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Electronic Imaging

SCIENCE AND TECHNOLOGY

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PROCEEDINGS

Digital Photography and Mobile Imaging XIII

Editors: Zhen He, Intel Corp. (United States)
Feng Li, GoPro Inc. (United States)
Jon S. McElvain, Dolby Labs., Inc. (United States)

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Digital Photography and Mobile Imaging XIII

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Michael Wang, Intel Corporation (United States)

Dietmar Wueller, Image Engineering GmbH & Co. KG (Germany)

Zhan Yu, Univ. of Delaware (United States)

Monday January 30, 2017

Camera Arrays and RGB-D Imaging Algorithms

Session Chairs: Francisco Imai, Canon U.S.A. Inc., and Kevin Matherson, Microsoft Corporation (United States)

8:50 – 10:10 AM

Grand Peninsula Ballroom A

8:50 **Stabilized high-speed video from camera arrays**, *Maha El Choubassi and Oscar Nestares, Intel Corporation (United States)* [DPMI-063]

9:10 **Panoramic background estimation from RGB-D videos**, *Christos Bampis¹, Gowri Somanath², Oscar Nestares², and Jijie Yao³; ¹The University of Texas at Austin (United States), ²Intel Labs, Intel Corporation (United States), and ³Intel Corporation (China)* [DPMI-064]

9:30 **Accurate measurement of point to point distances in 3D camera images**, *Kalpna Seshadrinathan, Oscar Nestares, and Yi Wu, Intel Corporation (United States)* [DPMI-065]

9:50 **A novel framework for fast MRF optimization**, *Gowri Somanath¹, Jijie Yao², and Yong Jiang², ¹Intel Corporation (United States) and ²Intel Corporation (China)* [DPMI-066]

10:10 – 10:50 AM Coffee Break

KEYNOTE: Accelerated Computational Tools

Session Chair: Michael Kriss, MAK Consultants (United States)

10:50 – 11:30 AM

Grand Peninsula Ballroom A

Heterogeneous computational imaging, *Kari Pulli, Intel Corporation (United States)* [DPMI-067]
Kari Pulli is a Senior Principal Engineer at Intel Corporation, working as the CTO of the Imaging and Camera Technologies Group. He has a long history in Computational Photography, Computer Vision, and Computer Graphics (earlier jobs include VP of Computational Imaging at Light, Sr. Director at NVIDIA Research, Nokia Fellow), with numerous publications (h-index = 30). Pulli has a PhD from the University of Washington, Seattle. He has also been a researcher / lecturer at Stanford, MIT, and University of Oulu. He has contributed to many multimedia standards at the Khronos Group, including OpenVX, and is a regular speaker and contributor at SIGGRAPH, CVPR, and many other conferences.

Emerging Architectures and Systems

Session Chair: Michael Kriss, MAK Consultants (United States)

11:30 AM – 12:30 PM

Grand Peninsula Ballroom A

11:30 **Is there a multi-camera future? (Invited)**, *Timothy Macmillan, Consultant (United States)* [DPMI-068]

11:50

Capturing light field video for 6-DOF VR playback (Invited), *William Jiang, Lytro Inc. (United States)* [DPMI-069]

12:10

Representation and compression for cinematic VR (Invited), *Hari Lakshman, Dolby Labs (United States)* [DPMI-070]

12:30 – 2:00 PM Lunch Break

El 2017 Opening Plenary and Symposium Awards

Session Chairs: Joyce E. Farrell, Stanford University, and Nitin Sampat, Rochester Institute of Technology (United States)

2:00 – 3:00 PM

Grand Peninsula Ballroom D

Giga-scale 3D computational microscopy, *Laura Waller, University of California, Berkeley (United States)*

Laura Waller is the Ted Van Duzer Endowed Assistant Professor of Electrical Engineering and Computer Sciences (EECS) at UC Berkeley. She is a Senior Fellow at the Berkeley Institute of Data Science, and received her BS (2004), MEng (2005), and PhD (2010) in EECS from the Massachusetts Institute of Technology (MIT). Waller's talk is on computational imaging methods for fast capture of gigapixel-scale 3D intensity and phase images in a commercial microscope that employs illumination-side and detection-side coding of angle (Fourier) space with simple hardware and fast acquisition. The result is high-resolution reconstructions across a large field-of-view, achieving high space-bandwidth-time product.

