

Optical Tomography and Spectroscopy of Tissue XIII

Sergio Fantini
Paola Taroni
Editors

4–6 February 2019
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 10874

Proceedings of SPIE, 1605-7422, V. 10874

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Optical Tomography and Spectroscopy of Tissue XIII, edited by Sergio Fantini, Paola Taroni, Proc. of SPIE
Vol. 10874, 1087401 · © 2019 SPIE · CCC code: 1605-7422/19/\$18 · doi: 10.1117/12.2531772

The papers 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. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIDigitalLibrary.org.

The papers 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 these proceedings:

Author(s), "Title of Paper," in *Optical Tomography and Spectroscopy of Tissue XIII*, edited by Sergio Fantini, Paola Taroni, Proceedings of SPIE Vol. 10874 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

ISSN: 1605-7422
ISSN: 2410-9045 (electronic)

ISBN: 9781510623903
ISBN: 9781510623910 (electronic)

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

Copyright © 2019, Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 1605-7422/19/\$18.00.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

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

**SPIE. DIGITAL
LIBRARY**

SPIDigitalLibrary.org

Paper Numbering: *Proceedings of SPIE* follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

Contents

vii *Authors*
ix *Conference Committee*

ADVANCES IN METHODS AND INSTRUMENTATION I

- 10874 03 **Self-calibrated frequency domain diffuse optical spectroscopy with a phased source array** [10874-2]
- 10874 04 **RTBioT: a real-time healthcare monitoring Bio-IoT device employing spatially resolved near infrared (NIR) spectroscopy (Invited Paper)** [10874-3]
- 10874 05 **Toward handheld real time frequency domain diffuse optical spectroscopy** [10874-5]

ADVANCES IN METHODS AND INSTRUMENTATION II

- 10874 08 **Multi-wavelength dual-detection channel system for time-resolved near-infrared spectroscopy** [10874-8]
- 10874 09 **Bioresorbable fibers for time-domain diffuse optical measurements: a step toward next generation optical implantable devices** [10874-9]
- 10874 0A **Water and lipid contents measured at various parts of the human body with a six-wavelength time-resolved spectroscopy system** [10874-10]

DIFFUSE OPTICAL TOMOGRAPHY

- 10874 0E **Using dynamic vascular optical spectroscopy to evaluate peripheral arterial disease (PAD) in patients who undergo a vascular intervention** [10874-14]
- 10874 0F **New method to diagnose joints affected by systemic lupus erythematosus based on frequency-domain optical transmission** [10874-15]

APPLICATIONS TO LIVER, KIDNEY, BREAST, INTESTINE

- 10874 0H **Near infrared spectroscopy system for quantitative monitoring of renal hemodynamics and oxygenation in rats** [10874-17]
- 10874 0I **High spatial frequency structured light imaging texture analysis using Gabor filtering differentiates tumor from normal tissue subtypes** [10874-18]

10874 OJ **Hyperspectral, hybrid continuous wave and frequency domain diffuse optical tomography in a handheld reflectance geometry for breast cancer diagnostics** [10874-19]

SPATIAL FREQUENCY DOMAIN IMAGING I

10874 OO **Short-wave infrared spatial frequency domain imaging for non-invasive quantification of tissue water content** [10874-24]

SPATIAL FREQUENCY DOMAIN IMAGING II

10874 OT **A multi spectral hand-held spatial frequency domain imaging system for imaging human colorectal cancer** [10874-29]

10874 OU **Hand-held multi-wavelength spatial frequency domain imaging for breast cancer imaging** [10874-30]

FLUORESCENCE IMAGING

10874 OV **New image reconstruction algorithm for fluorescence optical tomography based on the adjoint radiative transfer equation** [10874-31]

10874 OY **CCD-based temperature modulated fluorescence tomography** [10874-34]

FLUORESCENCE AND CHERENKOV RADIATION

10874 10 **Early detection of breast cancer using ER specific novel NIR fluorescent dye conjugate: a phantom study using FD-f-DOT system** [10874-36]

10874 13 **Noninvasive imaging of dual-agent uptake in glioma and normal tissue using MRI-coupled fluorescence tomography** [10874-39]

10874 14 **Correcting Cherenkov images for large-scale tissue-optical property attenuation using SFDI and patterned light reflectance for quantitative dosimetry** [10874-40]

DIFFUSE CORRELATION SPECTROSCOPY

10874 15 **Diffuse correlation tomography in the transport regime: a theoretical study of the sensitivity to Brownian motion (Invited Paper)** [10874-41]

