
PROGRAM AND PROCEEDINGS

# Imaging Sensors and Systems 2023

Conference Chairs
**Jon S. McElvain,** Dolby Labs., Inc. (US)
**Arnaud Peizerat,** Commissariat Commissariat à l'Énergie Atomique (France)
**Nitin Sampat,** Edmund Optics (US)

This document details the conference program, held as part of the 2023 IS&T International Symposium on Electronic Imaging, 15-19 January 2023. Manuscripts of conference papers are reproduced from PDFs as submitted and approved by authors; no editorial changes were made.



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# Imaging Sensors and Systems 2023

## Conference overview

The Imaging Sensors and Systems Conference (ISS) began 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 2023; refer to manuscript for final authors. Titles that are not listed with the proceedings files were presentation-only.*



## Best Paper Sponsor

# Imaging Sensors and Systems 2023

## MONDAY 16 JANUARY 2023

**Monday 16 January PLENARY: Neural Operators for Solving PDEs**
Session Chair: Robin Jenkin, NVIDIA Corporation (United States)
2:00 PM – 3:00 PM
Cyril Magnin I/II/III

*Deep learning surrogate models have shown promise in modeling complex physical phenomena such as fluid flows, molecular dynamics, and material properties. However, standard neural networks assume finite-dimensional inputs and outputs, and hence, cannot withstand a change in resolution or discretization between training and testing. We introduce Fourier neural operators that can learn operators, which are mappings between infinite dimensional spaces. They are independent of the resolution or grid of training data and allow for zero-shot generalization to higher resolution evaluations. When applied to weather forecasting, neural operators capture fine-scale phenomena and have similar skill as gold-standard numerical weather models for predictions up to a week or longer, while being 4-5 orders of magnitude faster.*

**Anima Anandkumar,** Bren professor, California Institute of Technology, and senior director of AI Research, NVIDIA Corporation (United States)

*Anima Anandkumar is a Bren Professor at Caltech and Senior Director of AI Research at NVIDIA. She is passionate about designing principled AI algorithms and applying them to interdisciplinary domains. She has received several honors such as the IEEE fellowship, Alfred. P. Sloan Fellowship, NSF Career Award, and Faculty Fellowships from Microsoft, Google, Facebook, and Adobe. She is part of the World Economic Forum's Expert Network. Anandkumar received her BTech from Indian Institute of Technology Madras, her PhD from Cornell University, and did her postdoctoral research at MIT and assistant professorship at University of California Irvine.*

**EI 2023 Highlights Session**
Session Chair: Robin Jenkin, NVIDIA Corporation (United States)
3:30 – 5:00 PM
Cyril Magnin II

*Join us for a session that celebrates the breadth of what EI has to offer with short papers selected from EI conferences.*

*NOTE: The EI-wide "EI 2023 Highlights" session is concurrent with Monday afternoon COIMG, COLOR, IMAGE, and IQSP conference sessions.*

IQSP-309
**Evaluation of image quality metrics designed for DRI tasks with automotive cameras,** *Valentine Klein, Yiqi LI, Claudio Greco, Laurent Chanas, and Frédéric Guichard, DXOMARK (France)*

SD&A-224

**Human performance using stereo 3D in a helmet mounted display and association with individual stereo acuity,** *Bonnie Posselt, RAF Centre of Aviation Medicine (United Kingdom)*

IMAGE-281

**Smartphone-enabled point-of-care blood hemoglobin testing with color accuracy-assisted spectral learning,** *Sang Mok Park[1], Yuhyun Ji[1], Semin Kwon[1], Andrew R. O'Brien[2], Ying Wang[2], and Young L. Kim[1]; [1]Purdue University and [2]Indiana University School of Medicine (United States)*

AVM-118

**Designing scenes to quantify the performance of automotive perception systems,** *Zhenyi Liu[1], Devesh Shah[2], Alireza Rahimpour[2], Joyce Farrell[1], and Brian Wandell[1]; [1]Stanford University and [2]Ford Motor Company (United States)*