3:00 – 3:30 PM Coffee Break

Imaging System Assessment

Session Chairs: Joyce Farrell, Stanford University, and Bo Mu, BAE Systems Imaging Solutions (United States)

3:30 – 4:50 PM

Grand Peninsula Ballroom A

3:30

Quantifying the luminance ratio of interior and exterior scenes: Challenges and tradeoffs in definitions, current standards, measurement methodologies and instrumentation, capturing capabilities of digital cameras, effects of veiling glare, *Fernando Voltolini de Azambuja, Nitin Sampat, and Stephen Viggiano, Rochester Institute of Technology (United States)* [DPMI-071]

3:50

Sensitivity analysis applied to ISO recommended camera color calibration methods to determine how much of an advantage, if any, does spectral characterization of the camera offer over the chart-based approach, *Keith Borrino¹, Fernando Voltolini de Azambuja², Nitin Sampat², and J.A. Stephen Viggiano², ¹GoPro, Inc., ²Rochester Institute of Technology (United States)* [DPMI-072]

4:10

Perceptual optimization driven by image quality metrics (Invited), *Zhou Wang, University of Waterloo (Canada)* [DPMI-073]

4:30

Looming challenges in mobile imaging quality: New technologies and new markets (Invited), David Cardinal, Cardinal Photo & Extremetech.com (United States) [DPMI-074]

5:00 – 6:00 PM All-Conference Welcome Reception, Atrium

Tuesday January 31, 2017

KEYNOTE: Mobile Device Camera IQ Joint Session

Session Chairs: Susan Farnand, Rochester Institute of Technology, and Jackson Roland, Apple Inc. (United States)

8:50 – 9:20 AM

Grand Peninsula Ballroom A

This session is jointly sponsored by: Image Quality and System Performance XIV and Digital Photography and Mobile Imaging XIII.

Towards the development of the IEEE P1858 CPIQ standard – A validation study, Elaine Jin¹, Jonathan Phillips¹, Susan Farnand², Margaret Belska³, Vinh Tran³, Ed Chang¹, Yixuan Wang³, and Benjamin Tseng⁴; ¹Google Inc. (United States), ²Rochester Institute of Technology (United States), ³NVIDIA (United States), and ⁴Apkudo (Australia) [IQSP-249]

Elaine W. Jin holds a PhD in optical engineering from Zhejiang University in China, and a PhD in psychology from the University of Chicago. She has worked in the imaging industry for 15+ years including employment at Polaroid Corporation, Eastman Kodak Company, Micron Technologies, Aptina Imaging, Marvell Semiconductors, and Intel Corporation. She currently is a staff image scientist at Google, working on developing cutting-edge consumer hardware products. Her primary research interests include imaging systems design and analysis, color imaging, and psychophysics. She has published 22 journal and conference papers, and authored 14 US patents / patent applications. She joined the CPIQ initiative (Camera Phone Image Quality) in 2006, and since then has made major contributions in the development of the softcopy quality ruler method, and the CPIQ metrics for visual noise, texture blur, spatial frequency responses, chroma level, and color uniformity. She currently leads the Color/Tone Subgroup of the IEEE CPIQ Standard Working Group.

Mobile Device Camera IQ Joint Session

Session Chairs: Susan Farnand, Rochester Institute of Technology, and Jackson Roland, Apple Inc. (United States)

9:20 – 10:20 AM

Grand Peninsula Ballroom A

This session is jointly sponsored by: Image Quality and System Performance XIV and Digital Photography and Mobile Imaging XIII.

