Advances in Very-High-Resolution Remote Sensing

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This special issue addresses very-high-resolution (VHR) remote sensing data processing and applications. As a matter of fact, satellite and airborne remote sensing is currently undergoing a technical revolution with the appearance and blooming development of VHR sensors. For these sensors, *high resolution* can be *spectral* with hundreds of narrow bands, *spatial* where the resolution of image pixels can be much less than 1 m, and *temporal* where the data are collected from the same area on multiple dates. The need for VHR remote sensing data has grown in parallel to this technical revolution. Application areas for VHR remote sensing images include *energy* (biomass energy and forest inventory, optimal solar photovoltaic installations, snow cover monitoring for the prediction of hydroelectric energy production), *water* (prevention and management of draughts, floods, monitoring of water quality, understanding of the oceanic circulation at mesoscales and smaller, observations of the temporal and spatial variations in water volumes stored in rivers, lakes, and wetlands in order to fulfill our basic need for fresh water), and the *environment* (detection of pollution, measurement of the climate change, monitoring of urban growth and management of urban planning, data assimilation with large-scale models).

This special issue focuses on the frontiers of very-high-resolution optical and microwave remote sensing data processing and on important application areas, including urban environments, precision agriculture, and natural disasters such as earthquakes.

In order to fully exploit all the potential offered by the new generations of VHR sensors and to actually face all the applications with a very high societal impact, advanced signal and image processing methods are required. Unfortunately, most of the traditional processing algorithms fail when the resolution increases significantly. For instance, statistical learning becomes intractable with hyperspectral images because of the dimensionality of the data. Similarly, while it was easy to classify urban versus nonurban areas with medium resolution data, VHR data enable the accurate classification at the building scale, but this requires a complete redesign of the whole processing chain. These types of problems become more serious with synthetic aperture radar (SAR) because of its "side-looking imaging geometry." There are also new multitemporal and multifrequency fully polarimetric SAR systems

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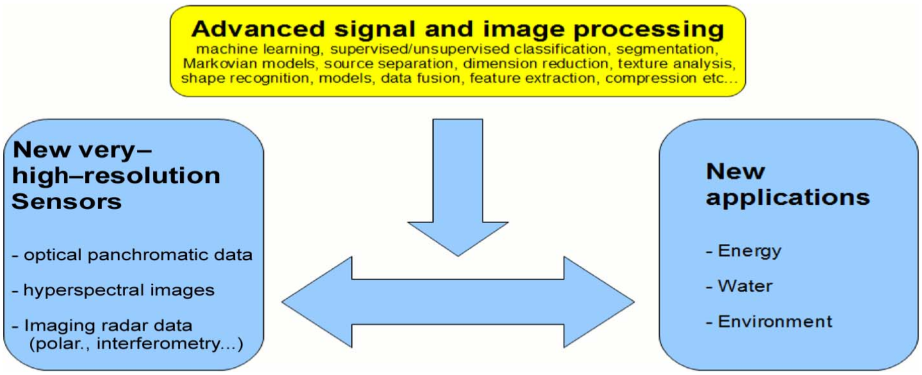

Fig. 1. ***A schematic showing the dimensions of topics addressed in this issue. The individual papers address very-high-resolution sensors, advanced signal and image processing approaches, and applications.***

becoming available from new SAR systems for Earth environment study. These new data sets not only offer a wide ranging and new higher spatial resolution information but also diverse backscattering information from the rapidly changing surface of the Earth, including water and energy that powers the environmental dynamics of the Earth. In this special issue, we cannot include all new developments in this area but we focused on the frontiers of VHR SAR data processing, the development of new applications for multifrequency high-resolution SAR systems, and the development of new environmental applications, including natural disasters such as earthquakes.

The papers in the special issue address one cell in a 3-D matrix (see Fig. 1) with the following dimensions:

— advanced signal and image processing (supervised classification, active learning, Markovian models, change detection, binary partition trees, computational aspects, signal processing, etc.);
— very-high-resolution sensors (hyperspectral data, SAR, POLSAR, ISAR, etc.);
— applications addressed with respect to the general framework (human settlements, agriculture, melt ponds, earthquakes, tsunami).

In the first paper, "Human settlements: A global challenge for EO data processing and interpretation" by Gamba, a consistent framework for information processing in urban remote sensing is provided, stressing the need for a global approach that is able to exploit the detailed information available from Earth Observation (EO) data sets.

The second paper, "Using high-resolution airborne and satellite imagery to assess crop growth and yield variability for precision agriculture" by Yang *et al.*, gives an overview on the use of airborne multispectral and hyperspectral imagery and high-resolution satellite imagery for assessing crop growth and yield variability.

The third paper, "Active learning: Any value for classification of remotely sensed data?" by Crawford *et al.*, provides an overview of active learning methods for VHR remote sensing data but active learning is an interactive information extraction approach that guides the selection of unlabeled data to be labeled by a human analyst.

The fourth paper, "A novel framework for the design of change-detection systems for very-high-resolution remote sensing images" by Bruzzone and Bovolo, focuses on the challenging problem of change detection in VHR images but also addresses change detection in multitemporal remote sensing images in general.