CEREBRAL BLOOD FLOW

- 10874 1D **Dynamic measurements of absolute cerebral blood flow with coherent hemodynamics spectroscopy** [10874-49]
- 10874 1E **Frequency dependent hemodynamic response to intracranial pressure changes** [10874-50]

FUNCTIONAL BRAIN IMAGING

- 10874 1H **An fNIRS probe positioning system using augmented reality technology** [10874-53]
- 10874 1I **Comparison of spontaneous and induced coherent hemodynamics in the human brain** [10874-54]

BREAST IMAGING

- 10874 1L **Monitoring total hemoglobin concentration changes across neoadjuvant chemotherapy in PgR-positive and PgR-negative breast cancer with diffuse optical tomography** [10874-57]
- 10874 1N **Multi-wavelength time domain diffuse optical tomography for breast cancer: initial results on silicone phantoms** [10874-59]

POSTER SESSION

- 10874 1S **Quantifying joint blood flow in a rat model of rheumatoid arthritis with dynamic contrast-enhanced near-infrared spectroscopy** [10874-63]
- 10874 1U **A three-wavelength 240-channel NIRS-DOT system of lock-in photon-counting mode for brain functional investigation** [10874-65]
- 10874 1V **A multi-wavelength single-pixel SFD imaging system based on lock-in photon-counting detection** [10874-66]
- 10874 1W **Phantom verification for lock-in-photon-counting-based diffuse optical tomography system** [10874-67]
- 10874 1X **Anisotropy factor reconstruction as a new endogenous contrast for cancer diagnosis with optical tomography** [10874-68]
- 10874 21 **A dual-wavelength spread spectrum-based spectroscopic system For time-domain near-infrared diffuse optical imaging** [10874-72]
- 10874 25 **Spatial-temporal constraints guided dynamic fluorescence tomographic model for enhanced imaging of organs and functional structures in small animals** [10874-76]

- 10874 27 **In silico investigation of near-infrared light propagation in the joints of the human hand**
[10874-78]
- 10874 29 **Adaptive extraction of permissible source region based on matched filtering for bioluminescence tomography** [10874-80]
- 10874 2A **Depth dependent coherent hemodynamics during induced blood pressure oscillations**
[10874-81]
- 10874 2B **A miniature frequency domain diffuse optical optode for quantitative wearable oximetry**
[10874-82]
- 10874 2C **An integration model of steady-state single-fiber diffuse reflectance** [10874-83]
- 10874 2J **A point-of-care handheld region-of-interest (ROI) 3D functional diffuse optical tomography (fDOT) system** [10874-90]

Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Abdalsalam, Ola, 03
Abdelal, Heba, 0T
Addoum, Ahmad, 0V, 1X
Algarawi, Maha, 0Y
Alipour, Zahra, 0T
Altoe, Mirella L., 1L
Antaki, James F., 0U
Applegate, Matthew B., 0O
Arridge, Simon R., 1N, 21
Askanase, A. D., 0F
Asllanaj, Fatmir, 0V, 1X
Bajakian, D. R., 0E
Behera, Anurag, 08
Beier, Frank, 1S
Blaney, Giles, 1D, 1I, 2A
Boetti, Nadia G., 09
Bruza, Petr, 14
Buttafava, Mauro, 08
Campbell, Chris, 0J
Cantow, Kathleen, 0H
Ceci-Ginistrelli, Edoardo, 09
Chapman, Jr., William, 0T
Chatterjee, Deyali, 0T
Chaudury, Rachita, 2B
Chen, Duofang, 29
Chen, Xueli, 29
Cho, Seonguk, 04
Chung, Phil-sang, 04
Cohen, David, 27
Contassot-Vivier, Sylvain, 1X
Contini, Davide, 08
Crew, Katherine, 1L
Dalla Mora, Alberto, 08, 09, 1N
Dan, Mai, 1V
Danias, G., 0F
Da Silva, Anabela, 1S
Davis, Scott C., 13
Desjardins, Lise, 1S
Ding, Xuemei, 1U
Diop, Mamadou, 1S, 27
Di Sciacca, Giuseppe, 1N
Di Sieno, Laura, 08, 09, 1N
Du, Wenwen, 1W
Dumas, John Paul, 0O
Durduran, Turgut, 15
Erfanzadeh, Mohsen, 0T
Erkol, Hakan, 0Y
Fantini, Sergio, 1D, 1I, 2A
Farina, Andrea, 09, 1N
Ferocino, Edoardo, 1N
Flemming, Bert, 0H
Folaron, Margaret R., 13
Fong, C. J., 0E
Forghani, Farnoush, 0J
Frantz, A. T., 0F
Gao, Feng, 1U, 1V, 1W
Geraldino-Pardilla, L., 0F
Gladstone, David J., 14
Gladytz, Thomas, 0H
Grosenick, Dirk, 0H
Gulsen, Gultekin, 0Y
Hachadorian, Rachael L., 14
Hadway, Jennifer A., 1S
He, Xiangdong, 1W
Hebden, Jeremy C., 21
Hershman, Dawn L., 1L
Hibshoosh, Hanina, 1L
Hielscher, Andreas H., 0E, 0F, 1L, 25
Hill, Brian Y., 04
Hoi, J. W., 0E
Homma, Shu, 0A
Hoppe, Alexander, 0H
Hou, Xi, 1V
Howard, Scott, 03
Huang, Yi, 29
Ioussoufovitch, Seva, 1S
Istfan, Raef, 2B
Janner, Davide, 09
Jarvis, Lesley A., 14
Jermyn, Michael, 14
Jose, Iven, 10
Jun, Seunghyeok, 04
Kainerstorfer, Jana M., 0U, 1E
Kalinsky, Kevin, 1L
Kanhironan, Rajan, 2J
Kapoor, T., 0F
Kawaguchi, Hiroshi, 1H
Kim, Dongkyu, 25
Kim, Hyun K., 0E, 1L, 25
Kim, Sehwan, 04
Kim, Y., 0E, 0F
Kitsmiller, Vincent J., 05, 0J
Konugolu Venkata Sekar, Sanathana, 09
Krishnamurthy, Nishanth, 1I
Kwong, Tiffany C., 0Y
LaRochelle, Steven, 2B
Lee, Jong H., 25
Lee, Minseok, 04

