https://doi.org/10.2352/ISSN.2470-1173.2019.10.IQSP-A10

PROCEEDINGS

IS&T International Symposium on

Electronic Imaging

SCIENCE AND TECHNOLOGY

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

Image Quality and System Performance XVI

Editors: **Nicolas Bonnier,** Apple Incorporated (United States);
Stuart Perry, University of Technology Sydney (Australia)

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

Society for Imaging Science and Technology
7003 Kilworth Lane • Springfield, VA 22151 USA
703/642-9090; 703/642-9094 fax
info@imaging.org; www.imaging.org

ISSN 2470-1173
https://doi.org/10.2352/ISSN.2470-1173.2019.10.IQSP-A10
Manuscripts are reproduced from PDFs as submitted and approved by authors; no editorial changes have been made.

Image Quality and System Performance XVI

Conference overview

We live in a visual world. The perceived quality of images is of crucial importance in industrial, medical, and entertainment application environments. Developments in camera sensors, image processing, 3D imaging, display technology, and digital printing are enabling new or enhanced possibilities for creating and conveying visual content that informs or entertains. Wireless networks and mobile devices expand the ways to share imagery and autonomous vehicles bring image processing into new aspects of society.

The power of imaging rests directly on the visual quality of the images and the performance of the systems that produce them. As the images are generally intended to be viewed by humans, a deep understanding of human visual perception is key to the effective assessment of image quality.

This conference brings together engineers and scientists from industry and academia who strive to understand what makes a high-quality image, and how to specify the requirements and assess the performance of modern imaging systems. It focuses on objective and subjective methods for evaluating the perceptual quality of images, and includes applications throughout the imaging chain from image capture, through processing, to output, printed or displayed, video or still, 2D or 3D, virtual, mixed or augmented reality, LDR or HDR.

Awards

Best Student Paper
Best Paper

Conference Chairs: **Nicolas Bonnier,** Apple Inc. (United States); and **Stuart Perry,** University of Technology Sydney (Australia)

Program Committee: **Alan Bovik**, University of Texas at Austin (United States); **Peter Burns,** Burns Digital Imaging (United States); **Brian Cooper,** Lexmark International, Inc. (United States); **Luke Cui,** Amazon (United States); **Mylène Farias,** University of Brasilia (Brazil); **Susan Farnand,** Rochester Institute of Technology (United States); **Frans Gaykema,** Océ Technologies B.V. (the Netherlands); **Jukka Häkkinen,** University of Helsinki (Finland); **Dirk Hertel,** E Ink Corporation (United States); **Robin Jenkin,** NVIDIA Corporation (United States); **Elaine Jin,** NVIDIA Corporation (United States); **Mohamed-Chaker Larabi,** University of Poitiers (France); **Göte Nyman,** University of Helsinki (Finland); **Jonathan Phillips,** Google Inc. (United States); **Sophie Triantaphillidou,** University of Westminster (United Kingdom); and **Clément Viard,** DxOMark Image Labs (United States)

Conference Sponsors

NVIDIA

DOLBY VISION

IQSP

IMAGE QUALITY AND SYSTEM PERFORMANCE XVI

Monday, January 14, 2019

Automotive Image Quality — Joint Session

Session Chairs: Patrick Denny, Valeo (Ireland); Stuart Perry, University of Technology Sydney (Australia); and Peter van Beek, Intel Corporation (United States)

8:50 – 10:10 am
Grand Peninsula Ballroom D

This session is jointly sponsored by: Autonomous Vehicles and Machines 2019, and Image Quality and System Performance XVI.

8:50 AVM-026
Updates on the progress of IEEE P2020 Automotive Imaging Standards Working Group, *Robin Jenkin, NVIDIA Corporation (United States)*

9:10 AVM-027
Signal detection theory and automotive imaging, *Paul Kane, ON Semiconductor (United States)*

9:30 AVM-029
Digital camera characterisation for autonomous vehicles applications, *Paola Iacomussi and Giuseppe Rossi, INRIM (Italy)*

9:50 AVM-030
Contrast detection probability - Implementation and use cases, *Uwe Artmann[1], Marc Geese[2], and Max Gäde[1]; [1]Image Engineering GmbH & Co KG and [2]Robert Bosch GmbH (Germany)*

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

IQSP

Printing System Performance

Session Chair: Mylène Farias, University of Brasilia (Brazil)

