PROGRESS IN BIOMEDICAL OPTICS AND IMAGING
Vol. 13, No. 16

Dynamics and Fluctuations in Biomedical Photonics IX

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21–23 January 2012
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 8222

Proceedings of SPIE, 1605-7422, v. 8222

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:
Author(s), "Title of Paper," in *Dynamics and Fluctuations in Biomedical Photonics IX*, edited by Valery V. Tuchin, Donald D. Duncan, Kirill V. Larin, Martin J. Leahy, Ruikang K. Wang, Proceedings of SPIE Vol. 8222 (SPIE, Bellingham, WA, 2012) Article CID Number.

ISSN 1605-7422
ISBN 9780819488657

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

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The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID number.

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Introduction

These proceedings are from the Dynamics and Fluctuations in Biomedical Photonics IX, held on January 21–23, 2012 at the SPIE Photonics West Conference in San Francisco, California. It was a two-day meeting featuring 44 oral presentations and a third day featuring a poster session with 14 poster presentations from leading international research groups.

The goal of the conference was to gather essentially different groups of leading researchers along with students, such as biophysicists, medical doctors and physicians, mathematicians, and optical and laser engineers to report the current state of the art and to facilitate future progress in the development of optical and laser technologies based on dynamics and fluctuations approaches (such as speckle-based coherence imaging, microcirculation analysis using various optical techniques and methods, dynamics of molecular diffusion including nanoparticles, etc.) towards biomedical science and clinical applications. These approaches should be useful for diagnosis and therapy of devastating life-threatening diseases such as those of the heart, cancer, vascular, mental illness, and many others that manifest as a breach of the living organism's immune systems at the level of molecule, cell, organ, or organism as a whole. We hope that proceedings of this conference will contribute to the development of such interdisciplinary fields of science and applications as dynamics and structures of living systems, biomedical optics and laser medicine, and that it will be helpful for scientists, medical doctors, engineers, and students.

The conference was organized into several sessions: Speckle Technologies, chaired by Prof. Duncan; Tissue and Cell Dynamics, chaired by Prof. Leahy; Clinical Imaging and Evaluation, chaired by Prof. Wang; Functional Imaging and Spectroscopy, chaired by Prof. Kirkpatrick; Tissue and Cell Mechanical Properties, chaired by Prof. Larin; Terahertz Imaging and Impact, chaired by Prof. Tuchin; and a poster session. Most of the sessions featured invited talks. The special features of this year conference were a keynote lecture by Prof. Jürgen Popp from Friedrich-Schiller Univ., Germany, and Institut für Photonische Technologien e.V., Germany, entitled "The many facets of Raman spectroscopy for innovative biomedical diagnostics" and a special panel discussion on 3D and 4D microcirculation imaging (described in details below). Both of these sessions drew significant attention from the audience and resulted in wide discussions of these topics.

The keynote lecture delivered by Prof. Jürgen Popp described recent advances in development and application of Raman Spectroscopy technology for real-time diagnostics of tissue pathology both in vitro and in vivo. Prof. Popp is Scientific Director of Institute of Photonic Technology, Jena and Institute of Physical Chemistry and Abbe Center of Photonics at Institute of Photonic

Technology. He is world-leading expert in development and application of innovative frequency-, time- and spatially resolved laser micro-spectroscopical methods and techniques and development and application of linear and non-linear Raman-technologies for biophotonics. The results of J. Popp work were published in more than 300 articles. Prof. Popp coordinates the European Network of Excellence "Photonics4Life" and is Editor-in-Chief of "Journal of Biophotonics". Since 2009 he is Fellow of the Society for Applied Spectroscopy. His keynote lecture described in detail recent progress in biomedical applications of Raman spectroscopy with concentration on cancer imaging and detection.

The oral sessions and corresponding poster session of the conference featured eight invited talks and overall 58 presentations which described, among others, advanced theoretical, computational and experimental studies in dynamics of microcirculation within skeletal muscles, tissue structural characterization, speckle-based measurement of the light scattering by RBCs, the origin of laser speckle contrast imaging, and the role of microcomputed tomography in microvascular imaging. The reader is encouraged to browse the table of contents for this issue to learn about different methods and techniques developed and applied to study complex problems of dynamics and fluctuations in biological systems on the scale ranging from cell to the whole body.

The conference chairs would like to thank the members of the technical program committee for their help in organizing the conference. We sincerely appreciate the support of the SPIE and the conference staff. Finally, we would like to thank all of the conference attendees and manuscript authors for their contributions and participation, especially invited speakers, which helped to make this meeting a success.

Valery V. Tuchin
Donald D. Duncan
Kirill V. Larin
Martin J. Leahy
Ruikang K. Wang

Report on the Panel Discussion on 3D and 4D Microcirculation Imaging: Where Will the Clinical Impact Be?

