Optical Sensors and Sensing, 2019: introduction to the joint feature issue

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Abstract: This joint feature issue of *Optics Express* and *Applied Optics* highlights contributions from authors who presented their latest research at the OSA Optical Sensors and Sensing Congress, held in San Jose, California, USA from 25–27 June 2019. The joint feature issue comprises 6 contributed papers, which expand upon their respective conference proceedings. The published papers introduced here cover a range of timely research topics in optics and photonics for active open-path sensing, radiometry, and adaptive optics and fiber devices.

1. Introduction

The OSA Optical Sensors and Sensing (OSS) Congress [1], held in San Jose, California, USA, brought together experts from several related areas of optics and photonics research. Specifically, the co-located OSA topical meetings were Fourier Transform Spectroscopy (FTS), Hyperspectral Imaging and Sounding of the Environment (HISE), Optical Sensors (SENSORS), and Optics and Photonics for Sensing the Environment (ES). The conference program included a diverse group of plenary, invited, and contributed speakers from around the world who discussed current trends at the intersection of light, photonics, and sensing.

The joint feature issue comprises 6 total publications, with 2 papers published in *Optics Express* and 4 papers published in *Applied Optics*. In the following sections, we introduce each paper and provide context for how they fit within the broader OSS Congress themes.

2. Active open-path sensing: combs and lidar.

Active open-path sensing often requires spatially coherent light sources with high resolution and broad optical bandwidth. Optical frequency combs are one laser source which meets these criteria, and their application to sensing greenhouse gases and fugitive emissions has emerged as a viable and enabling approach that is useful in the field. Guay et al. [2] now report work towards a simpler method of phase correcting dual-comb interferograms without the need for self-referenced frequency combs. By foregoing carrier-envelope-offset stabilization of the individual combs, Guay et al. eliminated expensive fiber-coupled waveguide frequency doubling devices and electronic stabilization in favor of interferogram post-correction, all while maintaining a high degree of relative phase coherence, and ultimately sensitivity. Their demonstration of methane sensing in the near-infrared represents a step towards further robustness in field-deployable dual-comb spectroscopy systems.

Light detection and ranging, or lidar, while traditionally a powerful tool in remote sensing for climate and weather applications, has recently enabled groundbreaking work in archeology and geology. While common lidar targets like vegetation show strong reflection, there exist many other weakly reflecting targets of interest. In their paper, Kaasalainen and Malkamäki [3] demonstrate multi-wavelength lidar measurements of a low reflectance target, searching for valuable ore in a mixture of low-value rocks. By performing careful distance calibration and evaluating the lidar return signals at multiple wavelengths and at a high sampling rate, they attribute wavelength-dependent differences in return intensities to be the signature of the higher-valued ores. The advances in lidar instrumentation and retrieval algorithms required to analyze minerals *in situ* will also have implications for other weakly reflecting surfaces, thus further expanding the impact of lidar.

3. Radiometry: vertical columns and ocean glint.

Vertical gas profiling provides critical inputs for climate and weather forecasting, including gas column densities, dry air mole fractions, and temperature and pressure profiles. Using laser heterodyne radiometry, Bomse et al. [4] report precision profiles for water and carbon dioxide in the field with a two-channel instrument which tracks and collects solar radiation. By designing multiple channels into a field-deployable instrument, laser heterodyne radiometry can ground-truth sparsely timed acquisitions from more expensive downward-looking missions, like satellite and flight-based measurement campaigns. In the two-channel instrument, absorption by well-mixed molecular oxygen provides a temperature and pressure profile for the gas column which enables precision retrievals of the water and carbon dioxide column densities using home-build retrieval algorithms and publicly available spectroscopic reference data.

Accurate measurements of water-leaving radiance are required in order to retrieve water quality parameters of ecological and environmental importance. In both coastal and inland waters and the open ocean, quality parameters include the concentrations of optically active organic and inorganic constituents (e.g., chlorophyll, suspended sediments, and colored dissolved organic matter) within the water column. In their work, O'Shea et al. [5] report a spectral optimization algorithm tested on field data from a lightweight imaging spectrometer and determine its ability to correct for contamination of measured water-leaving radiance by surface-reflected light, or glint. The synergistic improvement of hyperspectral imaging spectrometers and reliable glint correction algorithms like those reported by O'Shea et al. will enhance near-real-time water quality assessments using agile, easy-to-deploy platforms such as unmanned aerial vehicles.

4. Adaptive optics and fiber devices: filters and grating sensors.

To perform adequate optical protection filtering without limiting the dynamic range of technical vision sensors (e.g., the human eye), Ezhov et al. [6] propose several adaptive and local filtering approaches. Traditional means of vision sensor protection simply rely upon total intensity reduction, and are not necessarily spatially selective (e.g., a welding shield protects the eyes from the arc, but eliminates light from the remainder of the scene). In their work, Ezhov et al. apply their proposed methods towards locally adaptive optical protection using several spatially selective liquid crystal displays and a light source loosely matched to the solar spectrum. In that way, they begin to evaluate device performance for automated matching of both scene and sensor dynamic range.

Fibers with directly written grating technology enable low-cost sensing over kilometer distances. Sartiano and Sales [7] report a combination of pulsed laser technology and densely spaced weak gratings to facilitate faster measurements over shorter total distances on the meter scale. With the weak gratings, Sartiano and Sales report sub-cm resolution with fast dynamic response, with rates as high as 245 kHz. Following a demonstration of temperature sensing, they also apply their densely spaced weak gratings, interrogated by a gain-switched laser diode, to active strain sensing.

5. Outlook: Optical Sensors and Sensing Congress 2020

The next Optical Sensors and Sensing Congress will take place in Vancouver, British Columbia, Canada from 22–26 June 2020. It will be co-located with the OSA Imaging and Applied Optics Congress, resulting in the concurrent running of ten OSA topical meetings in one location.

Finally, the joint feature issue guest editors, along with all the congress and topical meeting co-chairs, would like to thank our numerous committee members as well as the OSA professional staff for their support in creating a fantastic scientific program for inaugural OSA Optical Sensors and Sensing Congress 2019.

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