

PROCEEDINGS OF SPIE

Three-Dimensional Imaging, Visualization, and Display 2018

Bahram Javidi
Jung-Young Son
Osamu Matoba
Manuel Martínez-Corral
Adrian Stern
Editors

16–17 April 2018
Orlando, Florida, United States

Sponsored by
SPIE

Cosponsored by
NHK-ES (Japan)

Published by
SPIE

Volume 10666

Proceedings of SPIE 0277-786X, V. 10666

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

Three-Dimensional Imaging, Visualization, and Display 2018, edited by Bahram Javidi, Jung-Young Son, Osamu Matoba, Manuel Martínez-Corral, Adrian Stern, Proc. of SPIE Vol. 10666, 1066601
© 2018 SPIE · CCC code: 0277-786X/18/\$18 · doi: 10.1117/12.2502394

Proc. of SPIE Vol. 10666 1066601-1

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 *Three-Dimensional Imaging, Visualization, and Display 2018*, edited by Bahram Javidi, Jung-Young Son, Osamu Matoba, Manuel Martínez-Corral, Adrian Stern, Proceedings of SPIE Vol. 10666 (SPIE, Bellingham, WA, 2018) Seven-digit Article CID Number.

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

ISBN: 9781510618435
ISBN: 9781510618442 (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 3D IMAGING

10666 02	Design options for 360 degree viewable table-top digital color holographic displays (Invited Paper) [10666-1]
10666 03	Enhanced 3D performance by biconvex electrowetting lenticular lens structure (Invited Paper) [10666-2]
10666 04	3D TV based on integral photography (Invited Paper) [10666-3]

SESSION 2 3D IMAGE ACQUISITION AND PROCESSING I

10666 07	Ray-space processing for omnidirectional FTV (Invited Paper) [10666-6]
10666 08	Compressive sensing with a block-strategy for fast image acquisitions [10666-7]
10666 09	Privacy-enabled displays [10666-8]
10666 0A	Computational reconstruction technique in integral imaging with enhanced visual quality [10666-9]

SESSION 3 3D VISUALIZATION AND RELATED TECHNOLOGIES

10666 0C	Seeing the sound we hear: optical technologies for visualizing sound wave (Invited Paper) [10666-11]
10666 0D	Optical 3D visualization under inclement weather conditions (Invited Paper) [10666-12]

SESSION 4 3D IMAGE ACQUISITION AND PROCESSING II

10666 0G	Depth and width reproducibility of integral photography from multi-view stereoscopic image (Invited Paper) [10666-14]
10666 0H	Plenoptic imaging techniques for improving accuracy and robustness of object tracking (Invited Paper) [10666-15]

10666 OI **Forming aerial 3D images with smooth motion parallax in combination of arc 3D display with AIRR (Invited Paper)** [10666-16]

10666 OJ **Virtual reality for crime scene visualization** [10666-17]

SESSION 5 DIGITAL HOLOGRAPHY IN METROLOGY AND IMAGING

10666 OK **Digital holography under non paraxial conditions (Keynote Paper)** [10666-18]

10666 OL **Random amplitude or phase modulation for three-dimensional sensing and imaging (Invited Paper)** [10666-19]

10666 OM **Automated quantification of cardiomyocytes beating profile with time-lapse digital holographic microscopy (Invited Paper)** [10666-20]

SESSION 6 HUMAN FACTOR

10666 OP **Monocular depth sense in a light field display (Invited Paper)** [10666-23]

10666 OQ **Microstereopsis is good, but orthostereopsis is better: precision alignment task performance and viewer discomfort with a stereoscopic 3D display** [10666-24]