3:30 – 4:50 pm
Grand Peninsula Ballroom E

3:30 IQSP-300
Detection of streaks on printed pages, *Runzhe Zhang[1], Eric Maggard[2], Renee Jessome[2], Yousun Bang[2], Minki Cho[2], and Jan Allebach[1]; [1]Purdue University and [2]HP, Inc. (United States)*

3:50 IQSP-301
Segmentation-based detection of local defects on printed pages, *Qiulin Chen[1], Eric Maggard[2], Renee Jessome[2], Yousun Bang[3], Minki Cho[3], and Jan Allebach[1]; [1]Purdue University (United States), [2]HP, Inc. (United States), and [3]HP-Korea (Republic of Korea)*

4:10 IQSP-302
Banding estimation for print quality, *Wan-Eih Huang[1], Eric Maggard[2], Renee Jessome[2], Yousun Bang[2], Minki Cho[2], and Jan Allebach[1]; [1]Purdue University and [2]HP, Inc. (United States)*

4:30 IQSP-303
Blockwise detection of local defects on printed pages, *Xiaoyu Xiang[1], Eric Maggard[2], Renee Jessome[2], Yousun Bang[2], Minki Cho[2], and Jan Allebach[1]; [1]Purdue University and [2]HP, Inc. (United States)*

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

Tuesday January 15, 2019

7:15 – 8:45 am Women in Electronic Imaging Breakfast

Image Quality Modeling I

Session Chair: Stuart Perry, University of Technology Sydney (Australia)

8:50 – 9:30 am
Grand Peninsula Ballroom E

8:50 IQSP-304
A referenceless image quality assessment based on BSIF, CLBP, LPQ, and LCP texture descriptors, *Pedro Garcia Freitas, Luisa Eira, Samuel Santos, and Mylène Farias, University of Brasilia (Brazil)*

9:10 IQSP-305
Compensating MTF measurements for chart quality limitations, *Norman Koren, Imatest LLC (United States)*

Image Quality Modeling II

Session Chair: Stuart Perry, University of Technology Sydney (Australia)

9:30 – 10:10 am
Grand Peninsula Ballroom E

IQSP-306
KEYNOTE: Conscious of streaming (Quality), *Alan Bovik, The University of Texas at Austin (United States)*

Alan Bovik is the Cockrell Family Regents Endowed Chair professor at The University of Texas at Austin. He has received many major international awards, including the 2019 IEEE Fourier Award, the 2017 Edwin H. Land Medal from IS&T/OSA, the 2015 Primetime Emmy Award for Outstanding Achievement in Engineering Development from the Academy of Television Arts and Sciences, and the 'Society' and 'Sustained Impact' Awards of the IEEE Signal Processing Society. His is a Fellow of IEEE, OSA, and SPIE. His books include The Handbook of Image and Video Processing, Modern Image Quality Assessment, *and* The Essential Guides to Image and Video Processing. *Bovik co-founded and was the longest-serving editor-in-chief of the IEEE Transactions on Image Processing and created the IEEE International Conference on Image Processing in Austin, Texas, in November 1994.*

10:00 am – 7:00 pm Industry Exhibition

10:10 – 10:50 am Coffee Break

Display Performance

Session Chair: Nicolas Bonnier, Apple Inc. (United States)

10:50 am – 12:30 pm
Grand Peninsula Ballroom E

10:50 IQSP-307
Combining quality metrics using machine learning for improved and robust HDR image quality assessment, *Anustup Choudhury and Scott Daly, Dolby Laboratories, Inc. (United States)*

11:10 IQSP-308
Subjective evaluations on perceptual image brightness in high dynamic range television, *Yoshitaka Ikeda and Yuichi Kusakabe, NHK (Japan Broadcasting Corporation) (Japan)*

11:30 IQSP-309
Image quality evaluation on an HDR OLED display, *Dalin Tian, Lihao Xu, and Ming Ronnier Luo, Zhejiang University (China)*

11:50 IQSP-310
A comprehensive framework for visual quality assessment of light field tensor displays, *Irene Viola[1], Keita Takahashi[2], Toshiaki Fujii[2], and Touradj Ebrahimi[1]; [1]École Polytechnique Fédérale de Lausanne (EPFL) (Switzerland) and [2]Nagoya University (Japan)*

