

IS&T International Symposium on
**Electronic
Imaging**
SCIENCE AND TECHNOLOGY

PROCEEDINGS

13 January 2019 – 17 January 2019 • Burlingame, CA, USA

Image Sensors and Imaging Systems 2019

Editors: **Arnaud Darmont**, (deceased September 2018) APHESA SPRL (Belgium),
Arnaud Peizerat, Commissariat à l'Énergie Atomique (France),
Ralf Widenhorn, Portland State Univ. (United States)

These papers represent the program of Electronic Imaging 2019,
held January 13 – 17, 2019, at the Hyatt Regency San Francisco Airport in Burlingame, CA.

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Image Sensors and Imaging Systems 2019

Conference overview

Solid state optical sensors and solid state cameras have established themselves as the imaging systems of choice for many demanding professional applications such as scientific and industrial applications. The advantages of low-power, low-noise, high-resolution, highgeometric fidelity, broad spectral sensitivity, and extremely high quantum efficiency have led to a number of revolutionary uses.

This conference aims at being a place of exchanges and at giving the opportunity to a quick publication of new works in the areas of solid state detectors, solid state cameras, new optical concepts, and novel applications. To encourage young talent, a best student paper contest is organized.

Award (jointly with the PMII conference)

Arnaud Darmont Best Paper Award*

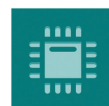
*The Arnaud Darmont Best Paper Award is given in recognition of IMSE Conference Chair Arnaud Darmont who passed away unexpectedly in September 2018.

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.

Conference Chairs: Arnaud Darmont, APHESA SPRL (Belgium), Arnaud Peizerat, Commissariat à l'Énergie Atomique (France); and Ralf Widenhorn, Portland State University (United States)

Program Committee: Nick Bulitka, Lumenera Corp. (Canada); Calvin Chao, Taiwan Semiconductor Manufacturing Company (Taiwan); Glenn H. Chapman, Simon Fraser University (Canada); Tobin Delbrück, Institute of Neuroinformatics, University of Zurich and ETH Zurich (Switzerland); James A. DiBella, Imperx (United States); Antoine Dupret, Commissariat à l'Énergie Atomique (France); Boyd A. Fowler, OminVision Technologies, Inc. (United States); Eiichi Funatsu, OmniVision Technologies, Inc. (United States); Rihito Kuroda, Tohoku University (Japan); Kevin J. Matherson, Microsoft Corp. (United States); Min-Woong Seo, Samsung Electronics, Semiconductor R&D Center (Republic of Korea); Gilles Sicard, Commissariat à l'Énergie Atomique (France); Nobukazu Teranishi, University of Hyogo (Japan); Jean-Michel Tualle, University Paris 13 (France); Orly Yadid-Pecht, University of Calgary (Canada); and Xinyang Wang, GPIXEL (China)

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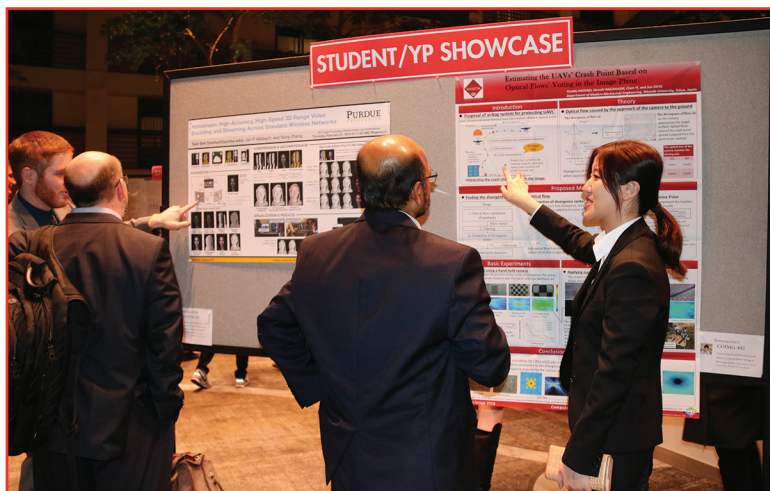


