

PROCEEDINGS OF SPIE

Three-Dimensional Imaging, Visualization, and Display 2019

**Bahram Javidi
Jung-Young Son
Osamu Matoba**
Editors

**15–16 April 2019
Baltimore, Maryland, United States**

Sponsored by
SPIE

Cosponsored by
NHK-ES (Japan)

Published by
SPIE

Volume 10997

Proceedings of SPIE 0277-786X, V. 10997

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

Three-Dimensional Imaging, Visualization, and Display 2019, edited by Bahram Javidi
Jung-Young Son, Osamu Matoba, Proc. of SPIE Vol. 10997, 1099701 · © 2019
SPIE · CCC code: 0277-786X/19/\$18 · doi: 10.1117/12.2537994

Proc. of SPIE Vol. 10997 1099701-1

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 *Three-Dimensional Imaging, Visualization, and Display 2019*, edited by Bahram Javidi, Jung-Young Son, Osamu Matoba, Proceedings of SPIE Vol. 10997 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

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

ISBN: 9781510626591
ISBN: 9781510626607 (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 \$21.00 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 *Authors*
ix *Conference Committee*

SESSION 1 3D IMAGING AND RELATED TECHNOLOGIES I

- 10997 02 **Compressive sensing with variable density sampling for 3D imaging (Keynote Paper)** [10997-1]
- 10997 03 **3D image processing using deep neural network (Invited Paper)** [10997-2]
- 10997 04 **Sampling requirements for lightfield displays with a large depth of field** [10997-3]
- 10997 05 **Comparison of reconstructed image quality in 3D display using optimized binary phase modulation** [10997-5]
- 10997 06 **Manipulation of material perception with light-field projection (Invited Paper)** [10997-4]

SESSION 2 3D DISPLAYS

- 10997 07 **Aquatic information display and its applications for behavioral biology experiments (Invited Paper)** [10997-6]
- 10997 08 **Aktina vision: full-parallax light field display system with resolution of 330,000 pixels using top-hat diffusing screen** [10997-7]
- 10997 09 **Calibration method applied to a tunable tensor display system** [10997-8]
- 10997 0A **AR optics using two depths (Invited Paper)** [10997-9]

SESSION 3 3D IMAGING AND RELATED TECHNOLOGIES II

- 10997 0B **Reproducibility of depth distance by one-dimensional integral photography (Invited Paper)** [10997-10]
- 10997 0C **Active 3D fluorescence imaging based on holography (Invited Paper)** [10997-11]
- 10997 0E **Accurate and consistent depth estimation for light field camera arrays (Invited Paper)** [10997-13]

SESSION 4 3D IMAGING AND RELATED TECHNOLOGIES III

- 10997 0F **Emulation of three-dimensional vision in plants in the red/far-red region by artificial photosynthesis** [10997-14]
- 10997 0G **Capturing of a light field image and its real-time aerial reconstruction with AIRR** [10997-15]

SESSION 5 DIGITAL/ELECTRO-HOLOGRAPHY AND RELATED I

- 10997 0H **Dedicated computer for computer holography and its future outlook (Invited Paper)** [10997-16]
- 10997 0I **New product development through fusion of hologram technology (Invited Paper)** [10997-17]

SESSION 6 DIGITAL/ELECTRO-HOLOGRAPHY AND RELATED II

- 10997 0J **Marker-free automatic quantification of red blood cell fluctuations with different storage periods by holographic imaging (Invited Paper)** [10997-18]
- 10997 0K **Digital holographic microscopy as a screening technology for diabetes (Invited Paper)** [10997-19]

SESSION 7 DIGITAL/ELECTRO-HOLOGRAPHY AND RELATED III

- 10997 0M **Phase imaging in-line digital holography with random phase modulation (Invited Paper)** [10997-21]

SESSION 8 3D IMAGING AND RELATED TECHNOLOGIES IV

- 10997 0O **FPGA-based phase measuring profilometry system** [10997-23]
- 10997 0P **A HMD with automatic control of interocular distance (Invited Paper)** [10997-24]
- 10997 0Q **3D visualization in multifocus fluorescence microscopy** [10997-25]
- 10997 0R **Extracting sound from flow measured by parallel phase-shifting interferometry using spatio-temporal filter** [10997-26]

POSTER SESSION

- 10997 OS **Overview of automated sickle cell disease diagnosis by analysis of spatio-temporal cell dynamics in digital holographic microscopy [10997-28]**
- 10997 OT **Three-dimensional ghost imaging based on differential optical path [10997-30]**
- 10997 OU **Robust object recognition in 3D scene by stereo vision image processing with the generalized Hough transform [10997-31]**
- 10997 OX **An overview of spatial-temporal human gesture recognition under degraded environments using integral imaging [10997-34]**

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.

