

PROCEEDINGS OF SPIE

Sensors and Systems for Space Applications XI

Khanh D. Pham

Genshe Chen

Editors

16–17 April 2018

Orlando, Florida, United States

Sponsored and Published by
SPIE

Volume 10641

Proceedings of SPIE 0277-786X, V. 10641

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

Sensors and Systems for Space Applications XI, edited by Khanh D. Pham,
Genshe Chen, Proc. of SPIE Vol. 10641, 1064101 · © 2018 SPIE
CCC code: 0277-786X/18/\$18 · doi: 10.1117/12.2501414

Proc. of SPIE Vol. 10641 1064101-1

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 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 *Sensors and Systems for Space Applications XI*, edited by Khanh D. Pham, Genshe Chen, Proceedings of SPIE Vol. 10641 (SPIE, Bellingham, WA, 2018) Seven-digit Article CID Number.

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

ISBN: 9781510617933
ISBN: 9781510617940 (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 © 2018, 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/18/\$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

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

vii	<i>Authors</i>
ix	<i>Conference Committee</i>

SESSION 1 INSTRUMENT AND SENSOR ARCHITECTURE AND DESIGN FOR SPACE APPLICATIONS

10641 02	Modelling of celestial backgrounds [10641-1]
10641 03	Compact midwave imaging system (CMIS) for weather satellite applications [10641-2]
10641 04	Multi-band optical photometry of geosynchronous satellites [10641-3]
10641 05	Research on camera on orbit radial calibration based on black body and infrared calibration stars [10641-4]
10641 06	Optical design of space cameras for automated rendezvous and docking systems [10641-5]

SESSION 2 EMERGING SYSTEMS AND ARCHITECTURES FOR SPACE APPLICATIONS

10641 08	DDDAS for space applications [10641-7]
10641 09	Investigation of the dynamic enhanced cubature Kalman filter [10641-8]
10641 0A	Adaption from LWIR to visible wavebands of methods to describe the population of GEO belt debris [10641-9]
10641 0B	Analysis of three-dimensionally proliferated sensor architectures for flexible SSA [10641-10]

SESSION 3 PERCEPTION AND AUTONOMY FOR AEROSPACE APPLICATIONS

10641 0C	Markov logic network based complex event detection under uncertainty [10641-11]
10641 0D	Multitask assessment of roads and vehicles network (MARVN) [10641-12]
10641 0E	A robotic orbital emulator with lidar-based SLAM and AMCL for multiple entity pose estimation [10641-13]

- 10641 OF **Using multiple IMUs in a stacked filter configuration for calibration and fine alignment**
[10641-14]
- 10641 OG **Finding common ground by unifying autonomy indices to understand needed capabilities**
[10641-15]

SESSION 4 EMERGING CONCEPTS FOR SPACE COMMUNICATIONS

- 10641 OH **An anti-jamming GPS receiver antenna testing system** [10641-16]
- 10641 OI **Link establishment criterion and topology optimization for hybrid GPS satellite communications with laser crosslinks** [10641-17]
- 10641 OJ **Intelligent path loss prediction engine design using machine learning in the urban outdoor environment** [10641-18]

SESSION 5 OPTICAL DETECTION AND ANALYSIS FOR FREE SPACE LASER COMMUNICATIONS

- 10641 OK **Space qualification of InGaAs photodiodes and photoreceivers** [10641-19]
- 10641 OL **Sources of background light on space based laser communication links** [10641-20]
- 10641 OM **Quantum limited performance of optical receivers** [10641-21]
- 10641 ON **Predicting the performance of linear optical detectors in free space laser communication links**
[10641-22]
- 10641 OO **The performance of Geiger mode avalanche photo-diodes in free space laser communication links** [10641-23]

SESSION 6 SPACE SENSORS AND MISSION OPTIONS I

- 10641 OP **Alignment of the Korsch type off-axis 3 mirror optical system using sensitivity table method**
[10641-24]
- 10641 OQ **Low-cost, compact, and robust gas abundance sensor package** [10641-25]

SESSION 7 SPACE SENSORS AND MISSIONS OPTIONS II

- 10641 OR **Backside illuminated CMOS-TDI line scan sensor for space applications** [10641-26]

- 10641 OS **Think the way to measure the Earth Radiation Budget and the Total Solar Irradiance with a small satellites constellation** [10641-27]
- 10641 OT **Facility for orbital material processing** [10641-30]
- 10641 OU **A federated capability-based access control mechanism for internet of things (IoT)** [10641-29]

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.

