Special Section Guest Editorial: Multimodal Optical Sensing and Processing

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Optical measurement systems for industry is gaining relevance every day due to the intrinsic attractive features of optical methods, being non-contact, non-destructive, and in many cases full-field. In the frame of the new paradigm of Industry 4.0, the progress of technology has allowed the development of very sophisticated optical metrology tools, and each one of them is able to furnish high resolution data in space and time measurements. However, the even more intricate geometries of products made possible thanks to the advanced manufacturing and 3D printing fabrication together with the continuous innovation about the materials (i.e. composites, bioinspired, etc.) poses every day new challenges to metrology to achieve complete inspection and testing of advanced engineering components and structures. Such complexity cannot be afforded by single inspection and characterization tools but instead requires a change of the paradigm by adopting multi-modal and multi-sensing strategies. An ensemble of optical methods allows detection of information as it comes from different data channels by corresponding sensors and combines them during processing with the objective to achieve an integrated and robust solution of the inverse problem in optical metrology. In fact, the need to solve inverse problems in case of ill-posedness issues still exists. Consequently, the addition of more information delivered by the named data-channels can help to regularize the reconstruction problem in a much more stable manner.

The multimodal optical analysis is based on diverse data channels corresponding to the various modalities of the light field, such as intensity, frequency, phase, angular spectrum, polarization, angular momentum of light, etc. Optical methods employed in the framework of multimodal sensing can be boosted by artificial intelligence (AI) as it can facilitate the fusion of diverse measurement data from multiple-sensors. Only in this way will it be possible to achieve a unified interpretation of such multifaced physical data for building-up a full picture about the properties and characteristics of the sample under investigation, thus avoiding treating the data from each optical method separately or at most as a simple sum-up of single measurements.

Our goal for this special section is to present emerging algorithms and sensing techniques that have the potential to advance the state of the art in multimodal sensing for optical metrology. We present here a collection of five papers that introduce new algorithms to improve optical sensing devices.

Patruno et al. describe a deep learning approach to mobile robot navigation. The idea is to associate by a CNN image data from a TV camera to the control of the mobile robot. Du et al. use the SIRT reconstruction technique to remove artifacts and improve the image quality in optical projection tomography. Aalam et al. present an optical system for terahertz reflectivity measurement housed in a handheld THz scanner head unit, realized by additive manufacturing. Wang et al. characterize polymeric thin films applying a variety of optical methods. Finally, Singh et al. calculate the elastic modulus of tissue-mimicking phantoms and ex-vivo biological tissue using holographic imaging by tracing Rayleigh wave propagation on tissue surface.

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