The fifth paper, "Land-cover mapping by Markov modeling of spatial–contextual information in very-high-resolution remote sensing images" by Moser *et al.*, focuses on the use of Markov random fields' (MRFs) modeling for classification of VHR remote-sensing image data. As the paper demonstrates, advanced MRF-based techniques for land-cover classification of VHR data are a powerful and flexible family of stochastic models for spatial–contextual information in image processing and analysis.

The sixth paper, "Advances in spectral–spatial classification of hyperspectral images" by Fauvel *et al.*, discusses recent advances in spectral–spatial classification of hyperspectral images. Several techniques are investigated for combining spatial and spectral information. Experimental results on three different types of data sets show the importance of using both spectral and spatial information in classification.

The seventh paper, "Feature mining for hyperspectral image classification" by Jia *et al.*, provides a general overview and analysis of both conventional and advanced feature reduction methods for classification of hyperspectral images. Experiments using two widely available hyperspectral data sets are used to demonstrate the performance of selected feature selection and feature extraction approaches.

The eighth paper, "The promise of reconfigurable computing for hyperspectral imaging onboard systems: A review and trends" by Lopez *et al.*, discusses fast processing solutions that can be used to compress and/or interpret hyperspectral data onboard spacecraft imaging platforms in order to reduce downlink connection requirements and perform a more efficient exploitation of hyperspectral data sets in various applications.

The ninth paper, "Processing multidimensional SAR and hyperspectral images with binary partition tree" by Alonso-González *et al.*, presents a new hierarchical framework for the analysis of remote sensing data. The generic strategy, relying on the definition of a region model, a similarity measure and a pruning strategy, can be adapted to handle VHR SAR data or hyperspectral data for various applications.

The tenth paper, "Melt pond mapping with high-resolution SAR: The first view" by Kim *et al.*, successfully uses high-resolution SAR images to map melt ponds in the Arctic region where the traditionally used aerial photos have the problem of being severely disrupted by cloud or low solar zenith angle. Melt ponds represent the overall energy balance in the Arctic regions, where ice sheets are rapidly melting away, and the capability of high-resolution SAR systems provides us with a new tool to closely monitor the Earth's environmental change.

The eleventh paper, "Very-high-resolution airborne synthetic aperture radar imaging: Signal processing and applications" by Reigber *et al.*, gives a review about the abilities and needs of today's very high-resolution multiple frequency fully polarimetric airborne SAR sensors, based on and summarizing the longtime experience of the German Aerospace Center (DLR) with airborne SAR technology and its applications.

The twelfth paper, "Airborne SAR-efficient signal processing for very high resolution" by Cantalloube and Nahum, discusses an efficient technique implemented through parallel frequency domain processing for SAR image formation.

The thirteenth paper, "Point target classification via fast lossless and sufficient Ω–Ψ–Φ invariant decomposition of high-resolution and fully polarimetric SAR/ISAR data" by Paladini *et al.*, discusses classification of high-resolution SAR/ISAR data through decomposing the radar target Sinclair matrix, dispensing full resolution and lossless analysis. The invariant parameters represent the wave-particle nature of radar scattering phenomenon given the circular polarization of elemental packets of energy provide a simpler interpretation, faster parameter extraction, and better generalization properties compared to the state of the art.

The last paper, "Monitoring of the March 11, 2011, Off-Tohoku 9.0 earthquake with super-tsunami disaster by implementing fully polarimetric high-resolution POLSAR techniques" by Singh *et al.*, reflects the utilization of VHR polarimetric synthetic aperture radar (POLSAR) data for near-real-time earthquake and/or tsunami damage assessment in urban areas. Most natural disasters are a part of Earth's natural processes and the presentation in this paper, including the decomposition of fully polarimetric SAR, demonstrates an important near-real-time application.

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ABOUT THE GUEST EDITORS

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Prof. Benediktsson was the 2011–2012 President of the IEEE Geoscience and Remote Sensing Society (GRSS) and has been on the GRSS Administrative Committee since 2000. He was the Editor of the IEEE Transactions on Geoscience and Remote Sensing (TGRS) from 2003 to 2008 and has served as an Associate Editor of TGRS since 1999 and the IEEE Geoscience and Remote Sensing Letters since 2003. He received the Stevan J. Kristof Award from Purdue University in 1991 as an outstanding graduate student in remote sensing. In 1997, he was the recipient of the Icelandic Research Council's Outstanding Young Researcher Award; in 2000, he was granted the IEEE Third Millennium Medal; in 2004, he was a corecipient of the University of Iceland's Technology Innovation Award; in 2006, he received the yearly research award from the Engineering Research Institute of the University of Iceland; and in 2007, he received the Outstanding Service Award from the IEEE Geoscience and Remote Sensing Society. He was corecipient of the 2012 IEEE Transactions on Geoscience and Remote Sensing Best Paper Award. He is a Fellow of SPIE and a member of Societas Scinetiarum Islandica and Tau Beta Pi.

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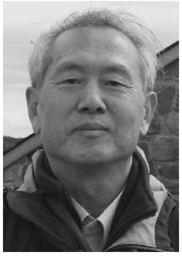

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