Abramovich, Gil, 0R	Lee, Kyoungmuk, 0P
Aslam, Shahid, 0Q	Li, Lun, 0I
Bekki, S., 0S	Lim, Jae-Wan, 02
Ben-Ari, Nimrod, 0R	Lin, Xingping, 0H
Bihl, Trevor, 0G	Ling, Haibin, 0D
Blasch, Erik, 08, 09, 0C, 0D, 0E, 0H, 0J, 0U	Lu, Jingyang, 0C, 0J
Boldt, John, 03	Lyke, James, 0I
Bruder, Stephen, 0F	McCormick, K., 0T
Brumer, Maya, 0R	Meffah, M., 0S
Cai, Yiran, 0D	Meng, Kevin, 0A
Chen, FanSheng, 05	Morgan, M. F., 03
Chen, Genshe, 08, 09, 0C, 0D, 0E, 0H, 0I, 0J, 0U	Murray-Krezan, Jeremy, 0A
Chen, Hua-mei, 0C	Nehmetallah, George, 0Q
Chen, Yu, 0U	Nixon, Conor, 0Q
Chen, Zhijiang, 0I	Ofer, Oren, 0R
Choi, Se-Chol, 0P	Pham, Khanh D., 08, 09, 0C, 0E, 0H, 0I, 0J
Cohen, Omer, 0R	Ryan, Kyle J., 03
Cox, Chadwick, 0G	Sarkissian, A., 0S
Cunio, Phillip M., 0B	Savarese, James, 0H
Damé, L., 0S	Schmitt, Henrique R., 04
Datta, Shubhashish, 0K	Seitzer, Patrick, 0A
Delloso, M., 0T	Shamay, Yaron, 0R
El-Osery, Aly I., 0F	Shay, Adi, 0R
Erdelyi, E., 0T	Sheaff, Carolyn, 0D
Esper, Jaime, 0Q	Shen, Dan, 08, 09, 0E, 0J
Farrell, Thomas C., 0L, 0M, 0N, 0O	Smith, Moira I., 02
Ferguson, Frank T., 0Q	Starodubov, D., 0T
Fisher, Eric, 0H	Su, XiaoFeng, 05
Flewelling, Brien., 0B	Sullivan, Nichole, 0C, 0D
Gershon, Gal, 0R	Tian, Xin, 0I
Goldberg, Arnold C., 03	Tran, Dat, 0Q
Gorius, Nicolas, 0Q	Volfson, L., 0T
Greenberg, Jacob M., 03	Wang, Ruichen, 0J
Hauchecorne, A., 0S	Wang, Tao, 0H
Heidinger, Andrew, 03	Wang, YuDu, 05
Hibbitts, Charles, 03	Wang, Zhonghai, 0E, 0H
Hickman, Duncan L., 02	Wedeward, Kevin, 0F
Hong, Jinsuk, 0P	Wei, Sixiao, 0I
Hsieh, Li-Tse, 0I	Wilson, John P., 03
Jenkins, Todd, 0G	Wu, Dong L., 03
Jeon, Yun-Ho, 02	Xiang, Xingyu, 0E, 0H
Jia, Bin, 09, 0C, 0E, 0H	Xu, Ronghua, 0U
Johnson, Natasha M., 0Q	Xu, Yiran, 0J
Joshi, Abhay M., 0K	Yang, Fang, 0D
Keckhut, P., 0S	Yee, Jeng H., 03
Kelly, Michael A., 03	Yi, Meng, 0D
Kim, Sug-Whan, 0P	Zhang, WanYing, 05
Kim, Youngsoo, 0P	Zhu, X., 06
Lee, Haeng-Bok, 0P	

Conference Committee

Symposium Chair

Arthur A. Morrish, Raytheon Space and Airborne Systems
(United States)

Symposium Co-chair

Ruth Moser, Air Force Research Laboratory (United States)

Conference Chairs

Khanh D. Pham, Air Force Research Laboratory (United States)
Genshe Chen, Intelligent Fusion Technology, Inc. (United States)

Conference Program Committee

Trevor J. Bihl, Air Force Institute of Technology (United States)
Erik P. Blasch, Air Force Research Laboratory (United States)
Yu Chen, Binghamton University (United States)
Joseph L. Cox, LinQuest (United States)
Sarah T. Crites, Institute of Space and Astronautical Science (Japan)
Thomas George, SaraniaSat Inc. (United States)
Ping Hagler, Missile Defense Agency (United States)
Richard T. Howard, NASA Marshall Space Flight Center (United States)
Uttam Kumar Majumder, Air Force Research Laboratory
(United States)
Brian K. McComas, Raytheon Missile Systems (United States)
Tien M. Nguyen, The Aerospace Corporation (United States)
Andre Samberg, Sec-Control Finland Ltd. (Finland)
Dan Shen, Intelligent Fusion Technology, Inc. (United States)
Ryan M. Weisman, Air Force Research Laboratory (United States)
Henry Zmuda, University of Florida (United States)

Session Chairs

- 1 Instrument and Sensor Architecture and Design for Space Applications
Henrique R. Schmitt, U.S. Naval Research Laboratory (United States)
- 2 Emerging Systems and Architectures for Space Applications
Yiran Xu, Intelligent Fusion Technology, Inc. (United States)

- 3 Perception and Autonomy for Aerospace Applications
Dan Shen, Intelligent Fusion Technology, Inc. (United States)
- 4 Emerging Concepts for Space Communications
Yu Chen, Binghamton University (United States)
- 5 Optical Detection and Analysis for Free Space Laser Communications
Thomas C. Farrell, Air Force Research Laboratory (United States)
- 6 Space Sensors and Mission Options I
Kevin Meng, Air Force Research Laboratory (United States)
- 7 Space Sensors and Missions Options II
Philip M. Canio, ExoAnalytic Solutions, Inc. (United States)