12:10 IQSP-311
Semantic label bias in subjective video quality evaluation: A standardization perspective, *Mihai Mitrea[1], Rania Bensaied[1], and Patrick Le Callet[2]; [1]Institut Mines-Telecom and [2]Université de Nantes (France)*

12:30 – 2:00 pm Lunch

Tuesday Plenary

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

The Quest for Vision Comfort: Head-Mounted Light Field Displays for Virtual and Augmented Reality, *Hong Hua, professor of optical sciences, University of Arizona (United States)*

Hong Hua will discuss the high promises and the tremendous progress made recently toward the development of head-mounted displays (HMD) for both virtual and augmented reality displays, developing HMDs that offer uncompromised optical pathways to both digital and physical worlds without encumbrance and discomfort confronts many grand challenges, both from technological perspectives and human factors. She will particularly focus on the recent progress, challenges and opportunities for developing head-mounted light field displays (LF-HMD), which are capable of rendering true 3D synthetic scenes with proper focus cues to stimulate natural eye accommodation responses and address the well-known vergence-accommodation conflict in conventional stereoscopic displays.

Dr. Hong Hua is a professor of optical sciences at the University of Arizona. With more than 25 years of experience, Hua is widely recognized through academia and industry as an expert in wearable display technologies and optical imaging and engineering in general. Hua's current research focuses on optical technologies enabling advanced 3D displays, especially head-mounted display technologies for virtual reality and augmented reality applications, and microscopic and endoscopic imaging systems for medicine. Hua has published more than 200 technical papers and filed a total of 23 patent applications in her specialty fields, and delivered numerous keynote addresses and invited talks at major conferences and events worldwide. She is an SPIE Fellow and OSA senior member. She was a recipient of NSF Career Award in 2006 and honored as UA Researchers @ Lead Edge in 2010. Hua and her students shared a total of 8 "Best Paper" awards in various IEEE, SPIE and SID conferences. Hua received her PhD in optical engineering from the Beijing Institute of Technology in China (1999). Prior to joining the UA faculty in 2003, Hua was an assistant professor with the University of Hawaii at Manoa in 2003, was a Beckman Research Fellow at the Beckman Institute of University of Illinois at Urbana-Champaign between 1999 and 2002, and was a post-doc at the University of Central Florida in 1999.

3:00 – 3:30 pm Coffee Break

Special Session on Image Quality in Standardization

Session Chair: Jonathan Phillips, Google Inc. (United States)

3:30 – 4:50 pm
Grand Peninsula Ballroom E

3:30 IQSP-312
Study of subjective and objective quality evaluation of 3D point cloud data by the JPEG Committee, *Stuart Perry[1], Antonio Pinheiro[2], Emil Dumic[3], and Luis Cruz[4]; [1]University of Technology Sydney (Australia), [2]University of Beira Interior (Portugal), [3]University North (Croatia), and [4]University of Coimbra (Portugal)*

3:50 IQSP-313
Reducing the cross-lab variation of image quality metrics, *Henry Koren[1] and Benjamin Tseng[2]; [1]Imatest LLC and [2]Apkudo (United States)*

4:10 IQSP-314
Adaptive video streaming with current codecs and formats: Extensions to parametric video quality model ITU-T P.1203, *Rakesh Rao Ramachandra Rao[1], Steve Göring[1], Patrick Vogel[1], Nicolas Pachatz[1], Juan Jose Villamar Villarreal[1], Werner Robitza[1], Peter List[2], Bernhard Feiten[2], and Alexander Raake[1]; [1]TU Ilmenau and [2]Deutsche Telekom (Germany)*

4:30 IQSP-315
Visual noise revision for ISO 15739, *Dietmar Wueller[1], Akira Matsui[2], and Naoyah Kato[2]; [1]Image Engineering GmbH & Co. KG (Germany) and [2]Sony (Japan)*

IQSP of the Future

4:50 – 5:30 pm
Grand Peninsula Ballroom E

Panel Moderator: Stuart Perry, University of Technology Sydney (Australia)

Panelists:
Nicolas Bonnier, Apple Inc. (United States)
Peter Burns, Burns Digital Imaging (United States)
Mylène Farias, University of Brasilia (Brazil)
Elaine Jin, NVIDIA Corporation (United States)

5:30 – 7:00 pm Symposium Demonstration Session

Wednesday January 16, 2019

Camera Image Quality I

Session Chair: Peter Burns, Burns Digital Imaging (United States)