IMAGE SENSORS AND IMAGING SYSTEMS 2019

Monday, January 14, 2019

10:10 – 11:00 am Coffee Break

12:30 – 2:00 pm Lunch

Monday Plenary

2:00 – 3:00 pm

Grand Peninsula Ballroom D

Autonomous Driving Technology and the OrCam MyEye, Amnon Shashua, President and CEO, Mobileye, an Intel Company, and senior vice president, Intel Corporation (United States)

The field of transportation is undergoing a seismic change with the coming introduction of autonomous driving. The technologies required to enable computer driven cars involves the latest cutting edge artificial intelligence algorithms along three major thrusts: Sensing, Planning and Mapping. Shashua will describe the challenges and the kind of computer vision and machine learning algorithms involved, but will do that through the perspective of Mobileye's activity in this domain. He will then describe how OrCam leverages computer vision, situation awareness and language processing to enable blind and visually impaired to interact with the world through a miniature wearable device.

Prof. Amnon Shashua holds the Sachs chair in computer science at the Hebrew University of Jerusalem. His field of expertise is computer vision and machine learning. Shashua has founded three startups in the computer vision and machine learning fields. In 1995 he founded CogniTens that specializes in the area of industrial metrology and is today a division of the Swedish Corporation Hexagon. In 1999 he cofounded Mobileye with his partner Ziv Aviram. Mobileye develops system-on-chips and computer vision algorithms for driving assistance systems and is developing a platform for autonomous driving to be launched in 2021. Today, approximately 32 million cars rely on Mobileye technology to make their vehicles safer to drive. In August 2014, Mobileye claimed the title for largest Israeli IPO ever, by raising \$1B at a market cap of \$5.3B. In August 2017, Mobileye became an Intel company in the largest Israeli acquisition deal ever of \$15.3B. Today, Shashua is the president and CEO of Mobileye and a senior vice president of Intel Corporation. In 2010 Shashua co-founded OrCam which harnesses computer vision and artificial intelligence to assist people who are visually impaired or blind.

3:00 – 3:30 pm Coffee Break

Panel: Sensing and Perceiving for Autonomous Driving

JOINT SESSION

3:30 – 5:30 pm

Grand Peninsula Ballroom D

This session is jointly sponsored by the EI Steering Committee.

Moderator: Dr. Wende Zhang, technical fellow, General Motors

Panelists:

Dr. Amnon Shashua, professor of computer science, Hebrew University; president and CEO, Mobileye, an Intel Company, and senior vice president, Intel Corporation

Dr. Boyd Fowler, CTO, OmniVision Technologies

Dr. Christoph Schroeder, head of autonomous driving N.A., Mercedes-Benz R&D Development North America, Inc.

Dr. Jun Pei, CEO and co-founder, Cepton Technologies Inc

Driver assistance and autonomous driving rely on perceptual systems that combine data from many different sensors, including camera, ultrasound, radar and lidar. The panelists will discuss the strengths and limitations of different types of sensors and how the data from these sensors can be effectively combined to enable autonomous driving.

5:00 – 6:00 pm All-Conference Welcome Reception

Wednesday January 16, 2019

Medical Imaging - Camera Systems

JOINT SESSION

Session Chairs: Jon McElvain, Dolby Laboratories (United States) and Ralf Widenhorn, Portland State University (United States)

8:50 – 10:30 am

Grand Peninsula Ballroom D

This medical imaging session is jointly sponsored by: Image Sensors and Imaging Systems 2019, and Photography, Mobile, and Immersive Imaging 2019.

