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Introduction

This proceedings volume is from the Dynamics and Fluctuations in Biomedical Photonics XIII conference, which was held on February 14 and 15, 2016 at the SPIE Photonics West Conference in San Francisco, California. It was a two-day meeting featuring 32 oral and invited presentations, as well as a joint poster session of 16 poster presentations from leading international research groups. The goal of the conference was to gather essentially different groups of leading researchers, such as biophysicists, medical doctors and physicians, mathematicians, optical and laser engineers, and students, to report the current state of the art. These groups also sought to facilitate future progress in the development of optical and laser technologies based on dynamics and fluctuations approaches (like laser-speckle, 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 the 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 useful to scientists, medical doctors, engineers and students.

Prof. Martin J. Leahy chaired a keynote session that had two presentations: an invited paper entitled "Functional monitoring of blood flow dynamics in brain with photon correlation techniques" by Prof. Arjun G. Yodh, et al., Univ. of Pennsylvania, (USA), and a keynote presentation about "Speckle fluctuations to probe dynamics on the macroscopic to microscopic scales'' by Prof. David A. Boas, Athinoula A. Martinos Ctr. for Biomedical Imaging (USA). David A. Boas is the 2016 recipient of the SPIE Britton Chance Biomedical Award. SPIE presents this award in recognition of his development, application, and dissemination of near infrared spectroscopy and imaging for breast cancer and brain function, and for his perseverance in developing several innovative microscopic methods to further advance our knowledge of cerebral physiology.

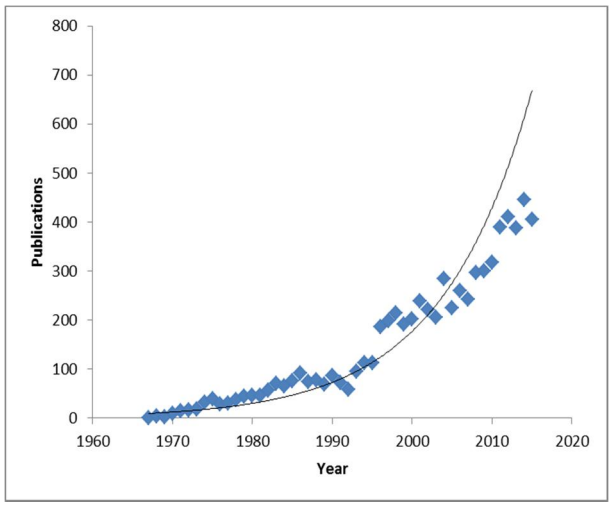
Most of the sessions featured invited presentations. The conference kicked off with the invited lectures: "Laser speckle micro rheology for micro-mechanical mapping of bio-materials" by Zeinab Hajjarian Kashany, et al., Harvard Medical School (USA); "Mapping transverse capillary flow speed using time-varying OCT speckle signals" by Woo June Choi and Ruikang K. Wang, Univ. of Washington (USA); "Quantitative Mueller matrix microscope: theory, equipment, calibration, and applications" by Hui Ma, et al., Tsinghua Univ. (China); "Quantification of volumetric cerebral blood flow using hybrid laser speckle contract and optical

coherence tomography" by Niksa Valim and Andrew K. Dunn, The Univ. of Texas at Austin (USA); "Topical application of nanoparticles: prospects and safety aspects" by Jürgen M. Lademann, et al., Charite Universitatsmedizin Berlin (Germany); and "Biodynamic profiling of three-dimensional tissue growth techniques" by Hao Sun, et al., Purdue Univ. (USA). These presentations drew significant attention from the audience and resulted in large coffee break discussions. These talks provided a nice overview of recent advances in multiple fields of biomedical optics and biophotonics related to dynamic and fluctuation research. The oral sessions and corresponding poster session featured many presentations that described different methods and techniques developed and applied to study complex problems of dynamics and fluctuations in biological systems on the scale ranging from cells to the whole body. The reader is encouraged to browse the table of contents for this issue to learn the full scope of this conference.