SESSION 7 3D IMAGE AND RELATED TECHNOLOGY I

10666 OS **Augmented reality integration of fused LiDAR and spatial mapping** [10666-26]

10666 OU **Characterizing three dimensional open cell structures without segmentation** [10666-28]

SESSION 8 3D IMAGE AND RELATED TECHNOLOGY II

10666 OW **3D reconstructions from spectral light fields (Invited Paper)** [10666-30]

10666 OY **High-resolution spatial image display with multiple UHD projectors** [10666-33]

10666 OZ **3D integral microscopy based in far-field detection** [10666-34]

10666 IO **Matching-based depth camera and mirrors for 3D reconstruction (Invited Paper)** [10666-35]

POSTER SESSION

- 10666 11 **Methods of voxel data rendering for visualizing on multi-layer volumetric displays** [10666-36]
- 10666 13 **Three-dimensional object visualization and detection in low light illumination using integral imaging: an overview** [10666-38]
- 10666 14 **Depth estimation of computational reconstruction in integral imaging by considering the pixel blink rate** [10666-39]
- 10666 15 **3D resolution enhancement of integral imaging using resolution priority integral imaging and depth priority integral imaging** [10666-40]
- 10666 16 **Depth resolution enhancement of computational reconstruction of integral imaging** [10666-41]
- 10666 17 **Digital holographic sound imaging for frequency estimation of piezoelectric vibrator** [10666-42]
- 10666 18 **An overview of flexible sensing integral imaging for three-dimensional profilometric reconstruction with occlusion removal** [10666-43]

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.

Arai, J., 04
August, Isaac, 0W
Bae, Dae Hyun, 0H
Barreiro, J. C., 0Z
Burke, David, 0S
Carmona-Ballester, David, 09
Casanova-González, Óscar, 09
Cho, Byeongwoo, 0A, 14, 15, 16
Cho, Myungjin, 0A, 0D, 14, 15, 16
Díaz-García, Lara, 09
Dufresne, Thomas E., 0U
Engström, Philip, 0J
Farber, Vladimir, 0W
Fernández-Valdivia, Juan J., 09
García-Sucerquia, J., 0Z
Gideon, John H., 0U
Gómez-Cárdenes, Óscar, 09
Harrington, Lawrence K., 0Q
Havig, Paul R., 0Q
Heft, Eric, 0Q
Heo, Jae-Pil, 0H
Hernández-Delgado, Ángela, 09
Hong, Keehoon, 02
Huynh, Huu-Hung, 10
Incardona, N., 0Z
Inoue, Kotaro, 0A, 14, 15, 16
Ishikawa, Kenji, 0C
Jaferzadeh, Keyvan, 0M
Javidi, Bahram, 0D, 13, 18
Johnston, Chase, 0S
Kalnins, L., 11
Kandere, U., 11
Kano, Masanori, 04, 0Y
Katayose, Yuta, 0G
Kawai, Kazuki, 0I
Kawakita, Masahiro, 04, 0Y
Kim, Cheoljoong, 03
Kim, Do Hyung, 0H
Kim, Jae Woo, 0H
Kim, Jae-Han, 02
Kim, Jinwoong, 02
Kim, Junoh, 03
Kim, Myungha, 08
Koo, Gyohyun, 03
Kurokawa, Hirokuni, 07
Lee, Beom-Ryeol, 0P
Lee, Hyoung, 0G, 0P
Lee, Junsik, 03
Leportier, Thibault, 08
Lim, Yongjun, 02
Llavador, A., 0Z
Markman, Adam, 13, 18
Marquet, P., 0K
Martinez-Corral, M., 0Z
Matoba, Osamu, 17
McIntire, John P., 0Q
Meunier, Jean, 10
Mishina, Tomoyuki, 04, 0Y
Mizushina, Haruki, 0I
Moon, Inkyu, 0M
Nambiar, Varun, 0S
Nguyen, Trong-Nguyen, 10
Niwa, Hayato, 0C
Noh, Hae Chan, 0H
Nomura, Takanori, 0L
Nurre, Joseph H., 0U
Oikawa, Yasuhiro, 0C
Oiknine, Yaniv, 0W
Okaichi, Naoto, 04, 0Y
Onuma, Takashi, 0C
Osmanis, I., 11
Osmanis, K., 11
Ozols, A., 11
Park, Min-Chul, 08, 0G
Park, Minsik, 02
Piché, M., 0K
Pichette, C., 0K
Rajput, Sudheesh K., 17
Rodríguez-Ramos, José M., 09
Sánchez-Ortiga, E., 0Z
Sasaki, Hisayuki, 04, 0Y
Scrofani, G., 0Z
Selleck, Matthew B., 0S
Selotkin, Vladyslav, 08
Shen, Xin, 13, 18
Shin, Dooseub, 03
Sim, Jee Hoon, 03
Smukulis, R., 11
Sola-Pikabea, J., 0Z
Son, Jung-Young, 08, 0P
Son, Wookho, 0P
Stern, Adrian, 0W
Suyama, Shiro, 0I
Tanimoto, Masayuki, 07
Thibault, S., 0K
Trujillo-Sevilla, Juan M., 09
Valters, G., 11
Walo, Daniel, 09