VDA-403

**Visualizing and monitoring the process of injection molding,** *Christian A. Steinparz[1], Thomas Mitterlehner[2], Bernhard Praher[2], Klaus Straka[1,2], Holger Stitz[1,3], and Marc Streit[1,3]; [1]Johannes Kepler University, [2]Moldsonics GmbH, and [3]datavisyn GmbH (Austria)*

COIMG-155

**Commissioning the James Webb Space Telescope,** *Joseph M. Howard, NASA Goddard Space Flight Center (United States)*

HVEI-223

**Critical flicker frequency (CFF) at high luminance levels,** *Alexandre Chapiro[1], Nathan Matsuda[1], Maliha Ashraf[2], and Rafal Mantiuk[3]; [1]Meta (United States), [2]University of Liverpool (United Kingdom), and [3]University of Cambridge (United Kingdom)*

HPCI-228

**Physics guided machine learning for image-based material decomposition of tissues from simulated breast models with calcifications,** *Muralikrishnan Gopalakrishnan Meena[1], Amir K. Ziabari[1], Singanallur Venkatakrishnan[1], Isaac R. Lyngaas[1], Matthew R. Norman[1], Balint Joo[1], Thomas L. Beck[1], Charles A. Bouman[2], Anuj Kapadia[1], and Xiao Wang[1]; [1]Oak Ridge National Laboratory and [2]Purdue University (United States)*

3DIA-104

**Layered view synthesis for general images,** *Loïc Dehan, Wiebe Van Ranst, and Patrick Vandewalle, Katholieke University Leuven (Belgium)*

ISS-329
**A self-powered asynchronous image sensor with independent in-pixel harvesting and sensing operations,** *Ruben Gomez-Merchan, Juan Antonio Leñero-Bardallo, and Ángel Rodríguez-Vázquez, University of Seville (Spain)*

COLOR-184
**Color blindness and modern board games,** *Alessandro Rizzi[1] and Matteo Sassi[2]; [1]Università degli Studi di Milano and [2]consultant (Italy)*

## TUESDAY 17 JANUARY 2023

**Sensor Design I (T1)**
**Session Chairs:** Jon McElvain, Dolby Laboratories (United States) and Min-Woong Seo, Samsung Electronics (Republic of Korea)
9:05 – 10:10 AM
Powell I/II

9:05
**Conference Welcome**

9:10 ISS-328
**Simulation and design of a burst mode 20Mfps global shutter high conversion gain CMOS image sensor in a standard 180nm CMOS image sensor process using sequential transfer gates,** *Xin Yue and Eric R. Fossum, Dartmouth College (United States)*

9:30 ISS-329
**A self-powered asynchronous image sensor with independent in-pixel harvesting and sensing operations,** *Ruben Gomez-Merchan, Juan Antonio Leñero-Bardallo, and Ángel Rodríguez-Vázquez, University of Seville (Spain)*

9:50 ISS-330
**Highly sensitive mutual-capacitive fingerprint sensor with reference electrode,** *Junghoon Yang, Sarawut Siracosit, and Sang-Hee Ko Park, Korea Advanced Institute of Science and Technology (Republic of Korea)*

**KEYNOTE: Innovative Imaging Systems (T2)**
Session Chairs: Francisco Imai, Apple Inc. (United States) and Kevin Matherson, Microsoft (United States)
10:50 AM – 12:30 PM
Powell I/II

10:50 ISS-331
**KEYNOTE: Metaphotonic routers for solid-state imaging: Making every photon count,** *Peter B. Catrysse, Stanford University (United States)*

*Dr. Peter B. Catrysse is a Senior Research Scientist in the E. L. Ginzton Laboratory (Stanford University). He holds a PhD and an MSc in Electrical Engineering from Stanford University. With his*

*doctoral research, he pioneered the integration of subwavelength metal optics for color filtering in standard deep-submicron CMOS technology. His recent work focuses on metaphotonics at the interface between fundamental physics and imaging applications. Dr. Catrysse has published more than 120 peer-reviewed papers, presented over 40 invited talks, and has been awarded 8 patents. He was named one of "50 Tech" pioneers by the Belgian Financial Times (2017) and is featured in the top 1% leading Engineering and Technology Scientists on the academic portal Research (2022). Dr. Catrysse is a Fellow of the Optical Society (Optica), a Fellow of the SPIE, a Senior Member of the IEEE, and a Hoover Foundation Brussels Fellow of the BAEF.*

