Special Section Guest Editorial: Advances in Onboard Compression and Processing for Space Data Systems

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SPIE.

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Next-generation instruments to be carried onboard spacecraft are collecting a large quantity of information at an increasing rate due to recent technological improvements. The result is the increasing importance that onboard payload data compression and processing are gaining in the framework of a spacecraft design. Powerful compression algorithms are required to match the available channel resources. Moreover, many Earth Observation satellites are required to transmit data on-ground in real time, this means that compression devices with very high throughput are requested. In science missions, one of the challenges is to have the capability to transmit to ground stations a high amount of data through a limited downlink. Thanks to onboard data compression, it is possible to transmit all of the data generated onboard, without any restriction, maximizing the scientific return. Moreover, other types of processing can be done onboard, e.g. encryption, compressive sensing, and data analysis, which open the door to new applications, such as vision-based spacecraft control.

This special section provides a picture of state-of-the-art research in the area of onboard payload data compression and processing. We wish to express our deep appreciation to all of the authors and reviewers for their high-quality contributions and enthusiastic efforts in this special section. Many of the papers are extended versions of material that was presented at the 4th Onboard Payload Data Compression (OBPDC) workshop held in Venice in October 2014, gathering individuals from academia and industry to share the most recent developments in this exciting field.

The special section contains eight papers. Two papers address onboard compression algorithms. "Image data compression with hierarchical pixel averaging and fully adaptive prediction error coder" by Iudica et al. introduces a novel image compression algorithm, the so-called hierarchical pixel averaging (HPA). It is a preprocessing stage envisaged for the fully adaptive prediction error coder (FAPEC), an entropy coder that can offer better results than the current standard—that is, the CCSDS 121.0 algorithm—when in presence of outliers. "Onboard joint nondestructive despeckling and wavelet-based data compression of multilook synthetic aperture radar images using reordered spatial oriented trees" by Bekhtin addresses the problem of onboard denoising and compression of multilook SAR images using a technique based on zerotrees in the wavelet domain.

Three papers also address onboard compression, with a focus on architectures and implementations. "On the hardware implementation of the arithmetic elements of the pairwise orthogonal transform" by Santos et al. validates that the low complexity of the pairwise orthogonal transform (POT) makes it feasible for a space-qualified field-programmable gate array (FPGA) implementation. "Reconfigurable architecture for real-time image compression onboard satellites" by Manthey, Krutz, and Juurlink presents a high-speed image compression architecture with region-of-interest (ROI) support and with flexible access to compressed data based on the Consultative Committee for Space Data Systems 122.0-B-1 image data compression standard. "Efficient field-programmable gate array implementation of CCSDS 121.0-B-2 lossless data compression algorithm for image compression" by Kranitis et al. describes an FPGA implementation of CCSDS 121.0-B-2 as an IP core enhanced with a 2D predictor and near-lossless compression, with maximum achievable throughput of 205 Msamples/s.

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Two papers describe novel instrument concepts. "Imaging method for highly squinted synthetic aperture radar with under-sampled echo data" by Gu et al. applies compressive sensing in order to achieve a very low bit-rate SAR raw data stream, and proposes a corresponding reconstruction algorithm for highly squinted data. "Proposal for Infrared Atmospheric Sounding Interferometer on-board data compression" by García-Sobrino et al. investigates the modification of the IASI Level 0 processing chain such that improved data transmission rate could be provided. IASI is an Infrared Atmospheric Sounder Interferometer on the Metop series of European meteorological polar-orbiting satellites. Finally, "Spatial Resolution Enhancement of Hyperspectral Images Based on Redundant Dictionaries" by Wang, Wang, and Zhang proposes a postprocessing technique in order to enhance spatial resolution of hyperspectral images based on sparsity methods, taking advantage of their spectral and spatial correlations.

Enrico Magli received the MSc and PhD degrees from the Politecnico di Torino, Turin, Italy, in 1997 and 2001, respectively. He is currently an associate professor with the Politecnico di Torino. His research interests are in the field of compressive sensing, image and video coding, and vision. He was a corecipient of the IEEE Geoscience and Remote Sensing Society Transactions Prize Paper Award in 2011.

Raffaele Vitulli received his MS degree in electronic engineering in 1991 from Politecnico of Bari, Italy. He is currently a staff member of the European Space Agency, and he is working for the On-Board Payload Data Processing Section, located at ESTEC (NL). He is participating in the work of the Consultative Committee for Space Data System as a member of the Multispectral/Hyperspectral Data Compression Working Group. He is chairman and organizer of the On-Board Payload Data Compression Workshop.