Watanabe, Hayato, 04, 0Y
Watamaniuk, Scott N. J., 0Q
Won, Yong Hyub, 03
Wright, Steve T., 0Q
Yamamoto, Hirotsugu, 0I
Yano, Sumio, 0G, 0P
Yatabe, Kohei, 0C
Yun, Hui, 0A, 14, 15, 16
Zabels, R., 11

Conference Committee

Symposium Chair

Robert Fiete, Harris Corporation (United States)

Symposium Co-chair

Jay Kumler, JENOPTIK Optical Systems, LLC (United States)

Conference Chairs

Bahram Javidi, University of Connecticut (United States)

Jung-Young Son, Konyang University (Korea, Republic of)

Osamu Matoba, Kobe University (Japan)

Conference Co-chairs

Manuel Martínez-Corral, Universidad de València (Spain)

Adrian Stern, Ben-Gurion University of the Negev (Israel)

Conference Program Committee

Arun Anand, Maharaja Sayajirao University of Baroda (India)

Jun Arai, NHK Japan Broadcasting Corporation (Japan)

V. Michael Bove Jr., MIT Media Laboratory (United States)

Michael T. Eismann, Air Force Research Laboratory (United States)

Pietro Ferraro, Institute of Applied Science & Intelligent Systems (Italy)

Toshiaki Fujii, Nagoya University (Japan)

Hong Hua, College of Optical Sciences, The University of Arizona
(United States)

Yi-Pai Huang, National Chiao Tung University (Taiwan)

Naomi Inoue, National Institute of Information and Communications
Technology (Japan)

Dae-Sik Kim, SAMSUNG Electronics Co., Ltd. (Korea, Republic of)

Jinwoong Kim, Electronics and Telecommunications Research
Institute (Korea, Republic of)

Janusz Konrad, Boston University (United States)

Thomas J. Naughton, National University of Ireland, Maynooth
(Ireland)

Wolfgang Osten, Universität Stuttgart (Germany)

Min-Chul Park, Korea Institute of Science and Technology
(Korea, Republic of)

David J. Rabb, Air Force Research Laboratory (United States)

José Manuel Rodríguez Ramos, Universidad de La Laguna (Spain)

Toralf Scharf, Ecole Polytechnique Fédérale de Lausanne
(Switzerland)
Sumio Yano, Shimane University (Japan)
Zeev Zalevsky, Bar-Ilan University (Israel)

Session Chairs

- 1 3D Imaging
Jung-Young Son, Konyang University (Korea, Republic of)
Bahram Javidi, University of Connecticut (United States)
- 2 3D Image Acquisition and Processing I
Chrysanthe Preza, The University of Memphis (United States)
- 3 3D Visualization and Related Technologies
Osamu Matoba, Kobe University (Japan)
- 4 3D Image Acquisition and Processing II
Adrian Stern, Ben-Gurion University of the Negev (Israel)
- 5 Digital Holography in Metrology and Imaging
Simon Thibault, Université Laval (Canada)
- 6 Human Factor
Jung-Young Son, Konyang University (Korea, Republic of)
- 7 3D Image and Related Technology I
Manuel Martínez-Corral, Universidad de València (Spain)
- 8 3D Image and Related Technology II
Takanori Nomura, Wakayama University (Japan)