11:30 ISS-332
**DiffuserCam: Multi-dimensional lensless imaging (Invited),** *Laura Waller, University of California, Berkeley (United States)*

11:50 ISS-333
**Wide-viewing-zone light-field capturing using Turtleback convex reflector (JIST-first),** *Hiroaki Yano and Tomohiro Yendo, Nagaoka University of Technology (Japan)*

12:10 ISS-334
**Digital camera obscuras,** *Henry G. Dietz, University of Kentucky (United States)*

**Tuesday 17 January PLENARY: Embedded Gain Maps for Adaptive Display of High Dynamic Range Images**
Session Chair: Robin Jenkin, NVIDIA Corporation (United States)
2:00 PM – 3:00 PM
Cyril Magnin I/II/III

*Images optimized for High Dynamic Range (HDR) displays have brighter highlights and more detailed shadows, resulting in an increased sense of realism and greater impact. However, a major issue with HDR content is the lack of consistency in appearance across different devices and viewing environments. There are several reasons, including varying capabilities of HDR displays and the different tone mapping methods implemented across software and platforms. Consequently, HDR content authors can neither control nor predict how their images will appear in other apps.*

*We present a flexible system that provides consistent and adaptive display of HDR images. Conceptually, the method combines both SDR and HDR renditions within a single image and interpolates between the two dynamically at display time. We compute a Gain Map that represents the difference between the two renditions. In the file, we store a Base rendition (either SDR or HDR), the Gain Map, and some associated metadata. At display time, we combine the Base image with a scaled version of the Gain Map, where the scale factor depends on the image metadata, the HDR capacity of the display, and the viewing environment.*

**Eric Chan,** Fellow, Adobe Inc. (United States)

*Eric Chan is a Fellow at Adobe, where he develops software for editing photographs. Current projects include Photoshop, Lightroom, Camera Raw, and Digital Negative (DNG). When not writing*

*software, Chan enjoys spending time at his other keyboard, the piano. He is an enthusiastic nature photographer and often combines his photo activities with travel and hiking.*

**Paul M. Hubel,** director of Image Quality in Software Engineering, Apple Inc. (United States)

*Paul M. Hubel is director of Image Quality in Software Engineering at Apple. He has worked on computational photography and image quality of photographic systems for many years on all aspects of the imaging chain, particularly for iPhone. He trained in optical engineering at University of Rochester, Oxford University, and MIT, and has more than 50 patents on color imaging and camera technology. Hubel is active on the ISO-TC42 committee Digital Photography, where this work is under discussion, and is currently a VP on the IS&T Board. Outside work he enjoys photography, travel, cycling, coffee roasting, and plays trumpet in several bay area ensembles.*

### Image Processing (T3)

**Session Chairs:** Jon McElvain, Dolby Laboratories (United States) and Nitin Sampat, Edmund Optics, Inc (United States)
3:30 – 4:50 PM
Powell I/II

3:30 ISS-335
**Panoramic Photoacoustic Computed Tomography (PACT): From small-animal wholebody imaging to human breast cancer diagnosis (Invited),** *Lei Li, Rice University (United States)*

3:50 ISS-336
**Array camera image fusion using physics-aware transformers (JIST-first),** *Qian Huang, Minghao Hu, and David J. Brady, The University of Arizona (United States)*

4:10 ISS-337
**Self-supervised intensity-event stereo matching (JIST-first),** *Jinjin Gu[1], Jinan Zhou[2], Ringo S. Chu[3], Yan Chen[4], Jiawei Zhang[4], Xuanye Cheng[4], Song Zhang[4], and Jimmy S. Ren[3,5,6]; [1]The University of Sydney (Australia), [2]The Chinese University of Hong Kong (Hong Kong), [3]Sensetime Research HK (Hong Kong), [4]SenseTime Research (China), [5]Qing Yuan Research Institute (Hong Kong), and [6]Shanghai Jiao Tong University (China)*