Lee, Ting-Yim, 1S
 Li, Jiao, 1W
 Li, Shuying, 0T
 Li, Tongxin, 1V
 Liu, Dongyuan, 1U
 Liu, Han, 1W
 Macdonald, Callum M., 15
 Maloney, Benjamin W., 0I
 Mankodiya, Kunal, 2J
 Markel, Vadim A., 15
 Marone, Alessandro, 0E, 0F, 1L, 25
 Martelli, Fabrizio, 1N
 McClatchy, David M., 0I
 Mehrabi, Mehrnaz, 0Y
 Meng, Boyu, 13
 Milanese, Daniel, 09
 Mimura, Tetsuya, 0A
 Morrison, Laura B., 1S
 Mutch, Matthew, 0T
 Nandy, Sreyankar, 0T
 Nelson, Samantha, 1E
 Neville, K. E., 0F
 Niendorf, Thoralf, 0H
 Nouzi, Farouk, 0Y
 Ohmae, Etsuko, 0A
 O'Sullivan, Thomas D., 03, 05, 0J
 Pan, Tiantian, 1U
 Papadimitriou, Konstantinos I., 21
 Paulsen, Keith D., 0I
 Pham, Thao, 1D, 1I, 2A
 Piao, Daqing, 2C
 Pierce, Mark C., 0O
 Pifferi, Antonio, 09, 1N
 Pillai, Vinay Jha, 10
 Pogue, Brian W., 0I, 14
 Pohlmann, Andreas, 0H
 Powell, Samuel, 2I
 Pugliese, Diego, 09
 Ramachandran, Hema, 10
 Renna, Marco, 08
 Rizzo, Elizabeth J., 0I
 Robbins, Constance M., 0U
 Roblyer, Darren M., 0O, 2B
 Ruesch, Alexander, 1E
 Sadeghipour, Negar, 13
 Sahyoun, Christine C., 0O
 Saikia, Manob Jyoti, 2J
 Samkoe, Kimberley S., 13
 Sampathkumaran, Uma, 0Y
 Sassaroli, Angelo, 1D, 1I, 2A
 Schmitt, Samantha, 1E
 Seeliger, Erdmann, 0H
 Smith, Matthew A., 1E
 St. Lawrence, Keith, 1S
 Stillwell, Roy A., 05
 Strawbridge, Rendall R., 13
 Streeter, Samuel S., 0I
 Sun, Tengfei, 2C
 Suzuki, Hiroaki, 0A
 Suzuki, Norihiro, 0A
 Taroni, Paola, 1N
 Tejada, Mariella, 1L
 Tichauer, Kenneth, 13
 Tosi, Alberto, 08
 Tricoli, Ugo, 15
 Tromberg, Bruce J., 04
 Ueda, Yukio, 0A
 Vasudevan, Sandhya, 0J
 Wada, Hiroko, 0A
 Wang, Bingyuan, 1U
 Wells, Wendy A., 0I
 Xie, Jinbin, 1W
 Yamada, Toru, 1H
 Yamashita, Yutaka, 0A
 Yang, Jason, 0U, 1E
 Yin, Guoyan, 1W
 Yoshimoto, Kenji, 0A
 Zanoletti, Marta, 08
 Zhang, Limin, 1W
 Zhang, Yao, 1U
 Zhang, Yide, 03
 Zhao, Kuanxin, 1V
 Zhao, Yanyu, 0O
 Zheng, Yifeng, 0T
 Zhou, Zhongxing, 1W
 Zhu, Quing, 0T
 Zhu, Shouping, 29

