JOINT SAR IMAGING AND DEM RECONSTRUCTION FROM MULTICHANNEL LAYOVER-AFFECTED SAR DATA

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1. ABSTRACT

Three dimensional reconstruction of earth surface has become a task of increasing importance in recent years. Thanks to the launch of new high-resolution radar sensors (TerraSAR-X and COSMO-SkyMed) a new scenario for SAR imaging with new possibilities of investigation and new challenges has taken place. Interferometric Synthetic Aperture Radar (InSAR) systems allow to generate 3D reconstruction of Earth Surface exploiting the phase of at least two SAR images. In InSAR processing the main task is related to phase unwrapping operation (PhU), since interferometric phase is only known in the principal interval $(-\pi\ \pi]$. Different methodology have been developed to solve this problem showing their effectiveness [1, 2].

However, in high sloped scenarios the PhU operation becomes an hard task to be performed principally because of SAR geometrical distortions that frequently occur. In particular, due to SAR geometry and the presence of strong height discontinuities in the imaged scene, various contributions superpose in the same range-azimuth resolution cell, producing the layover phenomenon [3].

Nowadays, as a consequence of new high-resolution radar sensors launch, the layover recovery becomes a compulsory task for a correct Digital Elevation Model (DEM) reconstruction. The interferometric response of a layover area does not follow anymore the height profile of the scene. In fact the interferometric phase is characterized by two discontinuities (one at the beginning and one at the end of the layover), often very close to each other. Between the two discontinuities the interferometric phase shows a behavior strictly dependent on how the three different contributions involved in layover mix up.

In such situation, a possible solution consists of considering among the three contributes only the dominant one in each resolution cell. This approach allows to well reconstruct and localize one of the three contributes [3], but it has two main drawbacks: it implies the loosing of the signal components relatives to regions of weak echo response and it cannot be generalized to a multiplicity of real situations. A second solution is the SAR tomography approach [4, 5], which consists of trying to separate and distinctly estimate each of the three complex contributes which collapse in layover pixels; this approach overcomes the limits of the previous one.

In this paper we are interested in investigating SAR tomography, proposing an approach based on classical statistical estimation techniques, in particular Maximum Likelihood Estimation (MLE). To overcome the limitations due to the presence of ambiguous solutions, which are intrinsic in the single-interferogram configuration, and to improve the performances of the estimator, we use multichannel configurations (either multi-frequency or multi-baseline) allowing to exploit multiple independent data.

We consider a Gaussian model for the target responses that allows to simply build the multichannel likelihood function from which the estimation is carried out. This permits us to identify and separate the three different contributes involved in the layover and to properly reconstruct the height profile.

In the paper, first, a study on achievable performances of the proposed approach has been conducted. To assess the performances of the proposed estimation, the Cramer Rao Lower Bounds (CRLBs) have been investigated for different system configuration and situations. Then an ML Estimator has been implemented on simulated data to estimate the unknown parameters. The obtained results, compared to the CRLBs, showed the effectiveness of the proposed method.

2. REFERENCES

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