IS&T International Symposium on

Electronic Imaging

SCIENCE AND TECHNOLOGY

26 January 2020 — 30 January 2020 • Burlingame, CA, USA

PROCEEDINGS

Imaging Sensors and Systems 2020

Editors: **Jon S. McElvain**, Dolby Labs., Inc. (United States),
Arnaud Peizerat, Commissariat à l'Énergie Atomique (France),
Nitin Sampat, Edmund Optics (United States),
Ralf Widenhorn, Portland State Univ. (United States)

These papers represent the program of Electronic Imaging 2020,
held 26 January — 30 January 2020, at the Hyatt Regency San Francisco Airport in Burlingame, CA.

Imaging Sensors and Systems 2020

Conference overview

The Imaging Sensors and Systems Conference (ISS) begins with EI 2020, from the merger of the Image Sensors and Imaging Systems Conference and the Photography, Mobile, and Immersive Imaging Conference. Through these conferences, ISS traces its roots to the earlier Digital Photography Conference, which ran for thirteen years.

ISS focuses on image sensing for consumer, industrial, medical, and scientific applications, as well as embedded image processing, and pipeline tuning for these camera systems. This conference will serve to bring together researchers, scientists, and engineers working in these fields, and provides the opportunity for quick publication of their work. Topics can include, but are not limited to, research and applications in image sensors and detectors, camera/sensor characterization, ISP pipelines and tuning, image artifact correction and removal, image reconstruction, color calibration, image enhancement, HDR imaging, light-field imaging, multi-frame processing, computational photography, 3D imaging, 360/cinematic VR cameras, camera image quality evaluation and metrics, novel imaging applications, imaging system design, and deep learning applications in imaging.

Award

Arnaud Darmont Memorial Best Paper Award*

*The Arnaud Darmont Memorial Best Paper Award is given in recognition of IMSE Conference Chair Arnaud Darmont who passed away unexpectedly in September 2018.

Arnaud dedicated his professional life to the computer vision industry. After completing his degree in electronic engineering from the University of Liège in Belgium (2002) he launched his career in the field of CMOS image sensors and high dynamic range imaging, founding APHESA in 2008. He was fiercely dedicated to disseminating knowledge about sensors, computer vision, and custom electronics design of imaging devices as witnessed by his years of teaching courses at the Electronic Imaging Symposium and Photonics West Conference, as well as his authorship of several publications. At the time of his death, Arnaud was in the final stages of revising the second edition of "High Dynamic Range Imaging – Sensors and Architectures", first published in 2013. An active member of the EMVA 1288 standardization group, he was also the standards manager for the organization where he oversaw the development of EMVA standards and fostered cooperation with other imaging associations worldwide on the development and the dissemination of vision standards. His dedication, knowledge, and boundless energy will be missed by the IS&T and Electronic Imaging communities.

Paper authors listed as of 1 January 2020; refer to manuscript for final authors.
Titles that are not listed with the proceedings files were presentation-only.

Conference Chairs: Jon S. McElvain, Dolby Laboratories, Inc. (United States); **Arnaud Peizerat,** Commissariat à l'Énergie Atomique (France); **Nitin Sampat,** Edmund Optics (United States); and **Ralf Widenhorn,** Portland State University (United States)

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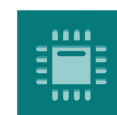
IMAGING SENSORS AND SYSTEMS 2020

Tuesday, January 28, 2020

7:30 – 8:45 am Women in Electronic Imaging Breakfast; pre-regispatration required

Depth Sensing I

Session Chairs: Jon McElvain, Dolby Laboratories (United States) and Arnaud Peizerat, CEA (France)