8:50

PMII-350

Plenoptic medical cameras (Invited), Liang Gao, University of Illinois Urbana-Champaign (United States)

9:10

PMII-351

Simulating a multispectral imaging system for oral cancer screening (Invited), Joyce Farrell, Stanford University (United States)

9:30

PMII-352

Imaging the body with miniature cameras, towards portable healthcare (Invited), Ofer Levi, University of Toronto (Canada)

9:50

PMII-353

Self-calibrated surface acquisition for integrated positioning verification in medical applications, Sven Jörissen¹, Michael Bleier², and Andreas Nüchter¹; ¹University of Wuerzburg and ²Zentrum für Telematik e.V. (Germany)

10:10

IMSE-354

Measurement and suppression of multipath effect in time-of-flight depth imaging for endoscopic applications, Ryota Miyagi¹, Yuta Murakami¹, Keiichiro Kagawa¹, Hajime Ngahara², Kenji Kawashima³, Keita Yasutomi¹, and Shoji Kawahito¹; ¹Shizuoka University, ²Osaka University, and ³Tokyo Medical and Dental University (Japan)

10:00 am – 3:30 pm Industry Exhibition

10:10 – 10:50 am Coffee Break

Automotive Image Sensing I

JOINT SESSION

Session Chairs: Kevin Matherson, Microsoft Corporation (United States); Arnaud Peizerat, CEA (France); and Peter van Beek, Intel Corporation (United States)

10:50 am – 12:10 pm

Grand Peninsula Ballroom D

This session is jointly sponsored by: Autonomous Vehicles and Machines 2019, Image Sensors and Imaging Systems 2019, and Photography, Mobile, and Immersive Imaging 2019.

10:50

IMSE-050

KEYNOTE: Recent trends in the image sensing technologies, Vladimir Koifman, Analog Value Ltd. (Israel)

Vladimir Koifman is a founder and CTO of Analog Value Ltd. Prior to that, he was co-founder of Advasense Inc., acquired by Pixim/Sony Image Sensor Division. Prior to co-founding Advasense, Koifman co-established the AMCC analog design center in Israel and led the analog design group for three years. Before AMCC, Koifman worked for 10 years in Motorola Semiconductor Israel (Freescale) managing an analog design group. He has more than 20 years of experience in VLSI industry and has technical leadership in analog chip design, mixed signal chip/system architecture and electro-optic device development. Koifman has more than 80 granted patents and several papers. Koifman also maintains Image Sensors World blog.

11:30

AVM-051

KEYNOTE: Solid-state LiDAR sensors: The future of autonomous vehicles, Louay Eldada, Quanergy Systems, Inc. (United States)

Louay Eldada is CEO and co-founder of Quanergy Systems, Inc. Eldada is a serial entrepreneur, having founded and sold three businesses to Fortune 100 companies. Quanergy is his fourth startup. Eldada is a technical business leader with a proven track record at both small and large companies and with 71 patents, is a recognized expert in quantum optics, nanotechnology, photonic integrated circuits, advanced optoelectronics, sensors and robotics. Prior to Quanergy, he was CSO of SunEdison, after serving as CTO of HelioVolt, which was acquired by SK Energy. Eldada was earlier CTO of DuPont Photonic Technologies, formed by the acquisition of Telephotonics where he was founding CTO. His first job was at Honeywell, where he started the Telecom Photonics business and sold it to Corning. He studied business administration at Harvard, MIT and Stanford, and holds a PhD in optical engineering from Columbia University.

Automotive Image Sensing II

JOINT SESSION

Session Chairs: Kevin Matherson, Microsoft Corporation (United States); Arnaud Peizerat, CEA (France); and Peter van Beek, Intel Corporation (United States)

12:10 – 12:50 pm

Grand Peninsula Ballroom D

This session is jointly sponsored by: Autonomous Vehicles and Machines 2019, Image Sensors and Imaging Systems 2019, and Photography, Mobile, and Immersive Imaging 2019.

