

PROCEEDINGS OF SPIE

Laser Radar Technology and Applications XXIV

Monte D. Turner
Gary W. Kamerman
Editors

16–17 April 2019
Baltimore, Maryland, United States

Sponsored and Published by
SPIE

Volume 11005

Proceedings of SPIE 0277-786X, V. 11005

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

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 *Laser Radar Technology and Applications XXIV*, edited by Monte D. Turner, Gary W. Kamerman, Proceedings of SPIE Vol. 11005 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510626751

ISBN: 9781510626768 (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 0277-786X/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	<i>Authors</i>
ix	<i>Conference Committee</i>

SESSION 1 SINGLE PHOTON SENSITIVE LIDAR AND DATE PROCESSING

- | | |
|----------|---|
| 11005 04 | Object detection and recognition using laser radar incorporating novel SPAD technology
[11005-6] |
| 11005 05 | Embedded implementation of a random feature detecting network for real-time classification of time-of-flight SPAD array recordings [11005-7] |

SESSION 2 LIDAR BATHYMETRY

- | | |
|----------|---|
| 11005 06 | Seahawk lidar [11005-13] |
| 11005 07 | Optical design of a deep water airborne bathymetric lidar [11005-14] |
| 11005 08 | Co-aligned dual wavelength circular scanner for airborne lidar bathymetry [11005-15] |

SESSION 3 LIDAR SYSTEMS AND MODELING

- | | |
|----------|---|
| 11005 0A | Compact lidar polarimetry via time-varying transmit polarization and an elliptical polarization analyzer [11005-2] |
| 11005 0B | Relationship between airborne lidar product specifications and end product requirements
[11005-3] |

SESSION 4 UAV AND COUNTER-UAV

- | | |
|----------|---|
| 11005 0C | Real-time counter-UAV system for long distance small drones using double pan-tilt scan laser radar [11005-8] |
| 11005 0D | Tracking and prediction of small unmanned aerial vehicles' flight behavior and three-dimensional flight path from laser gated viewing images [11005-9] |
| 11005 0E | UAV detection, tracking, and classification by sensor fusion of a 360° lidar system and an alignable classification sensor [11005-10] |

- 11005 0F **Development of a small unmanned aerial system-mounted texel camera** [11005-11]
- 11005 0G **Texturing of digital surface maps (DSMs) by selecting the texture from multiple perspective texel swaths taken by a low-cost small unmanned aerial vehicle (UAV)** [11005-12]

SESSION 5 AUTONOMOUS VEHICLES

- 11005 0H **A new lidar scanning system for autonomous vehicles for a reduced calibration processing time** [11005-16]
- 11005 0I **Mutual interference potential and impact of scanning lidar according to the relevant vehicle applications** [11005-17]
- 11005 0J **Signal interactions between lidar scanners** [11005-18]

SESSION 6 LIDAR SIGNAL AND DATA PROCESSING

- 11005 0K **Advances in lidar point cloud processing** [11005-19]
- 11005 0M **Analysis and exploitation of lidar waveform data** [11005-21]
- 11005 0N **Performance assessment of digital modulation and spreading code techniques for lidar with pulse coding** [11005-22]
- 11005 0O **Target discrimination using agile multispectral lidar** [11005-23]
- 11005 0P **Real-time realization of digital surface models and slope map using lidar for UAV navigation in challenging environment** [11005-24]

SESSION 7 HARSH ENVIRONMENT OPERATIONS AND ENVIRONMENTAL SENSING

- 11005 0Q **Er:YAG methane lidar laser technology** [11005-25]
- 11005 0R **Optimization of obscurant penetration with next generation lidar technology** [11005-26]

SESSION 8 ADVANCED LIDAR COMPONENTS I

- 11005 0W **Global shutter solid state flash lidar for spacecraft navigation and docking applications** [11005-31]
- 11005 0X **A fiber Kerr effect polarization state generator for temporally multiplexed polarimetric lidar** [11005-33]

11005 0Y **Comparative characteristics of highly sensitive photodetectors for modern lidar systems**
[11005-34]

SESSION 9 ADVANCED LIDAR COMPONENTS II

11005 0Z **Comparison of illumination sources for imaging systems for different applications** [11005-35]

11005 10 **3D imaging with 128×128 eye safe InGaAs p-i-n lidar camera** [11005-36]

11005 11 **Geiger-mode avalanche photodetector camera technology at Ball Aerospace** [11005-37]