Ph.D. defense dissertation

Advanced SAR Interferometry Methods for Ground Displacement Estimation from Spaceborne and Airborne Platforms

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Abstract

Interferometric synthetic aperture radar (InSAR) is a powerful technique to monitor ground deformation phenomena, such as landslides, ground subsidence, seismological activities, and volcano dynamics. In this dissertation, two major problems of the current advanced InSAR techniques are issued and corresponding approaches are proposed to solve them.

Among various multitemporal InSAR techniques, persistent (or permanent) scatterer InSAR (PSInSAR) technique has been widely used in a variety of cases due to its high accuracy and resistance to temporal and spatial decorrelations. One major drawback of the PSInSAR technique is the low spatial density of PSs, especially over non-urban areas without man-made structures. A Phase-Decomposition-based PSInSAR (PD-PSInSAR) method is developed in this dissertation to improve the coherence and spatial density of measurement points by processing the distributed scatterer (DS) dominated by two or more scattering mechanisms. The PD-PSInSAR performs eigendecomposition on coherence matrix in order to estimate the phases corresponding to the different scattering mechanisms, and then to implement these estimated phases in conventional PSInSAR process.

An important procedure in DS interferometry is the phase triangulation (PT). In this study, the mathematical framework for PT algorithms has been proposed. This dissertation introduces two modified PT algorithms and analyzes the mathematical relations between five different PT methods. The analysis shows that these five PT methods share very similar mathematical forms with different weight values. The proposed mathematical framework supports improved understanding and advanced estimation methods for the use of PT algorithms in DS interferometry.

Another major drawback of traditional InSAR is that only the deformation happened in the line-of-sight (LOS) direction can be detected. In order to estimate the

deformation in the along-track direction, a time-domain along-track SAR interferometry (TAI) technique is proposed. Comparing with the existing multiple-aperture SAR interferometry (MAI) method, the proposed technique utilized the full aperture to generate the single-look complex images, which indicates higher SNR and along-track resolution are obtained.

In the last part of the dissertation, a case study of Slumgullion landslide is performed to demonstrate the potentials and challenges of airborne InSAR as well as the possible solutions to improve the precision of the derived deformation measurements.