

PROCEEDINGS OF SPIE

Electro-Optical Remote Sensing X

Gary Kamerman
Ove Steinvall
Editors

26–27 September 2016
Edinburgh, United Kingdom

Sponsored by
SPIE

Cooperating Organisations
Innovation Centre for Sensor and Imaging Systems (United Kingdom)
ADS Scotland (United Kingdom)
The Knowledge Transfer Network (United Kingdom)
Visit Scotland (United Kingdom)
European Regional Development Fund (Belgium)
Technology Scotland (United Kingdom)

Published by
SPIE

Volume 9988

Proceedings of SPIE 0277-786X, V. 9988

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

Electro-Optical Remote Sensing X, edited by Gary Kamerman, Ove Steinvall,
Proc. of SPIE Vol. 9988, 998801 · © 2016 SPIE · CCC code:
0277-786X/16/\$18 · doi: 10.1117/12.2264051

Proc. of SPIE Vol. 9988 998801-1

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 *Electro-Optical Remote Sensing X*, edited by Gary Kamerman, Ove Steinvall, Proceedings of SPIE Vol. 9988 (SPIE, Bellingham, WA, 2016) six-digit Article CID Number.

ISSN: 0277-786X
ISSN: 1996-756X (electronic)
ISBN: 9781510603806
ISBN: 9781510603813 (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 © 2016, 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 0277-786X/16/\$18.00.

Printed in the United States of America.

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 six-digit CID article numbering system structured as follows:

- The first four 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*
- xi *Introduction*

ACTIVE SENSING I

- 9988 02 **Transient imaging for real-time tracking around a corner (Best Student Paper Award)** [9988-1]
- 9988 03 **Automated object detection and tracking with a flash LiDAR system** [9988-2]
- 9988 04 **Sensing and reconstruction of arbitrary light-in-flight paths by a relativistic imaging approach** [9988-3]
- 9988 05 **Penetration of pyrotechnic effects with SWIR laser gated viewing in comparison to VIS and thermal IR bands** [9988-4]

PASSIVE SENSING

- 9988 06 **Standoff midwave infrared hyperspectral imaging of ship plumes (Invited Paper)** [9988-6]
- 9988 07 **Expanding the dimensions of hyperspectral imagery to improve target detection** [9988-7]
- 9988 08 **Image enhancement and color constancy for a vehicle-mounted change detection system** [9988-8]
- 9988 09 **Detection of object vibrations from high speed infrared images** [9988-9]
- 9988 0A **Reconstruction method of compressed sensing for remote sensing images cooperating with energy compensation** [9988-10]

ACTIVE SENSING II

- 9988 0B **Optical and acoustical UAV detection (Invited Paper)** [9988-11]
- 9988 0C **Eye safe lidar and passive EO sensing for cloud monitoring** [9988-12]
- 9988 0D **Rapid 2-axis scanning lidar prototype** [9988-13]
- 9988 0E **Effect of optical turbulence along a downward slant path on probability of laser hazard** [9988-14]

SENSOR DEVELOPMENT

- 9988 OH **Noncontact thermoacoustic detection of targets embedded in dispersive media** [9988-17]
- 9988 OI **Research of dynamic goniometer method for direction measurements** [9988-18]
- 9988 OJ **Optimization design and evaluation specifications analysis for the optical remote system with a high spatial resolution** [9988-19]

INFRARED SENSING

- 9988 OK **High sensitivity InAs photodiodes for mid-infrared detection (Invited Paper)** [9988-20]
- 9988 OL **Real-time detection of small and dim moving objects in IR video sequences using a robust background estimator and a noise-adaptive double thresholding** [9988-21]
- 9988 OM **Use of multivariate analysis to minimize collecting of infrared images and classify detected objects** [9988-22]
- 9988 ON **Generating object proposals for improved object detection in aerial images** [9988-23]