9:20

A methodology for perceptual image quality assessment of smartphone cameras – Color quality, Susan Farnand, Rochester Institute of Technology (United States) [IQSP-250]

9:40

Assessing the ability of simulated laboratory scenes to predict the image quality performance of HDR captures (and rendering) of exterior scenes using mobile phone cameras, Amelia Spooner¹, Ashley Solter¹, Fernando Voltolini de Azambuja¹, Nitin Sampat¹, Stephen Viggiano¹, Brian Rodricks², and Cheng Lu³; ¹Rochester Institute of Technology, ²SensorSpace, LLC, and ³Intel Corporation (United States) [IQSP-251]

10:00

Cell phone camera “rankings”¹, Dietmar Wueller, Image Engineering GmbH & Co. KG (Germany) [DPMI-252]

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10:00 AM – 7:30 PM Industry Exhibition

10:20 – 10:50 AM Coffee Break

MTF Joint Session

Session Chairs: Peter Burns, Burns Digital Imaging, and Feng Li, GoPro Inc. (United States)

10:50 AM – 12:30 PM

Grand Peninsula Ballroom A

This session is jointly sponsored by: Image Quality and System Performance XIV and Digital Photography and Mobile Imaging XIII.

10:50

Characterization of entire imaging plane spatial frequency response, Victor Lenchenkov, Orit Skorka, Stan Micinski, and Radu Ispasoiu, ON Semiconductor (United States) [IQSP-253]

11:10

Reverse-projection method for measuring camera MTF, Stan Birchfield, Microsoft Corporation (United States) [IQSP-254]

11:30

Texture MTF from images of natural scenes, Riccardo Branca¹, Sophie Triantaphillidou¹, and Peter Burns²; ¹University of Westminster (United Kingdom) and ²Burns Digital Imaging (United States) [IQSP-255]

11:50

Camera phone texture preservation measurements with modulation transfer function: An alternative approach for noise estimation of random texture chart images, Nitin Suresh^{1,2}, Joshua Pfefer¹, and Quanzeng Wang¹; ¹U.S. Food and Drug Administration and ²University of Maryland (United States) [DPMI-256]

12:10

The effects of misregistration on the dead leaves cross-correlation texture blur analysis, Ranga Burada¹, Robert Sumner¹, and Noah Kram²; ¹Imatest, LLC and ²Rochester Institute of Technology (United States) [IQSP-257]

12:30 – 2:00 PM Lunch Break

EI 2017 Tuesday Plenary and Symposium Awards

Session Chairs: Joyce E. Farrell, Stanford University, and Nitin Sampat, Rochester Institute of Technology (United States)

2:00 – 3:00 PM

Grand Peninsula Ballroom D

VR 2.0: Making virtual reality better than reality, *Gordon Wetzstein, Stanford University (United States)*

Gordon Wetzstein is an Assistant Professor of Electrical Engineering and, by courtesy, of Computer Science, at Stanford University, and leads the Stanford Computational Imaging Group. He received a PhD in computer science from the University of British Columbia (2011) where his doctoral dissertation focused on computational light modulation for image acquisition and display. In his talk, Wetzstein explores the frontiers of VR systems engineering. Eventually, VR/AR systems will redefine communication, entertainment, education, collaborative work, simulation, training, telesurgery, and basic vision research, as next-generation computational near-eye displays evolve to deliver visual experiences that are better than the real world.

3:00 – 3:30 PM Coffee Break

Image Interpolation, Restoration, and Denoising Joint Session

Session Chairs: Karen Egiazarian, Tampere University of Technology (Finland), and Radka Tezaur, Intel Corporation (United States)

3:30 – 5:30 PM

Grand Peninsula Ballroom A

This session is jointly sponsored by: Digital Photography and Mobile Imaging XIII and Image Processing: Algorithms and Systems XV.