12:10

PMI-052

Driving, the future – The automotive imaging revolution (Invited), Patrick Denny, Valeo (Ireland)

12:30

AVM-053

A system for generating complex physically accurate sensor images for automotive applications, Zhenyi Liu^{1,2}, Minghao Shen¹, Jiaqi Zhang³, Shuangting Liu³, Henryk Blasinski², Trisha Lian², and Brian Wandell²; ¹Jilin University (China), ²Stanford University (United States), and ³Beihang University (China)

12:50 – 2:00 pm Lunch

Wednesday Plenary

2:00 – 3:00 pm

Grand Peninsula Ballroom D

Light Fields and Light Stages for Photoreal Movies, Games, and Virtual Reality, Paul Debevec, senior scientist, Google (United States)

Paul Debevec will discuss the technology and production processes behind “Welcome to Light Fields”, the first downloadable virtual reality experience based on light field capture techniques which allow the visual appearance of an explorable volume of space to be recorded and reprojected photorealistically in VR enabling full 6DOF head movement. The lightfields technique differs from conventional approaches such as 3D modelling and photogrammetry. Debevec will discuss the theory and application of the technique. Debevec will also discuss the Light Stage computational illumination and facial scanning systems which use geodesic spheres of inward-pointing LED lights as have been used to create digital actor effects in movies such as Avatar, Benjamin Button, and Gravity, and have recently been used to create photoreal digital actors based on real people in movies such as Furious 7, Blade Runner: 2049, and Ready Player One. The lighting reproduction process of light stages allows omnidirectional lighting environments captured from the real world to be accurately reproduced in a studio, and has recently be extended with multispectral capabilities to enable LED lighting to accurately mimic the color rendition properties of daylight, incandescent, and mixed lighting environments. They have also recently used their full-body light stage in conjunction with natural language processing and automultiscopic video projection to record and project interactive conversations with survivors of the World War II Holocaust.

Paul Debevec is a senior scientist at Google VR, a member of Google VR’s Daydream team, and adjunct research professor of computer science in the Viterbi School of Engineering at the University of Southern California, working within the Vision and Graphics Laboratory at the USC Institute for Creative Technologies. Debevec’s computer graphics research has been recognized with ACM SIGGRAPH’s first Significant New Researcher Award (2001) for “Creative and Innovative Work in the Field of Image-Based Modeling and Rendering”, a Scientific and Engineering Academy Award (2010) for “the design and engineering of the Light Stage capture devices and the image-based facial rendering system developed for character relighting in motion pictures” with Tim Hawkins, John Monos, and Mark Sagar, and the SMPTE Progress Medal (2017) in recognition of his achievements and ongoing work in pioneering techniques for illuminating computer-generated objects based on measurement of real-world illumination and their effective commercial application in numerous Hollywood films. In 2014, he was profiled in The New Yorker magazine’s “Pixel Perfect: The Scientist Behind the Digital Cloning of Actors” article by Margaret Talbot.

3:00 – 3:30 pm Coffee Break

Depth Sensing

Session Chair: Min-Woong Seo, Samsung Electronics (Republic of Korea)

3:30 – 4:50 pm

Regency C

3:30 IMSE-355

Measurement of disparity for depth extraction in monochrome CMOS image sensor with offset pixel apertures, Jimin Lee¹, Byoung-Soo Choi¹, Seunghyuk Chang², JongHo Park², SangJin Lee², and Jang-Kyoo Shin¹; ¹Kyungpook National University and ²Center for Integrated Smart Sensors (Republic of Korea)

3:50 IMSE-356

A range-shifting multi-zone time-of-flight measurement technique using a 4-tap lock-in-pixel CMOS range image sensor based on a built-in drift field photodiode, Keita Kondo¹, Keita Yasutomi¹, Kohei Yamada¹, Akito Komazawa¹, Yukitaro Handa¹, Yushi Okura¹, Tomoya Michiba¹, Satoshi Aoyama², and Shoji Kawahito^{1,2}; ¹Shizuoka University and ²Brookman Technology Inc. (Japan)

4:10 IMSE-357

A range-gated CMOS SPAD array for real-time 3D range imaging, Henna Ruokamo, Lauri Hallman, and Juha Kostamovaara, University of Oulu (Finland)

4:30 IMSE-358

3D scanning measurement using a time-of-flight range imager with improved range resolution, Yushi Okura, Keita Yasutomi, Taishi Takasawa, Keiichiro Kagawa, and Shoji Kawahito, Shizuoka University (Japan)

Image Sensors and Imaging Systems 2019 Interactive Posters Session

5:30 – 7:00 pm

The Grove

The following works will be presented at the EI 2019 Symposium Interactive Papers Session.

