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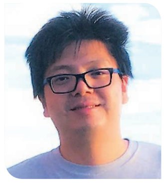

# A Special Issue on Synthetic Aperture Radar Interferometry

Synthetic aperture radar (SAR) interferometry (InSAR) provides the unique ability to quantitatively map Earth's elevation and surface deformation with high spatial resolution and precision. For this reason, it is used in many remote sensing applications (e.g., landslides, wetland water-level observation, and mining subsidence). Since *Seasat-A*, the very first SAR satellite, was launched by NASA in 1978, many InSAR missions have been completed, are in progress, or will be launched soon. These include the current *GF-3* and *Advanced Land Observing Satellite 2 (ALOS-2)* SAR satellites and the near-future *COSMO/Skymed 2nd Generation and Surface Water and Ocean Topography* (*SWOT*) mission. This has created a new class of radar data that has evolved significantly in recent decades. In the meantime, hundreds of research articles have been published exploring algorithms for InSAR signal processing and demonstrating related applications across many Earth observation fields of interest. It is fair to say that InSAR has evolved from its initial development as a new and pioneering radar remote sensing technique into a mature technology that can provide crucial constraints for a broad and diverse range of Earth-science processes.

This is the first of two special issues of *IEEE Geoscience and Remote Sensing Magazine* focused on InSAR, comprising 12 articles in total (the first seven in this issue and the following five scheduled for the June issue; all are now available in IEEE *Xplore*). The articles cover various InSAR signal processing techniques and applications in Earth science, and contributions came from researchers in several different countries. All of the articles were selected through a two-step process in which manuscripts were invited only following the positive review of a white paper. To foster collaboration among the science, technology, and education communities within the InSAR remote sensing field and attract a cross-disciplinary readership, we instructed authors to balance scientific depth and broader knowledge dissemination.

We open the special issue with four review articles focusing on InSAR-based deformation-monitoring techniques; these are often considered "black boxes" that are widely used but (sometimes) poorly understood by budding researchers. These four articles aim to dispel the magic behind the black box. The first, "Paradigm Changes in Surface-Motion Estimation From SAR" reviews the methodological development in surface motion estimation based on the authors' experience in the Dragon research project, a collaboration between the European Space Agency and the National Remote Sensing Center of China. The second article, "A Review of Time-Series Interferometric SAR Techniques," summarizes time-series InSAR techniques and their applications, introducing the development and basic principles of these techniques. The authors also classify many current time-series InSAR techniques from different perspectives, providing readers with a comprehensive understanding of the various methods available. The main objective of the third article, "Ground-Based Differential Interferometry SAR," is to illustrate theoretical issues and methodologies related to ground-based differential InSAR (GB-DInSAR), which use the SAR image phase to realize noncontact deformation inversion with submillimeter precision. In particular, the authors provide an application example of GB-DInSAR for monitoring the Geheyan Dam, located in Qingjiang, Hubei Province, China. "Use of SAR/InSAR in Mining Deformation Monitoring, Parameter Inversion, and Forward Predictions" provides a comprehensive review of important technical contributions recently made in InSAR-based 1D and 2D mining deformation monitoring, 3D mining displacement reconstruction, mechanical parameter inversion, and forward prediction. The pros and cons of these methods are analyzed to provide general guidance in choosing a suitable approach in practice.

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The next three tutorial/review articles focus on deformation-monitoring applications. “Monitoring Buildings at Landslide Risk With SAR” provides a review of current InSAR satellite data resources and processing methodologies for application to landslide risk, with an emphasis on the monitoring of buildings. At the end of the article, the authors argue that future small-satellite constellations planned to provide very-high-resolution SAR images with daily revisit time will supply more capability and inspire research in the development of new ideas in InSAR signal processing.

The feasibility of applying InSAR over floodplains and wetlands has been tested using interferometric coherences. “Interferometric SAR for Wetland Hydrology” reviews innovative applications of InSAR to hydraulic and hydrologic analysis of floodplains and wetlands, such as mapping 2D water-level changes. “Entering the Era of Earth Observation-Based Landslide Warning Systems” offers a tutorial for landslide forecasting and early warning using InSAR deformation-monitoring technology. In particular, the article uses two recent landslides in China as examples to demonstrate that 1) satellite radar observations can be used to detect deformation precursors to catastrophic landslide occurrences and 2) early warning can be achieved with real-time, in situ observations.

Previewing the June special issue, we move on to two articles on SAR tomography (TomoSAR) techniques, which extend and improve on traditional InSAR. “From Interferometric to Tomographic SAR” provides an overview of TomoSAR with a particular focus on its application in urban areas. The article provides several graphical summaries to give the readers a comprehensive view of TomoSAR. “Forest SAR Tomography” surveys single and polarimetric TomoSAR approaches with reference to the robustness of the reconstruction and reliability of extracted information. In addition, the article shows several application examples, including results obtained with the different processing techniques provided to summarize the efficiency of forest monitoring using TomoSAR.

Topics in InSAR ground moving-target indication (GMTI), polarimetric InSAR (Pol-InSAR), and interferometric phase denoising are included in the final three articles. “Along-Track Interferometric SAR systems for Ground-Moving Target Indication” reviews the techniques of GMTI using along-track interferometry. “InSAR Phase Denoising” gives a comprehensive overview of phase-denoising methods, classifying the established and emerging algorithms into four main categories: traditional local, transformed-domain, nonlocal, and sparsity-driven filters. “Polarimetric SAR Interferometry” briefly reviews the relevant techniques involved in system-parameter analysis of Pol-InSAR and presents a case study-based tutorial demonstrating how to analyze the impact of system parameters on the performance of an end application and so further optimize the system design.

The selected articles informally explain InSAR technology, but they do not shy away from demonstrating practical applications. Our hope is that, by addressing both aspects, readers of all levels will be able to gain a better understanding of the foundation of InSAR and the “when, how, and why” of applying this technology.

## AUTHOR INFORMATION

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