4:30 ISS-340
**Improvement of a facial recognition system based on one shot camera,** *Médégnonmi E. Houssou[1,2], Amadou Tidjani Sanda Mahama[1,2], Pierre Gouton[1], and Guy Degla[2]; [1]University of Burgundy (France) and [2]University of Abomey-Calavi (Benin)*

## WEDNESDAY 18 JANUARY 2023

### KEYNOTE: Processing at the Edge (W1) Joint Session

Session Chairs: Stanley Chan, Purdue University (United States) and Boyd Fowler, OmniVision Technologies (United States)
8:45 – 10:20 AM
Market Street

*This session is jointly sponsored by: Computational Imaging XXI, Imaging Sensors and Systems 2023, and the International Image Sensor Society (IISS).*

8:45
**COIMG/ISS Joint Sessions Welcome**

8:50 COIMG-177
**KEYNOTE: Deep optics: Learning cameras and optical computing systems,** *Gordon Wetzstein, Stanford University (United States)*

*Gordon Wetzstein is an Associate Professor of Electrical Engineering and, by courtesy, of Computer Science at Stanford University. He is the leader of the Stanford Computational Imaging Lab and a faculty co-director of the Stanford Center for Image Systems Engineering. At the intersection of computer graphics and vision, artificial intelligence, computational optics, and applied vision science, Prof. Wetzstein's research has a wide range of applications in next-generation imaging, wearable computing, and neural rendering systems. Prof. Wetzstein is a Fellow of Optica and the recipient of numerous awards, including an NSF CAREER Award, an Alfred P. Sloan Fellowship, an ACM SIGGRAPH Significant New Researcher Award, a Presidential Early Career Award for Scientists and Engineers (PECASE), an SPIE Early Career Achievement Award, an Electronic Imaging Scientist of the Year Award, an Alain Fournier Ph.D. Dissertation Award as well as many Best Paper and Demo Awards.*

9:40 COIMG-178
**Computational photography on a smartphone,** *Michael Polley, Samsung Research America (United States)*

10:00 COIMG-179
**Analog in-memory computing with multilevel RRAM for edge electronic imaging application,** *Glenn Ge, Teramem Inc. (United States)*

## Processing at the Edge (W2.1) Joint Session

**Session Chairs:** Stanley Chan, Purdue University (United States) and Boyd Fowler, OmniVision Technologies (United States)
10:50 – 11:50 AM
Market Street

*This session is jointly sponsored by: Computational Imaging XXI, Imaging Sensors and Systems 2023, and the International Image Sensor Society (IISS).*

10:50 COIMG-180
**Processing of real time, bursty and high compute iToF data on the edge (Invited),** *Cyrus Bamji, Microsoft Corporation (United States)*

11:10 COIMG-181
**A distributed on-sensor compute system in AR/VR devices and neural architecture search (NAS) framework for optimal workload distribution (Invited),** *Chiao Liu[1], Xin Dong[2], Ziyun Li[1], Barbara De Salvo[3], and H. T. Kung[2]; [1]Reality Labs, [2]Harvard University, and [3]Meta (United States)*

11:30 ISS-182
**A 2.2um three-wafer stacked back side illuminated voltage domain global shutter CMOS image sensor,** *Shimpei Fukuoka, OmniVision (Japan)*

**Wednesday 18 January PLENARY: Bringing Vision Science to Electronic Imaging: The Pyramid of Visibility**
Session Chair: Andreas Savakis, Rochester Institute of Technology (United States)
2:00 PM – 3:00 PM
Cyril Magnin I/II/III

*Electronic imaging depends fundamentally on the capabilities and limitations of human vision. The challenge for the vision scientist is to describe these limitations to the engineer in a comprehensive, computable, and elegant formulation. Primary among these limitations are visibility of variations in light intensity over space and time, of variations in color over space and time, and of all of these patterns with position in the visual field. Lastly, we must describe how all these sensitivities vary with adapting light level. We have recently developed a structural description of human visual sensitivity that we call the Pyramid of Visibility, that accomplishes this synthesis. This talk shows how this structure accommodates all the dimensions described above, and how it can be used to solve a wide variety of problems in display engineering.*