Conference Committee

Symposium Chairs

James G. Fujimoto, Massachusetts Institute of Technology (United States)
R. Rox Anderson, Wellman Center for Photomedicine, Massachusetts
General Hospital (United States) and Harvard Medical School
(United States)

Symposium Co-chairs

Jennifer K. Barton, The University of Arizona (United States)
Wolfgang Drexler, Medical University of Vienna (Austria)

Program Track Chairs

Tuan Vo-Dinh, Fitzpatrick Institute for Photonics, Duke University
(United States)
Anita Mahadevan-Jansen, Vanderbilt University (United States)

Conference Chairs

Sergio Fantini, Tufts University (United States)
Paola Taroni, Politecnico di Milano (Italy)

Conference Program Committee

Robert R. Alfano, The City College of New York (United States)
Erin M. Buckley, Georgia Institute of Technology (United States)
Regine Choe, University of Rochester (United States)
Hamid Dehghani, The University of Birmingham (United Kingdom)
Amir H. Gandjbakhche, National Institutes of Health (United States)
Sylvain Gioux, Laboratoire des sciences de l'Ingénieur, de l'Informatique
et de l'Imagerie (France)
Andreas H. Hielscher, Columbia University (United States)
Shudong Jiang, Thayer School of Engineering at Dartmouth
(United States)
Jana M. Kainerstorfer, Carnegie Mellon University (United States)
Anand T. N. Kumar, Athinoula A. Martinos Center for Biomedical Imaging
(United States)
Frederic Leblond, Ecole Polytechnique de Montréal (Canada)
Mark J. Niedre, Northeastern University (United States)
Eiji Okada, Keio University (Japan)
Thomas D. O'Sullivan, University of Notre Dame (United States)
Antonio Pifferi, Politecnico di Milano (Italy)
Anne Planat-Chrétien, CEA-LETI (France)

Valentina Quaresima, Università degli Studi dell'Aquila (Italy)
Darren M. Roblyer, Boston University (United States)
Ilias Tachtsidis, University College London (United Kingdom)
Heidrun Wabnitz, Physikalisch-Technische Bundesanstalt (Germany)
Quing Zhu, Washington University in St. Louis (United States)

Session Chairs

- 1 Advances in Methods and Instrumentation I
Jana M. Kainerstorfer, Carnegie Mellon University (United States)
- 2 Advances in Methods and Instrumentation II
Qianqian Fang, Northeastern University (United States)
- 3 Diffuse Optical Tomography
Sergio Fantini, Tufts University (United States)
- 4 Applications to Liver, Kidney, Breast, Intestine
Mamadou Diop, Lawson Health Research Institute (Canada)
- 5 Spatial Frequency Domain Imaging I
Sergio Fantini, Tufts University (United States)
Paola Taroni, Politecnico di Milano (Italy)
- 6 Spatial Frequency Domain Imaging II
Darren M. Roblyer, Boston University (United States)
- 7 Fluorescence Imaging
Mark J. Niedre, Northeastern University (United States)
- 8 Fluorescence and Cherenkov Radiation
Anand T. N. Kumar, Athinoula A. Martinos Center for Biomedical Imaging
(United States)
- 9 Diffuse Correlation Spectroscopy
Erin M. Buckley, Georgia Institute of Technology (United States)
- 10 Cerebral Blood Flow
Adam T. Eggebrecht, Washington University School of Medicine in
St. Louis (United States)
- 11 Functional Brain Imaging
Stefan A. Carp, Athinoula A. Martinos Center for Biomedical Imaging
(United States)
- 12 Breast Imaging
Paola Taroni, Politecnico di Milano (Italy)