Optical Engineering

SPIEDigitalLibrary.org/oe

Computational Imaging

David J. Brady
Robert Gibbons

SPIE

Computational Imaging

David J. Brady
Duke University
Duke Imaging and Spectroscopy Program
PO Box 90291
Durham, North Carolina 27708

Robert Gibbons
Raytheon Corporation
6620 Chase Oaks Boulevard
MS 8539
Plano, Texas 75023

Computational imaging consists of the integrated design of physical sensor components and digital processing algorithms. While the seeds of computational imaging began with intrinsically multiplexed data, such as radar and x-ray tomography, the idea of deliberately encoding traditionally analog imagers dates to the first emergence of electronic focal planes, and is now over a quarter century old. The explosion of computational power and sensor fidelity over that quarter century is, of course, astounding.

The act of sampling lies at the heart of computational imaging. Since the dawn of sampling theory, we have lived by the mantra that information cannot be created in processing. This has long been understood to mean that one can only estimate one image pixel per measurement. With the introduction of missing cone estimation, digital superresolution, and Fourier extrapolation methods in the 1990s, however, researchers began to see that information and pixels are not the same thing. It remains true that processing cannot increase the information content of data. But the theory of compressive sampling has definitively shown that processing can reliably return a pixel count in excess of the number of measurements.

As indicated by the papers in this special section, compressive sampling is particularly applicable to imaging systems that are naturally multidimensional or that otherwise require multiplex measurement. Zhang et al. focus on the definitive example: x-ray projection tomography. Less obvious, but more accessible to ordinary systems, Kittle et al. and Magalhaes et al. apply compressive sampling theory to spectral imaging, i.e., tomography over space and spectrum. Finally, Abolbashari et al. present an innovative example of compressive measurement over the dynamic range data cube.

As the application of advanced sampling theory to imager design matures, research is increasingly focused on efficient and effective data processing for real-time computational imaging. The final two manuscripts in this special section present innovations on this front. Zhang and Hu discuss the application of application-specific processors to exposure management. One expects that processing topologies may be developed with increasing specificity to computational imaging as this approach matures. Finally, Lee et al. take the computational approach to its end goal in presenting a study of direct object detection from millimeter-wave signals. We hope you find this collection of focused articles useful in extending computational imaging into your future endeavors.

David J. Brady is the Michael J. Fitzpatrick Endowed Professor of Photonics at Duke University, where he leads the Duke Imaging and Spectroscopy Program. He is the author of *Optical Imaging and Spectroscopy*. Brady is a Fellow of SPIE.

Robert Gibbons is a Principal Fellow at Raytheon Space and Airborne Systems.