**Andrew B. Watson,** chief vision scientist, Apple Inc. (United States)

*Andrew Watson is Chief Vision Scientist at Apple, where he leads the application of vision science to technologies, applications, and displays. His research focuses on computational models of early vision. He is the author of more than 100 scientific papers and 8 patents. He has 21,180 citations and an h-index of 63. Watson founded the Journal of Vision, and served as editor-in-chief 2001-2013 and 2018-2022. Watson has received numerous awards including the Presidential Rank Award from the President of the United States.*

**KEYNOTE: Sensor Design II (W3)**
Session Chairs: Min-Woong Seo, Samsung Electronics (Republic of Korea) and Hari Tagat, Casix (United States)
3:30 – 5:10 PM
Powell I/II

3:30 ISS-341
**KEYNOTE: Event camera noise and denoising,** *Tobi Delbrück, Institute of Neuroinformatics, University of Zurich and ETH Zurich (Switzerland)*

*Tobi Delbrück (IEEE M'99, SM'06, F'13) received his BSc in physics from University of California in 1986 and his PhD from Caltech in 1993 as the first student with the Computation and Neural Systems program with PhD supervisor Carver Mead. He is an ETH Honorary Professor of Physics and Electrical Engineering, and has been with the Institute of Neuroinformatics, University of Zurich and ETH Zurich since 1998. The Sensors Group that he co-directs together with Prof. Shih-Chii Liu works on a broad range of topics covering device physics to computer vision and control, with a theme of efficient neuromorphic processing in hardware. He co-organizes the Telluride Neuromorphic Engineering workshop and has organized live demonstration sessions at ISCAS,*

*NeuIPS, and AICAS and two conference Sessions at ISCAS. Delbrück 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 co-founded 3 companies (Inilabs, Insightness and Inivation). His papers have been awarded 13 IEEE awards and he was named a Fellow of the IEEE Circuits and Systems Society for his work on neuromorphic sensors and processing. He likes to read storybooks, play tennis, and sometimes tries card magic.*

4:10 ISS-342
**Quantum efficiency of various miniaturized backside illuminated CMOS pixels under ultraviolet illumination,** *Nour Fassi[1,2], Jean-Pierre Carrère[1], Pierre Magnan[2], Magali Estribeau[2], and Vincent Goiffon[2]; [1]STMicroelectronics and [2]ISAE-SUPAERO (France)*

4:30 ISS-343
**Color performance of 0.8 um CMOS image sensor with CMY color filters,** *An-Li Kuo, Pohsiang Wang, Hao-Wei Liu, William Tsai, Chia-Ning Hsu, Chien-Wen Lai, Yu C. Chang, Ching-Chiang Wu, and Ken Wu, VisEra Technologies (Taiwan)*

4:50 ISS-344
**Reset noise reduction method in 3-T pixels,** *Kaitlin M. Anagnost, Xin Yue, and Eric R. Fossum, Dartmouth College (United States)*

**Imaging Sensors and Systems 2023 Interactive (Poster) Paper Session**
5:30 – 7:00 PM
Cyril Magnin Foyer

*The following works will be presented at the EI 2023 Symposium Interactive (Poster) Paper Session.*

ISS-345
**DevCAM: An open-source multi-camera development system for embedded vision,** *Meher Akhil Birlangi, Dominique E. Meyer, and Falko Kuester, University of California, San Diego (United States)*

ISS-346
**Development of DVS evaluation methods from user perspective,** *Raeyoung Kim, Jun-seok Kim, Junhyuk Park, Paul K.J. Park, Jaeha Park, Chunghwan Park, Inchun Lim, Seongwook Song, and Juhyun Ko, Samsung (Republic of Korea)*

ISS-347
**Implementation of EMVA 1288 Standard Release 4.0 for Characterization of Image Sensors,** *Megan E. Borek, Imatest, LLC (United States)*

ISS-348
**On quantization of convolutional neural networks for image signal processor,** *Youngil Seo, Dongpan Lim, Jeongguk Lee, and Seongwook Song, Samsung Electronics (Republic of Korea)*