9:05 – 10:10 am
Regency A

9:05
Conference Welcome

9:10   ISS-103
A 4-tap global shutter pixel with enhanced IR sensitivity for VGA time-of-flight CMOS image sensors, *Taesub Jung, Yonghun Kwon, Sungyoung Seo, Min-Sun Keel, Changkeun Lee, Sung-Ho Choi, Sae-Young Kim, Sunghyuck Cho, Youngchan Kim, Young-Gu Jin, Moosup Lim, Hyunsurk Ryu, Yitae Kim, Joonseok Kim, and Chang-Rok Moon, Samsung Electronics (Republic of Korea)*

9:30   ISS-104
Indirect time-of-flight CMOS image sensor using 4-tap charge-modulation pixels and range-shifting multi-zone technique, *Kamel Mars[1,2], Keita Kondo[1], Michihiro Inoue[1], Shohei Daikoku[1], Masashi Hakamata[1], Keita Yasutomi[1], Keiichiro Kagawa[1], Sung-Wook Jun[3], Yoshiyuki Mineyama[3], Satoshi Aoyama[3], and Shoji Kawahito[1]; [1]Shizuoka University, [2]Tokyo Institute of Technology, and [3]Brookman Technology (Japan)*

9:50   ISS-105
Improving the disparity for depth extraction by decreasing the pixel height in monochrome CMOS image sensor with offset pixel apertures, *Jimin Lee[1], Sang-Hwan Kim[1], Hyeunwoo Kwen[1], Seunghyuk Chang[2], JongHo Park[2], Sang-Jin Lee[2], and Jang-Kyoo Shin[1]; [1]Kyungpook National University and [2]Center for Integrated Smart Sensors, Korea Advanced Institute of Science and Technology (Republic of Korea)*

10:00 am – 7:30 pm Industry Exhibition - Tuesday

10:10 – 10:30 am Coffee Break

KEYNOTE: Sensor Design Technology

Session Chairs: Jon McElvain, Dolby Laboratories (United States) and Arnaud Peizerat, CEA (France)

10:30 – 11:10 am
Regency A

ISS-115
3D-IC smart image sensors, *Laurent Millet[1] and Stephane Chevobbe[2]; [1]CEA/LETI and [2]CEA/LIST (France)*

Biographies and/or abstracts for all keynotes are found on pages 9–14

Sensor Design Technology

Session Chairs: Jon McElvain, Dolby Laboratories (United States) and Arnaud Peizerat, CEA (France)

11:10 am – 12:10 pm
Regency A

11:10   ISS-143
An over 120dB dynamic range linear response single exposure CMOS image sensor with two-stage lateral overflow integration trench capacitors, *Yasuyuki Fujihara, Maasa Murata, Shota Nakayama, Rihito Kuroda, and Shigetoshi Sugawa, Tohoku University (Japan)*

11:30   ISS-144
Planar microlenses for near infrared CMOS image sensors, *Lucie Dilhan[1,2,3], Jérôme Vaillant[1,2], Alain Ostrovsky[3], Lilian Masarotto[1,2], Céline Pichard[1,2], and Romain Paquet[1,2]; [1]University Grenoble Alpes, [2]CEA, and [3]STMicroelectronics (France)*

11:50   ISS-145
Event threshold modulation in dynamic vision spiking imagers for data throughput reduction, *Luis Cubero[1,2], Arnaud Peizerat[1], Dominique Morche[1], and Gilles Sicard[1]; [1]CEA and [2]University Grenoble Alpes (France)*

12:30 – 2:00 pm Lunch

PLENARY: Automotive Imaging

Session Chairs: Radka Tezaur, Intel Corporation (United States), and Jonathan Phillips, Google Inc. (United States)

2:00 – 3:10 pm
Grand Peninsula Ballroom D

Imaging in the Autonomous Vehicle Revolution, *Gary Hicok, senior vice president, hardware development, NVIDIA Corporation (United States)*

For abstract and speaker biography, see page 7

3:10 – 3:30 pm Coffee Break

PANEL: Sensors Technologies for Autonomous Vehicles — Joint Session

Panel Moderator: David Cardinal, Cardinal Photo & Extremetech.com (United States)

3:30 – 5:30 pm
Regency A

This session is jointly sponsored by: Autonomous Vehicles and Machines 2020, and Imaging Sensors and Systems 2020.