3:30

BM3D-HVS: Content-adaptive denoising for improved visual quality (Invited), *Karen Egiazarian^{1,2}, Aram Danielyan², Nikolay Ponomarenko^{1,2}, Alessandro Foi^{1,2}, Oleg Jeremeiev³, and Vladimir Lukin³; ¹Tampere University of Technology (Finland), ²Noiseless Imaging Oy (Finland), and ³National Aerospace University (Ukraine) [DPMI-083]*

3:50

Refining raw pixel values using a value error model to drive texture synthesis, *Henry Dietz, University of Kentucky (United States) [IPAS-084]*

4:10

Color interpolation based on colorization for RGB-white color filter array, *Paul Oh¹, Sukho Lee², and Moon Gi Kang¹; ¹Yonsei University and ²Dongseo University (Republic of Korea) [IPAS-085]*

4:30

Video frame synthesizing method for HDR video capturing system with four image sensors, *Takayuki Yamashita^{1,2} and Yoshihiro Fujita¹; ¹Ehime University and ²NHK (Japan) [IPAS-086]*

4:50

Robust defect pixel detection and correction for Bayer Imaging Systems, *Noha El-Yamany, Intel Corporation (Finland) [DPMI-088]*

5:30 – 7:30 PM Symposium Demonstration Session, Grand Peninsula Ballroom E

Wednesday February 1, 2017

KEYNOTE: Sharp High-quality Color Interpolation Joint Session

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

8:50 – 9:30 AM

Grand Peninsula Ballroom A

This session is jointly sponsored by: Image Sensors and Imaging Systems 2017 and Digital Photography and Mobile Imaging XIII.

Conference Chair Opening Remarks

Bayer pattern and image quality, *Jörg Kunze, Basler AG (Germany) [IMSE-077]*

Jörg Kunze has received his PhD in physics from the University of Hamburg (2004). He joined Basler in 1998, where he started as an electronics developer and where he currently is the team leader of New Technology. Kunze serves as an expert for image sensors, camera hardware, noise, color fidelity, 3D- and computational imaging and develops new algorithms for color image signal processing. The majority of the Basler patents name him as inventor.

Input Signal Quality & Characterization Joint Session

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

9:30 – 10:10 AM

Grand Peninsula Ballroom A

This session is jointly sponsored by: Image Sensors and Imaging Systems 2017 and Digital Photography and Mobile Imaging XIII.

9:30

Accurate joint geometric camera calibration of visible and far-infrared cameras, *Takashi Shibata^{1,2}, Masayuki Tanaka¹, and Masatoshi Okutomi¹; ¹Tokyo Institute of Technology and ²NEC Corporation (Japan) [IMSE-078]*

9:50

Interferometric measurement of sensor MTF and crosstalk, *Todor Georgiev, Jennifer Gille, Amber Sun, Lyubomir Baev, and Tharun Battula, Qualcomm Technologies, Inc. (United States) [DPMI-079]*

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10:00 AM – 4:00 PM Industry Exhibition

10:10 – 10:50 AM Coffee Break

KEYNOTE: Machine Vision Refina Improvement Joint Session

Session Chairs: Thomas Vogelsang, Rambus Inc., and Ralf Widenhorn, Portland State University (United States)

10:50 – 11:30 AM

Grand Peninsula Ballroom A

This session is jointly sponsored by: Image Sensors and Imaging Systems 2017 and Digital Photography and Mobile Imaging XIII.

