applied optics

Computational optical sensing and imaging: introduction

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The OSA Topical Meeting on Computational Optical Sensing and Imaging (COSI) was held June 25–June 28, 2018 in Orlando, Florida, USA, as part of the Imaging and Applied Optics Congress. In this feature issue, we present several papers that cover the techniques, topics, and advancements in the field presented at the COSI meeting highlighting the integration of opto-electric measurement and computational processing.

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Computational optical sensing and imaging (COSI), as the term suggests, relies on a hybrid system where optical hardware and measurements are merged with computational algorithms and signal processing to achieve the desired image, analysis, or interpretation of the environment or scene. The ability to combine computing techniques with optics allows the reformation of the imaging task, opening up different ways of potentially acquiring information–either indirectly, with fewer measurements, and likely fewer requirements on the optical design of the system. Computational optical sensing and imaging is a vitally important subfield in optics, especially in regimes where optics are difficult to fabricate. The integration of optics and computing for imaging and sensing stems from several motivations and is dependent on the specific scenario or application, but may include: making systems smaller, faster, lower cost, greater discrimination, or more intelligent.

Computational optical sensing and imaging has found applications spanning from fundamental science to applied areas such as security, defense and medical applications. A representative list of imaging techniques that can be considered under the umbrella of computational optical sensing and imaging includes: compressive sensing, light-field sensing, phase retrieval, inverse problems include blind deconvolution, coherent diffractive imaging, ptychography, deep learning for computational imaging, structured illumination, digital holography, and computational spectroscopy. From theoretical to experimental demonstration, COSI-related research continues to make a broad impact in the research and commercial domains.

In this special issue, we showcase one special guest editorial and five peer-reviewed research articles. This special issue begins with a review of the golden anniversary of the publication of Joseph W. Goodman's *Introduction to Fourier Optics* textbook celebrated at the 2018 OSA Imaging and Applied Optics Congress. *Introduction to Fourier Optics* has served as one of the foremost reference texts on the subject. Its material has strong ties to the computational optical sensing and imaging community, with chapters on optical information processing, holography, computational diffraction and propagation and point-spread function and transfer-function engineering.

The five peer-reviewed articles in this special issue cover a full range of topics where optics and processing merge. "Computational image speckle suppression using block matching and machine learning" describes the development of an image despeckling approach based on a nonlocal self-similarity filter and machine learning to suppress speckle artifacts and enhance reconstructed images with sharper edges. "Supervised spatio-spectral classification of fused images using superpixels" applies an optimization solution using alternating direction method of multipliers (ADMM) to fuse spatial information of an RGB image with the spectral information from a hyperspectral image; the use of superpixels reduces the classification time and improves the classification results. "Computational requirements for real-time ptychographic image reconstruction" examines the computational system requirements needed for real-time ptychographic x-ray computed tomography. "Shifting colored coded apertures design for spectral imaging" presents an optimization technique to design a shifting color coded aperture for use in compressive spectral imaging to produce a spatio-spectral data cube; simulations as well as experimental results are presented. "Wollaston prism-based structured illumination microscope with tunable-frequency" looks at the use of a Wollaston prism to create high contrast, tunable-frequency, structured illumination pattern that results in a super-resolution-enhanced image. This collection of papers demonstrate the diversity of applications and techniques in computational imaging, while highlighting research advances in the field today.