceborne [1] and airborne [2] geometries. For these geometries, the MB technique requires several passes of the airborne or spaceborne platform. The resulting baselines, in these kind of configurations, depend on the transmitter's path, which is difficult to control accurately. As a result, the baseline sampling is irregular and advanced spectral estimation techniques are needed to obtain the height profile. Also, the scene might have changed between the different passes, introducing temporal decorrelation and therefore resulting in erroneous 3D MB focusing.

This paper studies tomography in a particular bistatic geometry. Synthetic aperture is achieved through the motion of the transmitter with a set of stationary receivers pointed at the area of interest. The receivers are placed along a vertical line with a uniform separation between them. Then, MB focusing is performed using a single transmitter pass and a regular baseline sampling. With this approach, temporal decorrelation during MB focussing is eliminated and complex spectral estimation techniques are not needed.

To demonstrate the proposed tomographic technique, a set of indoor experiments were carried out in the Radiation Laboratory (RadLab), at the University of Michigan. A coherent, bistatic radar system, operating over 2.5 GHz bandwidth (12 cm bistatic range resolution) centered around 35 GHz, was used. A robotic arm was used to move the transmitter along a linear path in order to generate the synthetic aperture (precision better than $10^{-4}m$) [3]. The receiver module was attached to another robotic arm and the multibaseline data set is achieved by repeating the measurements of an indoor, stationary target scene with the receiver positioned at different vertical positions. Taking into account that the looking angle of the receiver is 80º ($\theta = 80\,^{\circ}$), the distance to the master receiver position is 6.5 m ($R_0 = 6.5m$) and the total vertical receiver baseline is 1m ($B_v = 1m$), the look angle variation is approx 8.7º ($\Delta\theta = 8.7\,^{\circ}$). The increment of baseline of each acquisition has been 0.1 m, having in total 11 images.

The tomographic technique was first tested experimentally using a set of canonical targets, such as spheres, trihedrals and cylinders, positioned at prescribed locations and heights within the target scene. In this test, the receiver was placed in azimuth close to the transmitter (1.2m is the distance between the receiver and the center of the synthetic aperture), resulting in a bistatic angle of 10.58 degrees. Figure 1(a) represents the power image for this targets in range-azimuth coordinates.

The description of the resolution cell with targets is the following:

*This work has been supported by the Spanish MCYT funds under the project TEC2007-65690/TCM, the Spanish Ramon y Cajal program, the Catalan Commission for Research (CIRIT) and the Spanish MEC granting the first author (AP2005-1484).

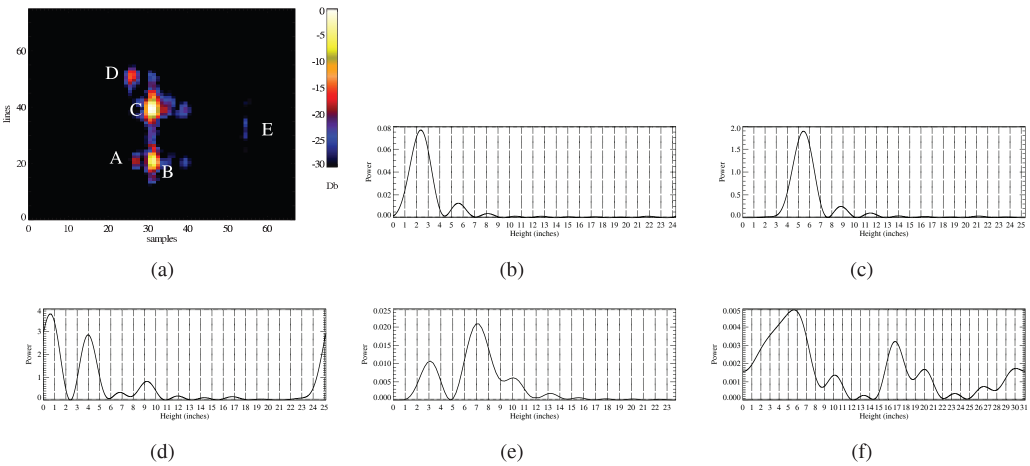

Fig. 1: Power image and plots of the distribution of power in height for the selected points.

Fig. 2: Complex scene to be studied by means of bistatic tomography.

- *A :* Sphere at 2.75 inches height
- *B :* Trihedral at 5 inches height
- *C :* Two cylinders, at 0.75 and 4 inches.
- *D :* Volumetric scattering of two layers at different heights.
- *E :* Distributed height scattering due to some reflections with the wall.

As it can be seen this description agrees with the plots (Fig. 1 of the distribution of power in height for the targets). A more complex scene will be analyzed by means of Bistatic tomography in the final paper version. The complex scene simulates an urban scenario and is composed of buildings, trees and rough surfaces. An example of this rough surface is shown in Figure 2. A detailed description of this novel approach to SAR tomography using bistatic radars with stationary receivers will be presented. The advantages of using bistatic geometry in SAR tomography over monostatic SAR will also be discussed, along with algorithms that were developed to optimize MB focussing. In addition, a detailed comparison between the different results will be provided.

1. REFERENCES

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