The Sunday afternoon panel discussion on Speckle in Biomedical Optics, which was moderated by Profs. Martin J. Leahy, National Univ. of Ireland, Galway (Ireland) and Sean Kirkpatrick, Michigan Technological Univ. (USA), included leading biophotonics researchers who have made seminal contributions to our understanding of speckle in biomedical optics and was seeded by one introductory slide from each panelist to present the latest developments and explore the most exciting future directions in speckle research. The discussion was opened by Martin Leahy (NUI Galway) with a general introduction and overview. The panelists introduced items of topical interest in the modelling, suppression and use of speckle. Sean Kirkpatrick outlined the origins of speckle and some of its uses. This followed excellent lectures from David Boas and Arjun Yodh on the use of speckle with particular emphasis on brain hemodynamics and regulation.

Figure 1.
Publication history of laser speckle.

Source: Scopus 15 March 2016 search for publications with 'laser' and 'speckle'.



Speckle technologies tend to be easy to implement, which turns out to be both an advantage and disadvantage. There are many publications on laser speckle. One key challenge is to develop standards for speckle measurements that yield quantitative, reliable and reproducible results between different laboratories, between different studies, and between different individuals in animal and clinical investigations.

Since the first paper on laser speckle, "Measurement potential of laser speckle velocimetry" by R. J. Adrian in 1966, the number of papers concerning laser speckle published each year has grown to 446 in 2014 (source: Scopus), with more than 7000 published before the end of 2015.

As outlined by Jessica Ramella-Roman, speckle is a sometimes unwanted feature of images generated with coherent light, since it adds noise to the images. Our understanding of speckle generated by laser light interaction with tissue has advanced across a broad range of biophotonics, so this is a good time to gather what has been learned with a view to cross-fertilizing the various applications for which speckle is an important feature. Advances have been made both in the suppression of speckle noise and in the extraction of key information relating to structure (e.g. type of plaque in the coronary artery) and function (microcirculatory blood flow).

Many of the recent papers are based on biophonic applications of speckle. Laser speckle blood perfusion imaging is a well-known[1] technique, sometimes known as LASCA, which makes use of the blurring of speckles from moving blood cells to identify and attempt to quantify flow variations. Its speed advantage over its cousin, laser Doppler, has opened up many additional bio applications of perfusion imaging. For example, Valery Tuchin outlined that full-field laser speckle flowmetry provides a real-time imaging of superficial blood microcirculation which allows one to detect changes in oscillatory dynamics of microvascular perfusion in living organs like kidneys. He showed how elevation of laser power

density affects quality of the recorded signal and improves detectability of temporal changes in microvascular perfusion providing better knowledge of dynamics in the rat kidney.[2]

Interestingly, it is possible to monitor variations of blood perfusion deep in tissue using diffuse correlation spectroscopy (DCS) as outlined by Arjun Yodh.[3] This very important development goes some way to overcome the limitation to superficial tissues, although there is a loss of spatial resolution. Fast DCS will open up new avenues for discovery of physiological phenomena using modulation amplitude, phase-difference between flow and pressure, distribution of flow oscillations, and particularly dynamics and autoregulation in the brain. Igor Meglinski discussed how Monte Carlo simulation can be used to better understand the dynamic diffusion correlation to measure flow.

A growing number of papers have investigated dynamic speckle signals in optical coherence tomography (OCT), and they have been applied to imaging for microvascular architecture in 3D, which has better resolution than diffuse methods and greater depth than the confocal microscopy. Doppler, phase shift, speckle variance, OMAG, and cmOCT are all benefits of this dynamic speckle to contrast functional vasculature.[4,5] David Sampson[6] reported on the use of speckle in optical coherence elastography for differentiation of tissue types and on the five-fold improvement in resolution provided by optical coherence tomography (OCM). Kirill Larin illustrated improvements using 3D speckle variance and anomaly detection with exquisite images of a mouse embryo yolk sack.[7] It was also shown how sub-resolution speckle variations could be used, like to map cilia beating in reproductive tracts.[8] Kishan Dholakia illustrated how the deterministic properties of laser speckle interaction with scattering media can be used to stabilize a laser to a 24 kHz dither by sub-femtometer measurement of the laser wavelength.[9]

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 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 and keynote speakers, who helped to make this meeting a success.

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