IMSE-359

How hot pixel defect rate growth from pixel size shrinkage creates image degradation, Glenn Chapman¹, Rohan Thomas¹, Klinsmann Meneses¹, Israel Koren², and Zahava Koren²; ¹Simon Fraser University (Canada) and ²University of Massachusetts Amherst (United States)

IMSE-360

Hybrid image-based defect detection for railroad maintenance, Gaurang Gavai, PARC (United States)

IMSE-361

Real time enhancement of low light images for low cost embedded platforms, Navinprashath R R, Radhesh Bhat, Narendra Kumar Chepuri, Tom Korah Manalody, and Dipanjan Ghosh, PathPartner Technology Pvt. Ltd. (India)

IMSE-362

Spline-based colour correction for monotonic nonlinear CMOS image sensors, Syed Hussain and Dileepan Joseph, University of Alberta (Canada)

IMSE-363

System-on-Chip design flow for the image signal processor of a nonlinear CMOS imaging system, Maikon Nascimento and Dileepan Joseph, University of Alberta (Canada)

Thursday January 17, 2019

Technology and Sensor Design I

Session Chair: Arnaud Peizerat, CEA (France)

8:50 – 9:30 pm

Regency C

IMSE-364

KEYNOTE: How CIS pixels moved from standard CMOS process to semiconductor process flavors even more dedicated than CCD ever was, Martin Waeny, TechnologiesMWV (Switzerland)

Martin Waeny graduated in microelectronics from IMT Neuchâtel (1997). In 1998 he worked on CMOS image sensors at IMEC. In 1999 he joined the CSEM, as a PhD student in the field of digital CMOS image sensors. In 2000 he won the Vision prize for the invention of the LINLOG Technology and in 2001 the Photonics circle of excellence award of SPIE. In 2001 he co-founded the Photonfocus AG. In 2004 he founded AVAIBA Lda, a design-house and supplier for specialty area and linescan image sensors and miniature wafer level camera modules for medical endoscopy. AVAIBA merged 2014 into CMOSIS (www_cmosis.com) and 2015 in AMS (www_ams.com). At AMS, Waeny served as member of the CIS technology office and acted as director of marketing for the micro camera modules. Since 2017 he has been CEO of TechnologiesMWV, an independent consulting company. Waeny was a member of the founding board of EMVA the European machine vision association and the 1288 vision standard working group. His research interests are in miniaturized optoelectronic modules and application systems of such modules, 2D and 3D imaging and image sensors and use of computer vision in emerging application areas.

Technology and Sensor Design II

Session Chair: Arnaud Peizerat, CEA (France)

9:30 – 10:10 am

Regency C

9:30

IMSE-365

On the implementation of asynchronous sun sensors, Juan A. Leñero-Bardallo¹, Ricardo Carmona-Galán², and Angel Rodríguez-Vázquez^{2,4}; ¹University of Oslo (Norway), ²Seville Institute of Microelectronics (Spain), ³University of Seville (Spain), and ⁴AnaFocus-e2v (Spain)

9:50

IMSE-366

A low-noise nondestructive-readout pixel for computational imaging, Takuya Nabeshima¹, Keita Yasutomi¹, Keiichiro Kagawa¹, Hajime Ngahara², Taishi Takasawa¹, and Shoji Kawahito¹; ¹Shizuoka University and ²Osaka University (Japan)

10:10 – 10:40 am Coffee Break

Image Sensor Noise

Session Chair: Ralf Widenhorn, Portland State University (United States)

10:40 – 11:40 am

Regency C

10:40

IMSE-367

Noise suppression effect of folding-integration applied to a column-parallel 3-stage pipeline ADC in a 2.1µm 33-megapixel CMOS image sensor, Kohei Tomioka¹, Toshio Yasue¹, Ryohei Funatsu¹, Tomoki Matsubara¹, Tomohiko Kosugi², Sung-Wook Jun², Takashi Watanabe^{2,3}, Masanori Nagase², Toshiaki Kitajima², Satoshi Aoyama², and Shoji Kawahito^{2,3}; ¹Japan Broadcasting Corporation (NHK), ²Brookman Technology, and ³Shizuoka University (Japan)