SIGNAL PROCESSING

- 9988 OO **Compressed sensing for super-resolution spatial and temporal laser detection and ranging** [9988-24]
- 9988 OP **Multi-spectral texture analysis for IED detection** [9988-25]
- 9988 OQ **Deep subspace mapping in hyperspectral imaging** [9988-26]
- 9988 OR **Evaluating automatic registration of UAV imagery using multi-temporal ortho images** [9988-27]
- 9988 OS **Importance of using field spectroscopy to support the satellite remote sensing for underground structures intended for security reasons in the eastern Mediterranean region** [9988-28]
- 9988 OT **Aerial vehicles collision avoidance using monocular vision** [9988-29]
- 9988 OU **Range intensity coding under triangular and trapezoidal correlation algorithms for 3D super-resolution range gated imaging** [9988-30]

POSTER SESSION

- 9988 OV **Remote sensing for oil products on water surface via fluorescence induced by UV filaments** [9988-31]

- 9988 OW **An efficient visual saliency analysis model for region-of-interest extraction in high-spatial-resolution remote sensing images** [9988-32]
- 9988 OY **Structured output tracking guided by keypoint matching** [9988-34]

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four 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.

Agapiou, Athos, 0S
Arbabian, Amin, 0H
Arens, Michael, 03
Auckloo, Akeel, 0K
Bacher, Emmanuel, 04
Balashov, Oleg, 0T
Berglund, Folke, 0C
Bergström, David, 0Q
Beyerer, Jürgen, 0N
Bokhman, E. D., 0I
Boyle, Kevin C., 0H
Cao, Zhiguo, 0Y
Chamberland, Martin, 06
Christnacher, Frank, 04, 0B, 0O
Corsini, Giovanni, 0L
David, John P. R., 0K
Diani, Marco, 0L
Fan, Songtao, 0U
Fang, Zhiwen, 0Y
Farley, Vincent, 06
Filatov, Yu. V., 0I
Gagnon, Jean-Philippe, 06
Gagnon, Marc-André, 06
Geints, Yu. E., 0V
Göhler, Benjamin, 0S
Gustafsson, David, 0P, 0Q
Gustafsson, K. Ove S., 0C, 0E
Guyot, Éric, 06
Hadjimitsis, Diofantos G., 0S
Hammer, Marcus, 03
Hartsell, Daryl, 0D
He, Jinping, 0A, 0J
Hebel, Marcus, 03
Hengy, Sébastien, 0B
Hullin, Matthias, 02
Ionin, A. A., 0V
Ivanov, P. A., 0I
Khuri-Yakub, Butrus T., 0H
Klein, Jonathan, 02, 04
Krüger, Wolfgang, 0R
Krysa, Andrey, 0K
Lagueux, Philippe, 06
Larichev, R. A., 0I
LaRocque, Paul E., 0D
Laurenzis, Martin, 02, 04, 0B, 0O
Lei, Pingshun, 0U
Letalick, Dietmar, 0M
Liu, Yuchen, 0A
Liu, Zhaojun, 0J
Lutzmann, Peter, 05, 09
Matwyschuk, Alexis, 0B
Melillos, George, 0S
Metzger, Nicolas, 04
Michaelides, Silas, 0S
Mokrousova, D. V., 0V
Monnin, David, 08
Muraviev, Vadim, 0T
Nan, Hao, 0H
Naz, Pierre, 0B
Ng, Jo Shien, 0K
Papadavid, George, 0S
Paunescu, Gabriela, 09
Pavlov, P. A., 0I
Pettersson, Henrik, 0P, 0Q
Prodromou, Maria, 0S
Ren, Pengdao, 0U
Ruan, Ningjuan, 0A, 0J
Salvador, Mark Z., 07
Saur, Günter, 0R
Savary, Simon, 06
Schertzer, Stéphane, 0B, 0O
Schmitt, Gwenaél, 0B
Schuchert, Tobias, 0N
Seleznev, L. V., 0V
Sinitsyn, D. V., 0V
Sommer, Lars W., 0N
Steinval, Ove, 0C
Strotov, Valery, 0T
Sun, Liang, 0U
Sunchugasheva, E. S., 0V
Svensson, Thomas, 0M
Tan, Chee Hing, 0K
Tektonidis, Marco, 08
Themistocleous, Kyriacos, 0S
Tremblay, Pierre, 06
Tripp, Jeffrey, 0D
Wadströmer, Niclas, 0Q
Wang, Lin, 0W
Wang, Shiyi, 0W
Wang, Xiaoyong, 0J
Wang, Xinwei, 0U
White, Benjamin, 0K
Xiao, Yang, 0Y
Zemlyanov, A. A., 0V
Zhang, Libao, 0W
Zhang, Shiyong, 0K
Zhao, Haibo, 0A
Zhou, Xinxin, 0K