Martin J. Leahy, National Univ. of Ireland, Galway (Ireland), National Biophotonics and Imaging Platform (Ireland), and Royal College of Surgeons (Ireland); Ruikang Wang, Univ. of Washington (United States); Vasilis Ntziachristos, Helmholtz Zentrum München GmbH (Germany); Vladimir P. Zharov, Univ. of Arkansas for Medical Sciences (United States); Jessica Ramella-Roman, The Catholic Univ. of America (United States)

A special panel, organized and moderated by Martin Leahy, was assembled with leading researchers in microcirculation imaging where they discussed 3D and 4D microcirculation imaging. The discussion focused on clinical applications and the developments necessary to move the technology to the bedside.

The discussion was opened by Martin Leahy (NUI Galway) with a general introduction and overview. The number of papers on microcirculation published in physical sciences doubled between 2006 and 2008 representing a jump from the long stable 5% of all microcirculation papers to 20%. This trend continues and means there is an explosion of interest in developing and evaluating new tools to study the microcirculation. Perhaps more than this, it heralds the arrival of 3D and 4D imaging. Biophotonics promises 3D microcirculation imaging at clinically relevant speeds and depths. Interestingly, according to Scopus, the highest cited paper in the Journal of Biomedical Optics in 2010 was on a 2D method, laser speckle contrast imaging [1]. At the time of writing (February 23, 2012) it had 40 citations of which 10 were from the medical and life sciences journals. Photoacoustic imaging and characterization of the microvasculature [2] had 26 citations with four in the medical and life sciences journals. This probably reflects the relative maturity of the techniques. Furthermore, microcirculation imaging dominated the top ten most cited papers in the Journal of Biomedical Optics in 2010.

Jessica Ramella-Roman, (Catholic Univ.) commented that, as translational research becomes more and more common in biophotonics, the need for rigorous validation of instrumentation and methodology increases. Several optical phantoms have been designed and used for proof-of-principle studies as well as to test the performance of a particular tool, but these efforts are often ad hoc and limited by researchers' expertise and interest. Recently several regulatory agencies including, the National Institute of Standards and Technology (NIST), the U.S. Food and Drug Administration (FDA), the Canada National Research Council, and the National Physics Laboratory in the UK, have recognized that validation in bio-photonics is an important issue as several techniques have come to maturity and have been used in clinics around the world. NIST sponsored a series of events in 2011 to identify phantoms materials, measurement standards, and figure of

merits for assessing optical system. Standardization and benchmarking of biophotonics techniques is becoming an important issue as several optical techniques reach the commercialization level and are used in the clinical environment; for this reason in the coming years we will witness a stronger involvement of regulatory agencies in this domain and better validation will be required from investigators as they develop novel techniques for clinical use.

There was some debate on the question of whether price matters. Ruikang Wang found that in his experience hospital eye departments were happy to pay c. $200k for an ophthalmic OCT system with microcirculation capabilities whereas Martin Leahy felt that the price point would be closer to $20k for basic ophthalmic OCT systems and the microcirculation aspect would have to prove its worth by gaining a reimbursement code. It was also felt that the price point would depend on the clinic level e.g. whether in a teaching hospital or purely service.

Vladimir Zharov, (Arkansas) was asked if 3D microcirculation imaging at depths of several cm is really practicable? His reply: 2D and in some cases 3D microcirculation in deep tissue is quite possible using photoacoustic methods. For example, photoacoustic techniques demonstrated imaging of microvessels in deeper tissue (typically 3-10 mm, and up to 5-7 cm in few studies) with better resolution compared to other optical imaging modalities. He also fielded a question on the practicalities of the photoacoustic technique for clinical use, specifically: "Why is photoacoustic tomography largely limited to pre-clinical use?" The photoacoustic technique and particularly tomography is a very fast growing area of biomedical imaging, which is safe for humans and relatively robust, so he does not see the principle limitations for the clinical application. It is just a question of time. In the current stage the researchers are trying to identify the best clinical targets, for example, detection of circulating tumor cells, assessing the sentinel lymph nodes or monitoring microcirculation's dysfunctions during various diseases, and working on the further parameter improvement. In particular, the use high pulse rate lasers allows the imaging speed to be dramatically increased. However, photoacoustic imaging is also promising in basic research, or on animal models of human diseases to explore new diagnosis and therapeutic approaches.

[1] D. A. Boas and A. K. Dunn, "Laser speckle contrast imaging in biomedical optics," J. Biomed. Opt. 15(1), 2010. http://dx.doi.org/10.1117/1.3285504
[2] S. Hu and L. V. Wang, "Photoacoustic imaging and characterization of the microvasculature," J. Biomed. Opt. 15(1), 2010. http://dx.doi.org/10.1117/1.3281673
[3] A. de la Zerda A, J-W Kim , E.I. Galanzha, S.S. Gambhir, and V.P. Zharov VP. Advanced contrast nanoagents for photoacoustic molecular imaging, cytometry, blood test and phototohermal theranostics. Wiley's Contrast Media and Molecular Imaging journal. 2011; 6:346-369.