Silicon retina technology (Invited), Tobi Delbruck, Institute for Neuroinformatics (INI) (Switzerland) [DPMI-080]

Tobi Delbruck (IEEE M'99-SM'06-F'13) received a PhD from Caltech (1993). He is currently a professor of physics and electrical engineering at ETH Zurich in the Institute of Neuroinformatics, University of Zurich and ETH Zurich, Switzerland, where he has been since 1998. His group, which he coordinates together with Shih-Chii Liu, focuses on neuromorphic event-based sensors and sensory processing. He has co-organized the Telluride Neuromorphic Cognition Engineering summer workshop and the live demonstration sessions at ISCAS and NIPS. Delbruck is past Chair of the IEEE CAS Sensory Systems Technical Committee. He worked on electronic imaging at Arithmos, Synaptics, National Semiconductor, and Foveon and has founded 3 spin-off companies, including inilabs.com, a non-for-profit organization that has distributed hundreds of R&D prototype neuromorphic sensors to more than a hundred organizations around the world. He has been awarded 9 IEEE awards.

12:40 – 2:00 PM Lunch Break

EI 2017 Wednesday Plenary and Symposium Awards

Session Chairs: Joyce E. Farrell, Stanford University, and Nitin Sampat, Rochester Institute of Technology (United States)

2:00 – 3:00 PM

Grand Peninsula Ballroom D

Designing VR video camera systems, Brian Cabral, Facebook, Inc. (United States)

Brian Cabral is Director of Engineering at Facebook, leading the Surround 360 VR camera team, specializing in computational photography, computer vision, and computer graphics. He has published a number of papers in the area of computer graphics and imaging including the pioneering Line Integral Convolution algorithm. Cabral discusses developing Facebook Surround 360, an open, high-quality 3D-360 video capture system. VR video capture systems are composed of multiple optical and digital components - all of which must operate as if they are one seamless optical system. The design of VR video cameras, optical choices, SNR, etc., require a new set of technologies and engineering approaches, with tight coupling to the computational system components.

3:00 – 3:30 PM Coffee Break

Emerging Imaging Sensor & Hardware Joint Session

Session Chairs: Thomas Vogelsang, Rambus Inc., and Ralf Widenhorn, Portland State University (United States)

11:30 – 11:50 AM

Grand Peninsula Ballroom A

This session is jointly sponsored by: Image Sensors and Imaging Systems 2017 and Digital Photography and Mobile Imaging XIII.

11:30

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TIK: A time domain continuous imaging testbed using conventional still images and video, Henry Dietz, Paul Eberhart, John Fike, Katie Long, Clark Demaree, and Jong Wu, University of Kentucky (United States) [DPMI-081]

KEYNOTE: Comparing CMOS Image Sensor Architectures Joint Session

Session Chairs: Thomas Vogelsang, Rambus Inc., and Ralf Widenhorn, Portland State University (United States)

11:50 AM – 12:40 PM

Grand Peninsula Ballroom A

This session is jointly sponsored by: Image Sensors and Imaging Systems 2017 and Digital Photography and Mobile Imaging XIII.

CMOS image sensor pixel design and optimization, Boyd Fowler, OmniVision Technologies (United States) [IMSE-082]

Image Sensors and Imaging Systems 2017 Awards

Boyd Fowler's research interests include CMOS image sensors, low noise image sensors, noise analysis, data compression, and machine learning and vision. He received his MSEE (1990) and PhD (1995) from Stanford University. After finishing his PhD he stayed at Stanford University as a research associate in the Electrical Engineering Information Systems Laboratory until 1998. In 1998, Fowler founded Pixel Devices International in Sunnyvale California. Between 2005 and 2013, Fowler was CTO and VP of Technology at Fairchild Imaging. He is currently at OmniVision Technologies leading the marketing department. Fowler has authored numerous technical papers, book chapters and patents.

Digital Photography and Mobile Imaging XIII Interactive Papers Session

5:30 – 7:00 PM

Grand Peninsula Ballroom E

The following works will be presented at the EI 2017 Symposium Interactive Papers Session.

A Canon hack development kit implementation of time domain continuous imaging, Katie Long, Henry Dietz and Clark Demaree, University of Kentucky (United States) [DPMI-075]

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Advanced HDR fusion method for image sensor with variable pixel exposure, Timofey Uvarov, OmniVision Technologies, Inc. (United States) [DPMI-076]