Abe, Erina, 07
Alonso, Julia R., 0Q
Amano, Toshiyuki, 06
Anand, Arun, 0S
Andemariam, Biree, 0S
Arocena, Miguel, 0Q
Awatsuji, Yasuhiro, 0C
Bonaque-González, Sergio, 09
Borer, Tim, 04
Cao, Jie, 0T
Carmona-Ballester, David, 09
Díaz-García, Lara, 09
Doblas, Ana, 0K
Fang, Yami, 0T
Fernández, Ariel, 0U
Fujii, Kengo, 0G
Fujii, Toshiaki, 03
García-Sucerquia, Jorge, 0K
Guadalupe-Suárez, Viana L., 09
Hao, Qun, 0T
Hasegawa, Akira, 0B
Heo, Jae-Pil, 0E
Hess, Albrecht, 0O
Horimai, Hideyoshi, 0I
Hwang, Yun Jeong, 0F
Hyun, Sang-Eek, 0E
Ishikawa, Kenji, 0R
Ito, Mitsuru, 0G
Ito, Tomoyoshi, 0H
Iwane, Toru, 0G
Jaferzadeh, Keyvan, 0J
Javidi, Bahram, 02, 0S, 0X
Ju, Byeong-Kwon, 0F
Jung, Hyejin, 0F
Junger, Christina, 0O
Kakue, Takashi, 0H
Kang, Ji-Hoon, 0F
Kano, Masanori, 0B
Kasezawa, Toshihiro, 0I
Kawakita, Masahiro, 0B
Kim, DaeYeon, 0F
Kim, Do Hyung, 0E
Kim, Hee-Seung, 0X
Kim, Jae Woo, 0E
Kim, Jung, 0P
Kim, Minjeong, 0F
Kim, Myungha, 0F
Kim, Sung Kyu, 0A
Komatsu, Satoru, 0X
Kravets, Vladislav, 02
Kumar, Manoj, 0C
Kurosawa, Kento, 05
Kwon, Yong Won, 0A
Lee, Beom-Ryeol, 0P
Lee, Hyoung, 0P
Llaguno, Juan M., 0U
Luo, Qiang, 0T
Marichal-Hernández, Jose G., 09
Markman, Adam, 0S, 0X
Martinez-Corral, Manuel, 0K
Matoba, Osamu, 05, 0C
Moon, Inkyu, 0J
Nakajima, Masao, 0G
Nakayama, Hirotaka, 0H
Nishitsuji, Takashi, 0H
Niitta, Kouichi, 05
Niwa, Hayato, 0R
Nomura, Takanori, 0M
Notni, Gunther, 0O
O'Connor, Timothy, 0S
Oikawa, Yasuhiro, 0R
Okaichi, Naoto, 0B
Oliva-García, Ricardo, 09
Omura, Takuya, 0B
Onuma, Takashi, 0R
Park, Jinwoo, 0F
Park, Min-Chul, 0B, 0F
Quan, Xiangyu, 05, 0C
Rivenson, Yair, 02
Rodríguez-Ramos, Jose M., 09
Rosenberger, Maik, 0O
Saavedra, Genaro, 0K
Sasaki, Hisayuki, 0B
Shen, Xin, 0X
Shim, Sang-Heon, 0E
Shimobaba, Tomoyoshi, 0H
Shimose, Kazuki, 0G
Sicilia-Cabrera, Miguel J., 09
Silva, Alejandro, 0Q
Son, Jung-Young, 0F, 0P
Son, Wook-Ho, 0P
Stern, Adrian, 02
Sugie, Takashige, 0H
Takeuchi, Hideaki, 07
Tanigawa, Risako, 0R
Trujillo-Sevilla, Juan M., 09
Wang, Fei, 0T
Washizu, Shigehiko, 05

Watanabe, Eiji, 07
Watanabe, Hayato, 08
Yamamoto, Hirotsugu, 07, 0G
Yamamoto, Yota, 0H
Yano, Sumio, 0B, 0F
Yasugi, Masaki, 07, 0G
Yatabe, Kohei, 0R
Yoon, Ki-Hyuk, 0A
Zhang, Fanghua, 0T
Zhang, Kaiyu, 0T

Conference Committee

Symposium Chairs

Jay Kumler, JENOPTIK Optical Systems, LLC (United States)
Ruth Moser, Air Force Research Laboratory (United States)

Symposium Co-chair

John Pellegrino, Electro-Optical Systems Laboratory, Georgia Institute of Technology (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 Program Committee

Arun Anand, The 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, Istituto di Scienze Applicate e Sistemi Intelligenti "Eduardo Caianiello" (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 Company, Ltd. (Korea, Republic of)
Jinwoong Kim, Electronics and Telecommunications Research Institute (Korea, Republic of)
Janusz Konrad, Boston University (United States)
Manuel Marínez-Corral, Universitat de València (Spain)
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)

Natan Tzvi Shaked, Tel Aviv University (Israel)

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

Sumio Yano, Shimane University (Japan)

Zeev Zalevsky, Bar-Ilan University (Israel)

Session Chairs

- 1 3D Imaging and Related Technologies I
Bahram Javidi, University of Connecticut (United States)
Jung-Young Son, Konyang University (Korea, Republic of)
- 2 3D Displays
Adrian Stern, Ben-Gurion University of the Negev (Israel)
- 3 3D Imaging and Related Technologies II
Osamu Matoba, Kobe University (Japan)
- 4 3D Imaging and Related Technologies III
Min-Chul Park, Korea Institute of Science and Technology
(Korea, Republic of)
- 5 Digital/Electro-Holography and Related I
Jung-Young Son, Konyang University (Korea, Republic of)
- 6 Digital/Electro-Holography and Related II
Jung-Young Son, Konyang University (Korea, Republic of)
- 7 Digital/Electro-Holography and Related III
Bahram Javidi, University of Connecticut (United States)
- 8 3D Imaging and Related Technologies IV
Osamu Matoba, Kobe University (Japan)