11:00

IMSE-368

Correlated Multiple Sampling impact analysis on 1/f^β noise for image sensors, Arnaud Peizerat, CEA (France)

11:20

IMSE-369

A comparison between noise reduction & analysis techniques for RTS pixels, Benjamin Hendrickson, Ralf Widenhorn, Marley Blouke, and Erik Bodegom, Portland State University (United States)

Color and Spectral Imaging

Session Chair: Ralf Widenhorn, Portland State University (United States)

11:40 am – 12:20 pm

Regency C

IMSE-370

KEYNOTE: The new effort for hyperspectral standardization - IEEE P4001, Christopher Durell, Labsphere, Inc. (United States)

Christopher Durell holds a BSEE and an MBA and has worked for Labsphere, Inc. in many executive capacities. He is currently leading Business Development for Remote Sensing Technology. He has lead product development efforts in optical systems, light measurement and remote sensing systems for more than two decades. He is a member of SPIE, IEEE, IES, ASTM, CIE, CORM, and ICDM and is a participant in CEOS/IVOS, QA4EO and other remote sensing groups. As of early 2018, Durell accepted the chair position on the new IEEE P4001 Hyperspectral Standards Working Group.

Color and Image Sensing

Session Chair: Ralf Widenhorn, Portland State University (United States)

12:20 – 12:40 pm

Regency C

IMSE-371

Method for the optimal approximation of the spectral response of multicomponent image, Pierre Gouton, Jacques Matanga, and Eric Bourillot, Université de Bourgogne (France)

12:40 – 2:10 pm Lunch

Embedded Image Signal Processing

Session Chair: Nick Bulitka, Lumenera Corporation (Canada)

2:10 – 2:50 pm

Regency C

2:10 IMSE-372
Digital circuit methods to correct and filter noise of nonlinear CMOS image sensors (JIST-first), *Maikon Nascimento, Jing Li, and Dileepan Joseph, University of Alberta (Canada)*

2:30 IMSE-373
Auto white balance stabilization in digital video, *Niloufar Pourian and Rastislav Lukac, Intel Corporation (United States)*

Novel Vision Techniques and Applications

Session Chair: Nick Bulitka, Lumenera Corporation (Canada)

2:50 – 3:30 pm

Regency C

2:50 IMSE-374
Fish-eye camera calibration using horizontal and vertical laser planes projected from a laser level, *Tai Yen-Chou, Yu-Hsiang Chiu, Jen-Hui Chuang, Yi-Yu Hsieh, and Yong-Sheng Chen, National Chiao Tung University (Taiwan)*

3:10 IMSE-375
Focused light field camera for depth reconstruction model, *Piotr Osinski, Robert Sitnik, and Marcin Malesa, Warsaw University of Technology (Poland)*

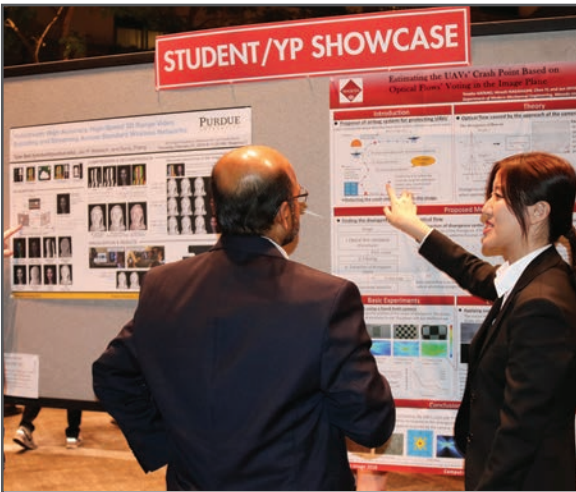
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