8:50 – 9:30 am
Grand Peninsula Ballroom E

8:50 IQSP-316
Multivariate statistical modeling for image quality prediction, *Praful Gupta[1], Christos Bampis[2], Jack Glover[3], Nicholas Paulter[3], and Alan Bovik[1]; [1]The University of Texas at Austin, [2]Netflix Inc., and [3]National Institute of Standards and Technology (United States)*

9:10 IQSP-317
Image quality assessment using computer vision, *Zhi Li[1], Palghat Ramesh[2,3], and Chu-heng Liu[3]; [1]Purdue University, [2]Palo Alto Research Center, and [3]Xerox Corporation (United States)*

Camera Image Quality II

Session Chair: Peter Burns, Burns Digital Imaging (United States)

9:30 – 10:10 am
Grand Peninsula Ballroom E

IQSP-318

KEYNOTE: Benchmarking image quality for billions of images, *Jonathan Phillips, Google Inc. (United States)*

Jonathan Phillips is co-author of Camera Image Quality Benchmarking, *a 2018 addition to the Wiley-IS&T Series in Imaging Science and Technology collection. His experience in the imaging industry spans nearly 30 years, having worked at Kodak in both chemical and electronic photography for more than 20 years followed by image scientist positions with NVIDIA and Google. Currently, he is managing a color science team at Google responsible for the display color of the Pixel phone product line. He was awarded the International Imaging Industry Association (I3A) Achievement Award for his groundbreaking work on modeling consumer-facing camera phone image quality, which is now incorporated into the IEEE Standard for Camera Phone Image Quality. Phillips has been project lead for numerous photography standards published by I3A, IEEE, and ISO. His graduate studies were in color science at Rochester Institute of Technology and his undergraduate studies were in chemistry and music at Wheaton College (IL).*

10:00 am – 3:30 pm Industry Exhibition

10:10 – 10:40 am Coffee Break

Video Quality

Session Chair: Elaine Jin, NVIDIA Corporation (United States)

10:40 am – 12:40 pm
Grand Peninsula Ballroom E

10:40 IQSP-319
Best practices for imaging system MTF measurement, *David Haefner, Stephen Burks, Josh Doe, and Bradley Preece, NVESD (United States)*

11:00 IQSP-320
Quantify aliasing – A new approach to make resolution measurement more robust, *Uwe Artmann, Image Engineering GmbH & Co. KG (Germany)*

11:20 IQSP-321
Subjective analysis of an end-to-end streaming system, *Christos Bampis[1], Zhi Li[1], Ioannis Katsavounidis[2], Te-Yuan Huang[1], Chaitanya Ekanadham[1], and Alan Bovik[3]; [1]Netflix Inc., [2]Facebook, Inc., and [3]The University of Texas at Austin (United States)*

11:40 IQSP-322
Saliency-based perceptual quantization method for HDR video quality enhancement, *Naty Sidaty, Wassim Hamidouche, Yi Liu, and Olivier Deforges, IETR/INSA (France)*

12:00 IQSP-323
Subjective and objective quality assessment for volumetric video compression, *Emin Zerman, Pan Gao, Cagri Ozcinar, and Aljosa Smolic, Trinity College Dublin (Ireland)*

12:20 IQSP-324
Analyzing the influence of cross-modal IP-based degradations on the perceived audio-visual quality, *Helard Becerra and Mylène Farias, University of Brasilia (Brazil)*

12:40 – 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

Immersive QoE

JOINT SESSION

Session Chair: Stuart Perry, University of Technology Sydney (Australia)

3:30 – 5:10 pm
Grand Peninsula Ballroom A

This session is jointly sponsored by: Human Vision and Electronic Imaging 2019, and Image Quality and System Performance XVI.

3:30 HVEI-216
Complexity measurement and characterization of 360-degree content, *Francesca De Simone[1], Jesús Gutiérrez[2], and Patrick Le Callet[2]; [1]CWI (the Netherlands) and [2]Université de Nantes (France)*

3:50 HVEI-217
Using 360 VR video to improve the learning experience in veterinary medicine university degree, *Esther Guervós[1], Jaime Jesús Ruiz[2], Pablo Perez[2], Juan Alberto Muñoz[1], César Díaz[3], and Narciso Garcia[3]; [1]Universidad Alfonso X El Sabio, [2]Nokia Bell Labs, and [3]Universidad Politécnica de Madrid (Spain)*

