PROCEEDINGS OF SPIE

Emerging Imaging and Sensing Technologies for Security and Defence II

Keith L. Lewis
Richard C. Hollins
Gerald S. Buller
Robert A. Lamb
Editors

13–14 September 2017
Warsaw, Poland

Sponsored by
SPIE

Cooperating Organisations
CENSIS: Innovation Centre for Sensor & Imaging Systems (United Kingdom)
Polish Technological Platform on Photonics (Poland)
MIRPHAB (France)
Photonics Society of Poland (Poland)
Cranfield University (United Kingdom)

Published by
SPIE

Volume 10438

Proceedings of SPIE 0277-786X, V. 10438

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

Emerging Imaging and Sensing Technologies for Security and Defence II, edited by Keith L. Lewis, Richard C. Hollins, Gerald S. Buller, Robert A. Lamb, Proc. of SPIE Vol. 10438, 1043801
 · doi: 10.1117/12.2302596

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 SPIEDigitalLibrary.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 *Emerging Imaging and Sensing Technologies for Security and Defence II*, edited by Keith L. Lewis, Richard C. Hollins, Gerald S. Buller, Robert A. Lamb, Proceedings of SPIE Vol. 10438 (SPIE, Bellingham, WA, 2017) Seven-digit Article CID Number.

ISSN: 0277-786X
ISSN: 1996-756X (electronic)

ISBN: 9781510613409
ISBN: 9781510613416 (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

Printed in the United States of America.

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

SPIEDigitalLibrary.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

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.

Conference Committee

Symposium Chair

Ric Schleijpen, TNO Defence, Security and Safety (Netherlands)

Symposium Co-Chairs

Karin Stein, Fraunhofer Institute of Optronics System Technologies and Image Exploitation IOSB (Germany)
Jan K. Jabczyński, Military University of Technology (Poland)

Conference Chairs

Keith L. Lewis, Sciovis Ltd. (United Kingdom)
Richard C. Hollins, Defence Science and Technology Laboratory (United Kingdom)
Gerald S. Buller, Heriot-Watt University (United Kingdom)
Robert A. Lamb, SELEX Galileo Ltd. (United Kingdom)

Conference Program Committee

Tibor Berceli, Budapest University of Technology and Economics (Hungary)
Arnaud Brignon, Thales Research & Technology (France)
Béatrice Cabon, Minatec (France)
John J. R. David, The University of Sheffield (United Kingdom)
Didier Decoster, Université des Sciences et Technologies de Lille (France)
Dominique Hamoir, ONERA (France)
Andrew R. Harvey, University of Glasgow (United Kingdom)
Christopher Hill, Malvern Lidar Consultants (United Kingdom)
Pengda Hong, Lehigh University (United States)
Javier Marti-Sendra, Universitat Politècnica de València (Spain)
Stephen P. McGeoch, Thales Optronics Ltd. (United Kingdom)
Ralf Ostendorf, Fraunhofer-Institut für Angewandte Festkörperphysik (Germany)
Miles J. Padgett, University of Glasgow (United Kingdom)
Miguel A. Piqueras, DAS Photonics (Spain)
Julien Poette, Institut National Polytechnique de Grenoble (France)
Béla Szentpáli, Research Institute for Technical Physics and Materials Science (Hungary)

Alexander Toet, TNO Defence, Security and Safety (Netherlands)
Mauro G. Varasi, Finmeccanica (Italy)
Jean-Pierre Vilcot, Université des Sciences et Technologies de Lille (France)

Session Chairs

1 Optical Devices and Techniques
Andrew R. Harvey, University of Glasgow (United Kingdom)

2 Computational and Hyperspectral Imaging
Robert A. Lamb, Leonardo MW Ltd. (United Kingdom)

3 Optical and Image Processing
Robert A. Lamb, Leonardo MW Ltd. (United Kingdom)

4 Applications
Gerald S. Buller, Heriot-Watt University (United Kingdom)

5 Joint Session I: Quantum Metrology, Sensing and Imaging
Robert A. Lamb, Leonardo MW Ltd. (United Kingdom)

6 Joint Session II: Components and Technologies for Quantum Devices
Gerald S. Buller, Heriot-Watt University (United Kingdom)

Introduction

Interest in emerging imaging and sensing technologies has been of fundamental importance to the security and defence community for many years, where it has informed the process of horizon scanning for both government and industry. Indeed in the USA, the Defence Advanced Research Projects Agency (DARPA) recognised its role at the outset as an enabler for the development of disruptive solutions for providing enhanced capability in military operations. Challenges posed when sensing under the difficult conditions encountered in military environments lie at the heart of many applications of photonics. Evolving threats have necessitated the need for innovation in the way that reliable solutions are brought to bear when armed forces are deployed. The Emerging Imaging and Sensing Technologies conference brought together emerging activities in sensor and optical technologies and explored their application for those areas of application that are of current interest. This year the conference was organised around the following six topical areas with the last two organised as joint sessions with the conference on Quantum Technologies and Quantum Information Science:

- Optical devices and techniques
- Computational and hyperspectral imaging
- Optical and image processing
- Applications
- Quantum metrology, sensing and imaging
- Components and technologies for quantum devices.

Interest in photon-counting sensing technologies continues, building on advances highlighted in previous conferences. At the device level, contributions covered a diverse range of topics ranging from the development of dual-mode non-linear fibers for supercontinuum generation to the assessment of tunnelling magnetoresistors for magnetic imaging tomography. The benefits of multi-aperture imaging were also explored in relation to the thermal infrared, whilst another paper addressed image enhancement techniques for low-resolution imagery in the visible and LWIR regimes. Challenges for the future of imaging were addressed in a keynote paper, drawing on information generated in research activity supported by DARPA. In the quantum arena, research on active atomic clocks was explored in relation to the detection of gravitational anomalies, whilst another paper addressed the feasibility of single particle imaging for biosensor applications.

The conference drew on contributions from a number of different nations, including China, Cyprus, Czech Republic, India, Iran, Japan, Poland, Russian Federation, Ukraine, UK, and USA.

Keith L. Lewis