Polarization and Orbital Angular Momentum of Light in Biomedical Applications: feature issue introduction

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Abstract: In the last decade, consistent and successful innovations have been achieved in the field of lasers and optics, collectively known as 'photonics', founding new applications in biomedicine, including clinical biopsy. Non-invasive photonics-based diagnostic modalities are rapidly expanding, and with their exponential improvement, there is a great potential to develop practical instrumentation for automatic detection and identification of different types and/or sub-types of diseases at a very early stage. While using conventional light for the studies of different properties of objects in materials science, astrophysics and biomedicine already has a long history, the interaction of polarized light and optical angular momentum with turbid tissue-like scattering media has not yet been ultimately explored. Since recently this research area became a hot topic. This feature issue is a first attempt to summarize the recognitions achieved in this emerging research field of polarized light and optical angular momentum for practical biomedical applications during the last years.

The scope of the *Biomedical Optics Express* journal encompasses fundamental research, technology development, biomedical studies and clinical applications related to optics, photonics and optical imaging in biomedicine. While using conventional light for the studies of different properties of objects in material science, astrophysics and biomedicine has already a long history, the interaction of polarized light waves with turbid tissue-like scattering media has not yet been ultimately explored. This is an emerging research field and there is a significant progress achieved last decade [1]. In fact, in addition to the conventional states of polarization, structurally shaped radially or azimuthally polarized light with optical angular momentum plays an emerging role in both classical and quantum science, and offers fascinating opportunities for exploring new fundamental ideas, as well as for being used as a tool for practical biomedical applications. This current feature issue was initially dedicated to the most recent progress in the use of polarized light and optical angular momentum for practical biomedical applications. Finally, this feature issue includes 19 papers (out of a total of 23 submissions) focusing predominantly on the current progress of polarized light application in biomedical studies, clinical and pre-clinical applications.

Nevertheless, in line with fields such as optical tweezers, editors anticipate the appearance of publications dedicated to the further and more diverse use of orbital or optical angular momentum in biomedical applications in coming years. The subjects of the current feature issue are listed below, and include:

- Endoscopy and Fiber Optics

- Microscopy

- Optical Biosensors

- Optical Coherence Tomography

- Optical Diagnostics

- Tissue Optics and Spectroscopy

We provide a short introduction for each paper and classify them into several categories as follows:

Endoscopy and fiber optics

A novel artificial neural network approach was developed for stand-alone differentiation of esophageal gastroscopic images to normal, pre-cancerous, early cancer and advanced cancer is presented by Du et al. [2].

Microscopy

Chen at al. report the advancements in non-invasive polarization-resolved second-harmonic generation (PSHG) microscopy for the non-destructive investigation of collagen molecular level properties [3]. Sprenger et al. introduced a high-contrast method of imaging intra- and peri-tumoural stroma based on polarized light microscopy [4]. Zhao et al. paired the enhanced image recombination transform algorithm with a light-efficient structured illumination microscope to obtain exquisite, multi-color super-resolution images of dynamic processes in live cells [5]. Iqbal et al. compared two popular modalities, namely Mueller matrix transformation (MMT) and direct interpretation of Mueller matrix (DIMM) for devising a better technique for the interpretation of polarimetric variables and optical characterization of turbid media [6]. Raoux et al. reported the use of polarization-resolved second harmonic generation (P-SHG) microscopy to characterize human corneas [7], demonstrating that P-SHG is an effective tool for automatic quantitative analysis of structural defects of human corneas and other collagen-rich tissues. Huynh et al. applied polar decomposition to extract fundamental optical parameters from the measured Mueller matrix images of bovine articular cartilage tissue [8]. Desapogu et al. reported how implementation of micro-wave photonics in polarization imaging approach can be adapted on a classical confocal fluorescence microscopy [9].

Optical biosensors

Li et al. investigated an opportunity to assess the glucose concentration changes in turbid media utilizing light depolarization [10].

Optical coherence tomography

Afsharan et al. utilized polarization-sensitive optical coherence tomography (PS-OCT) to determine the polarization properties of human retinal vessel walls [11].

Optical diagnostics

Roa et al. integrated convolutional neural networks (CNN) and K-nearest neighbor (K-NN) techniques for the quantitative analysis of Mueller matrix images and classifying cervical collagen and elastin [12]. Bibikova et al. explored theoretically an opportunity of independent control of the state of light polarization at two different wavelengths [13]. Jain et al. utilized polarimetric imaging to investigate the structural anisotropy of different regions in a coronal cross-section of a human brain *in vitro* [14]. Ivanov et al. introduced an enhanced diagnostic approach for assessment of *ex vivo* colon specimens by combine use of Stokes and Mueller matrix polarimetry approaches [15].

Tissue optics and spectroscopy

Liu et al. evaluated the correlation between multiple texture features of images and polarization parameters derived from the Mueller matrix images [16]. Zhu et al. considered how to demarcate layered structures within the concept of complex Mueller matrix and multi-color backscattering polarimetry [17]. Macdonald et al. investigated potential improvements of continuous-wave diffuse reflectance spectroscopy within highly scattering media by employing polarization gating [18]. Song et al. utilized Stokes polarization imaging approach for evaluation of so-called tissue optical clearing [19]. Based on the statistical analysis of different polarimetric metrics derived from the experimental Mueller matrix, Rodrigues et al. presented an optical model for tissue classification [20].

We hope that this feature issue will encourage the scientific community to contribute more actively to this exciting emerging research field of polarization and orbital angular momentum of light in biomedical applications.

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