4:10 HVEI-218
Quality of Experience of visual-haptic interaction in a virtual reality simulator, *Kjell Brunnstrom[1,2], Elijs Dima[2], Mattias Andersson[2], Mårten Sjöström[2], Tahir Qureshi[3], and Mathias Johanson[4]; [1]RISE Acreo AB, [2]Mid Sweden University, [3]HIAB AB, and [4]Alkit Communications AB (Sweden)*

4:30 HVEI-219
Impacts of internal HMD playback processing on subjective quality perception, *Frank Hofmeyer, Stephan Fremerey, Thaden Cohrs, and Alexander Raake, Technische Universität Ilmenau (Germany)*

4:50 IQSP-220
Are people pixel-peeping 360° videos?, *Stephan Fremerey[1], Rachel Huang[2], and Alexander Raake[1]; [1]Technische Universität Ilmenau (Germany) and [2]Huawei Technologies Co., Ltd. (China)*

Image Quality and System Performance XVI Interactive Posters Session

5:30 – 7:00 pm
The Grove

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

IQSP-325
An examination of the effects of noise level on methods to determine curvature in range images, *Jacob Hauenstein and Timothy Newman, The University of Alabama in Huntsville (United States)*

IQSP-326
The characterization of an HDR OLED display, *Dalin Tian, Lihao Xu, and Ming Ronnier Luo, Zhejiang University (China)*

IQSP-327
Understanding fashion aesthetics: Training a neural network based predictor using likes and dislikes, *Rachel Bilbo, Kendal Norman, Zhi Li, and Jan Allebach, Purdue University (United States)*

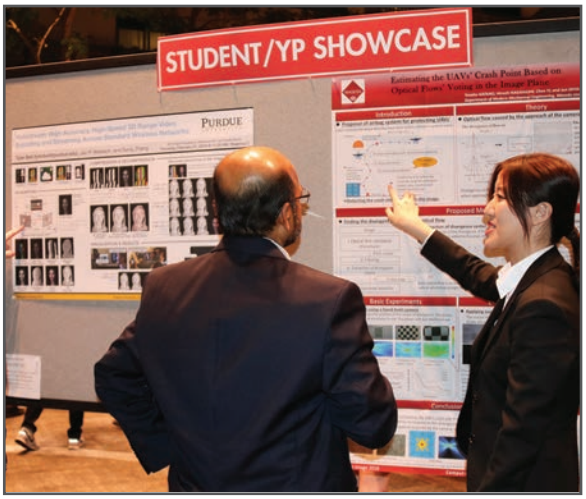
JOIN US AT THE NEXT EI!

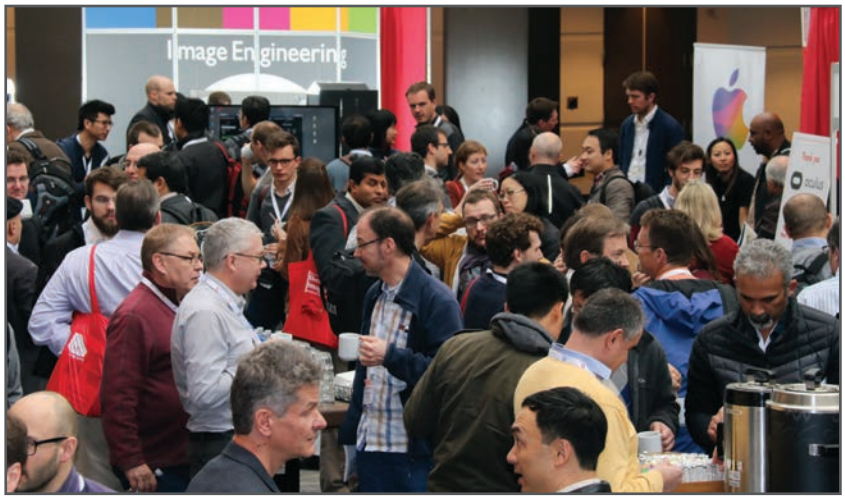
IS&T International Symposium on

Electronic Imaging

SCIENCE AND TECHNOLOGY

Imaging across applications . . . Where industry and academia meet!





• SHORT COURSES • EXHIBITS • DEMONSTRATION SESSION • PLENARY TALKS •
• INTERACTIVE PAPER SESSION • SPECIAL EVENTS • TECHNICAL SESSIONS •

www.electronicimaging.org

IS&T
imaging.org