Selected Topics in Biophotonics: Diffuse Optics and Optical Molecular Imaging

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SPECIAL SECTION GUEST EDITORIAL

Selected Topics in Biophotonics: Diffuse Optics and Optical Molecular Imaging

The present special section entitled "Selected Topics in Biophotonics: Diffuse Optics and Optical Molecular Imaging" comprises invited review papers and contributed papers from the summer school Biophotonics '07 as well as contributed papers within the main scope of this section, i.e., within diffuse optics and optical molecular imaging.

Motivation and Purpose of Biophotonics Graduate Schools

Over the past decade, lasers, optical methods, and instruments based on light interaction with tissues have emerged as powerful techniques for medical diagnostics, monitoring wide spectra of tissue function and pathology together with therapy. In biophysics and biology, optical sensing and manipulation of cells have furthered understanding of basic cell function. Across the world, major research centers are highly active in this field that in a broad sense may be labeled biophotonics. Therefore, education within this area is becoming increasingly important.

Around 2000, we realized the increasing need for education for graduate students and postdoctoral fellows. Accordingly, we developed a series of graduate summer schools aiming at filling this void, the first school being held in 2003 and every second year since then. Our main purpose with the biennial graduate summer school is to provide education within biophotonics for students and young scientists at the highest international level. Our aim is to attract internationally renowned researchers as lecturers who would attract the most talented young researchers in the field of biophotonics.

Format of the Biophotonics Graduate Summer School

The format of the school is a combination of lectures and student poster presentations—with time between lectures for discussions and the exchange of new scientific ideas. The lecturers cover one topic in one full session comprising four lectures. Thereby both the basics of each topic and the state of the art are thoroughly covered. On one hand, this choice limits the number of topics taught at each school. On the other hand, the topics selected for the schools are covered in detail. Therefore, the range of topics taught will change from school to school.

The school targets graduate students and postdoctoral fellows with a limit of approximately of 50 participants. Applicants must submit a three-page summary of their research and results or planned research project. After the application deadline, the organizers conduct a peer review of the summaries and applicants are admitted based on the outcome of the review process. It is our experience that this procedure ensures the highest scientific level among the students admitted into the school. An important feature of the school format is that students and lecturers spend the entire week together providing excellent opportunities for the exchange of scientific ideas, networking, and socializing.

The 3rd International Graduate Summer School Biophotonics '07 (www.biop.dk/biophotonics07/) covered the basics of lasers and their application in medicine, tissue optics, photodynamic therapy, optical tweezers and their applications in biophotonics, optical biosensors, molecular imaging based on optical methods, and optical coherence tomography.

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We are pleased to introduce the contributions to this special section on "Selected Topics in Biophotonics: Diffuse Optics and Optical Molecular Imaging" comprising two invited review papers as well as 17 contributed papers, mainly from the participants of the school but also from other researchers in the field.

The two invited review papers are entitled "Tutorial on diffuse light transport" by Jacques and Pogue, and "Molecular imaging with optics: a primer and case for near-infrared fluorescence techniques in personalized medicine" by Sevick-Muraca and Rasmussen. These papers of tutorial character from lecturers at the school provide an excellent background to the fields of diffuse optics and molecular imaging, respectively. The two invited review papers are the first ones in a planned series of tutorial review papers following each school (biennially) providing high-level educational material to the benefit of the scientific community and, in addition, fulfilling our own motivation for creating the school in the first place.

Following the two invited review papers, we have organized the contributed papers according to their main topic, starting with papers categorized as contributions within diffuse optics, including measurements of absorption and scattering properties, and followed by molecular imaging and fluorescence spectroscopy articles, first on a macroscopic scale, followed by cellular studies. The section ends with two contributions from areas other than the two main topics of the section. All of the contributions, however, reflect the core topics of the school and span the fields of biomedical optics and biophotonics.

The first article within the diffuse optics category is written by Alerstam et al. describing a scalable white Monte Carlo technique providing the possibility for fast and accurate analysis of time-of-flight recordings in situations when the conventionally used diffusion approximation fails to provide accurate results. This is typically the case for prostate cancer. Wang et al. then show that multispectral frequency domain measurements on breast tissue provide more accurate and robust data as compared to the broadband continuous wave technique. More wavelengths in the frequency domain result in less noise and higher accuracy in the evaluated chrompohore concentrations. They evaluated this interesting approach in region-guided spectroscopy of breast tissue using information obtained from magnetic resonance imaging. Mallia et al. then present a clinical study of diffuse reflectance spectroscopy for oral pre-cancer diagnostics, followed by a paper by Vacas-Jacques et al. describing a technique using ballistic photons in a low-coherence interferometric transillumination setup for biomedical analysis. Next is a paper by Pop and Neamtu describing an investigation of light scattering of the

aggregation process of red blood cells. Ending this part, Samatham et al. present a novel technique to measure the scattering coefficient μ_s and anisotropy factor g of tissue. This suggested approach is based on confocal microscopy, measuring the epi-reflectance as a function of depth in the tissue. The method seems to exhibit great potential and its simplicity suggests a straightforward adoption to *in vivo* measurements once the technique is further developed and evaluated.

The next set of articles is more focused towards molecular imaging and fluorescence spectroscopy of tissues and cells. The first three papers consider subsurface fluorescence imaging in animals. First Turchin et al. describe a robust system for multispectral noncontact fluorescence tomography. They illustrate the potential of the system *in vivo* by imaging cells transfected with red fluorescence proteins and then injected into mice. Next, Bourayou et al. present a fluorescence tomography technique optimized for mouse brain imaging. Sampath et al. then demonstrate how fluorescence imaging can be used to track the path of the lymph drainage from a region of a malignant tumor, to be able to locate and resect lymph nodes for histopathological examination of tumor spread. They illustrate the developed technique with convincing evidence that this may have the potential to become clinically important in the future. Following that comes two papers from Mermut et al., using liposomes as simplified models for cell membranes to study interactions with photosensitizers for photodynamic therapy. In the development of new photosensitizers it is critical to understand the photophysical properties in the cellular environment. These papers suggest using well-controlled liposomes for such studies. In these papers they present fluorescence studies both with spectral and time-resolved techniques to investigate how the confinement of the liposomes affect the fluorescence properties of various photosensitizers. Then follows four articles by Heikal, Bednarkiewicz, Bruns, and Prent et al., respectively, dealing with various techniques for microscopy tools for cellular imaging and spectroscopy. The article by Bruns et al. describes a very elegant system based on total internal reflections for high content screening of plasma membranes utilizing fluorescence lifetimes and anisotropies. Prent et al. show how second-harmonic generation microscopy can be used to assess structures and dynamics in 100-nm scales. The special section then ends with an article by Tkaczyk et al. concerning flow cytometry and a report by Fischer et al. on risk estimation for skin damage of femtosecond pulses. This is a very interesting area in order to provide an improved understanding and thereby, in the future, better norms for laser safety for such short pulses.

Acknowledgments

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Special Section Guest Editors