Zhou, Yan, 0U
Zingoni, Andrea, 0L

Conference Committee

Symposium Chairs

David H. Titterton, United Kingdom Defence Academy
(United Kingdom)

Symposium Co-chairs

Ric Schleijpen, TNO Defense, Security and Safety (Netherlands)
Karin Stein, Fraunhofer-Institut für Optronik, Systemtechnik und
Bildauswertung (Germany)
Stuart S. Duncan, Leonardo-Finmeccanica (United Kingdom)

Conference Chairs

Gary Kamerman, FastMetrix, Inc. (United States)
Ove Steinvall, Swedish Defence Research Agency (Sweden)

Conference Programme Committee

Robert J. Grasso, RJG Consulting (United States)
Laurent Hespel, ONERA (France)
Dennis K. Killinger, University of South Florida (United States)
Martin Laurenzis, Institut Franco-Allemand de Recherches de Saint-
Louis (France)
Peter Lutzmann, Fraunhofer-Institut für Optronik, Systemtechnik und
Bildauswertung (Germany)
Kenneth J. McEwan, Defence Science and Technology Laboratory
(United Kingdom)
Vasyl Molebny, National Taras Shevchenko University of Kyiv (Ukraine)
Philip St John Russell, Max-Planck-Institut für die Physik des Lichts
(Germany)
Peter N. Randall, QinetiQ Ltd. (United Kingdom)
Philippe Réfrégier, Institut Fresnel (France)
Knut Stenersen, Norwegian Defence Research Establishment
(Norway)
Monte D. Turner, Air Force Research Laboratory (United States)

Session Chairs

- 1 Active Sensing I
Ove Steinvall, FOI-Swedish Defence Research Agency (Sweden)

- 2 Passive Sensing
Kenneth J. McEwan, Defence Science and Technology Laboratory
(United Kingdom)
- 3 Active Sensing II
Gary Kamerman, FastMetrix, Inc. (United States)
- 4 Sensor Development
Benjamin Goekler, Fraunhofer-Institut für Optronik, Systemtechnik und
Bildauswertung (Germany)
- 5 Infrared Sensing
Robert Grasso, EOIR Technologies (United States)
- 6 Signal Processing
Ove Steinvall, FOI-Swedish Defence Research Agency (Sweden)

Introduction

This conference, devoted to Electro-Optical Remote Sensing, collected over 30 contributions. The papers were distributed among the topics of active sensing, passive sensing, sensor development, and signal processing. Active sensing was also presented at other conferences in the symposium.

Among the papers on active sensing we note an interesting paper by Klein et.al, paper 998802, on real-time tracking around a corner. The paper presents a novel reconstruction algorithm based on computer graphics rendering instead of the conventional back propagation algorithms. This paper was chosen for the Best Student Paper Award. Papers on active sensing also involved automated detection and tracking on 3-D flash imagery as (Hammer et.al., IOSB) well as penetration of pyrotechnic effects with SWIR laser gated-viewing in comparison to VIS and thermal IR bands (Göhler et.al., IOSB). Other interesting papers in active imaging presented UAV detection and tracking (Christnacher et.al., ISL) and reconstruction of light-in-flight in path using photon counting techniques (Laurenzis, ISL).

The passive sensing papers presented work on high-sensitivity InAs photodiodes for mid-infrared detection (Jo Shien Ng et.al., Univ. of Sheffield) and other papers on signal processing related work. The sensor development contained papers on multiband optics (Sanghera et.al., NRL) and noncontact thermos-acoustic detection of targets embedded in dispersive media (Boyle et.al. Stanford Univ.).

The signal processing session contained papers on super-resolution in laser imaging (Laurenzis et.al., ISL and Xinwei Wang, et.al., Institute of Semiconductors). Other papers presented processing on multiband infrared sensors imaging using texture statistics (Henrik Petersson, et.al., FOI) as well as deep sub-space mapping in hyperspectral imaging (Wadströmer et.al., FOI).

The above papers are just examples and for other papers we refer to the conference proceedings.

**Gary Kamerman
Ove Steinvall**