Imaging sensors are at the heart of any self-driving car project. However, selecting the right technologies isn't simple. Competitive products span a gamut of capabilities includi ng traditional visible-light cameras, thermal cameras, lidar, and radar. Our session includes experts in all of these areas, and in emerging technologies, who will help us understand the strengths, weaknesses, and future directions of each. Presentations by the speakers listed below will be followed by a panel discussion.

Biographies and/or abstracts are found on pages 15–21

Introduction, *David Cardinal, consultant and technology journalist (United States)*

LiDAR for Self-driving Cars, *Nikhil Naikal, VP of Software Engineering, Velodyne Lidar (United States)*

Challenges in Designing Cameras for Self-driving Cars, *Nicolas Touchard, VP of Marketing, DXOMARK (France)*

Using Thermal Imaging to Help Cars See Better, *Mike Walters, VP of product management for thermal cameras, FLIR Systems, Inc. (United States)*

Radar's Role, *Greg Stanley, field applications engineer, NXP Semiconductors (the Netherlands)*

Tales from the Automotive Sensor Trenches, *Sanjai Kohli, CEO, Visible Sensors, Inc. (United States)*

Auto Sensors for the Future, *Alberto Stochino, founder and CEO, Perceptive (United States)*

5:30 – 7:30 pm Symposium Demonstration Session

Wednesday, January 29, 2020

KEYNOTE: Imaging Systems and Processing — Joint Session

Session Chairs: Kevin Matherson, Microsoft Corporation (United States) and Dietmar Wueller, Image Engineering GmbH & Co. KG (Germany)

8:50 – 9:30 am
Regency A

This session is jointly sponsored by: The Engineering Reality of Virtual Reality 2020, Imaging Sensors and Systems 2020, and Stereoscopic Displays and Applications XXXI.

ISS-189

Mixed reality guided neuronavigation for non-invasive brain stimulation treatment, *Christoph Leuze, research scientist in the Incubator for Medical Mixed and Extended Reality, Stanford University (United States)*

Biographies and/or abstracts for all keynotes are found on pages 9–14

Imaging Systems and Processing I

Session Chairs: Kevin Matherson, Microsoft Corporation (United States) and Dietmar Wueller, Image Engineering GmbH & Co. KG (Germany)

9:30 – 10:10 am
Regency A

9:30   ISS-212
Soft-prototyping imaging systems for oral cancer screening, *Joyce Farrell, Stanford University (United States)*

9:50   ISS-213
Calibration empowered minimalistic multi-exposure image processing technique for camera linear dynamic range extension, *Nabeel Riza and Nazim Ashraf, University College Cork (Ireland)*

10:00 am – 3:30 pm Industry Exhibition - Wednesday

10:10 – 10:30 am Coffee Break

Imaging Systems and Processing II

Session Chairs: Francisco Imai, Apple Inc. (United States) and Nitin Sampat, Edmund Optics, Inc (United States)

10:30 am – 12:50 pm
Regency A

10:30   ISS-225
Anisotropic subsurface scattering acquisition through a light field based apparatus, *Yurii Piadyk, Yitzchak Lockerman, and Claudio Silva, New York University (United States)*

10:50   ISS-226
CAOS smart camera-based robust low contrast image recovery over 90 dB scene linear dynamic range, *Nabeel Riza and Mohsin Mazhar, University College Cork (Ireland)*

11:10   ISS-227

TunnelCam - A HDR spherical camera array for structural integrity assessments of dam interiors, *Dominique Meyer[1], Eric Lo[1], Jonathan Klingspon[1], Anton Netchaev[2], Charles Ellison[2], and Falko Kuester[1]; [1]University of California, San Diego and [2]United States Army Corps of Engineers (United States)*

11:30   ISS-228

Characterization of camera shake, *Henry Dietz, William Davis, and Paul Eberhart, University of Kentucky (United States)*

11:50   ISS-229

Expanding dynamic range in a single-shot image through a sparse grid of low exposure pixels, *Leon Eisemann, Jan Fröhlich, Axel Hartz, and Johannes Maucher, Stuttgart Media University (Germany)*

12:10   ISS-230

Deep image demosaicing for submicron image sensors (JIST-first), *Irina Kim, Seongwook Song, SoonKeun Chang, SukHwan Lim, and Kai Guo, Samsung Electronics (Republic of Korea)*

12:30   ISS-231

Sun tracker sensor for attitude control of space navigation systems, *Antonio De la Calle-Martos[1], Rubén Gómez-Merchán[2], Juan A. Leñero-Bardallo[2], and Angel Rodríguez-Vázquez[1,2]; [1]Teledyne-Anafocus and [2]University of Seville (Spain)*

12:50 – 2:00 pm Lunch

PLENARY: VR/AR Future Technology

Session Chairs: Radka Tezaur, Intel Corporation (United States), and Jonathan Phillips, Google Inc. (United States)

2:00 – 3:10 pm
Grand Peninsula Ballroom D

Quality Screen Time: Leveraging Computational Displays for Spatial Computing, *Douglas Lanman, director, Display Systems Research, Facebook Reality Labs (United States)*

For abstract and speaker biography, see page 7

3:10 – 3:30 pm Coffee Break

Depth Sensing II

Session Chairs: Sergio Goma, Qualcomm Technologies, Inc. (United States) and Radka Tezaur, Intel Corporation (United States)

3:30 – 4:30 pm
Regency A

3:30   ISS-272

A short-pulse based time-of-flight image sensor using 4-tap charge-modulation pixels with accelerated carrier response, *Michihiro Inoue, Shohei Daikoku, Keita Kondo, Akihito Komazawa, Keita Yasutomi, Keiichiro Kagawa, and Shoji Kawahito, Shizuoka University (Japan)*

3:50   ISS-273

Single-shot multi-frequency pulse-TOF depth imaging with sub-clock shifting for multi-path interference separation, *Tomoya Kokado[1], Yu Feng[1], Masaya Horio[1], Keita Yasutomi[1], Shoji Kawahito[1], Takashi Komuro[2], Hajime Ngahara[3], and Keiichiro Kagawa[1]; [1]Shizuoka University, [2]Saitama University, and [3]Institute for Datability Science, Osaka University (Japan)*

4:10   ISS-274

A high-linearity time-of-flight image sensor using a time-domain feedback technique, *Juyeong Kim, Keita Yasutomi, Keiichiro Kagawa, and Shoji Kawahito, Shizuoka University (Japan)*

Imaging Sensors and Systems 2020 Interactive Papers Session

5:30 – 7:00 pm
Sequoia

The following works will be presented at the EI 2020 Symposium Interactive Papers Session.

                                             ISS-327

Camera support for use of unchipped manual lenses, *Henry Dietz, University of Kentucky (United States)*

                                             ISS-328

CIS band noise prediction methodology using co-simulation of camera module, *Euncheol Lee, Hyunsu Jun, Wonho Choi, Kihyun Kwon, Jihyung Lim, Seung-hak Lee, and JoonSeo Yim, Samsung Electronics (Republic of Korea)*

                                             ISS-329

From photons to digital values: A comprehensive simulator for image sensor design, *Alix de Gouvello, Laurent Soulier, and Antoine Dupret, CEA LIST (France)*

                                             ISS-330

Non-uniform integration of TDCI captures, *Paul Eberhart, University of Kentucky (United States)*

5:30 – 7:00 pm EI 2020 Symposium Interactive Posters Session

5:30 – 7:00 pm Meet the Future: A Showcase of Student and Young Professionals Research

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