



Color Imaging XXVIII: Displaying, Processing, Hardcopy, and Applications

Conference Chairs

Reiner Eschbach, Norwegian University of Science and Technology (Norway) and
Monroe Community College (US)

Gabriel G. Marcu, consultant (US)

Alessandro Rizzi, Università degli Studi di Milano (Italy)

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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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

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ISSN 2470-1173

<https://doi.org/10.2352/EI.2023.35.15.COLOR-A15>

PROGRAM AND PROCEEDINGS

Color Imaging XXVIII: Displaying, Processing, Hardcopy, and Applications

Conference overview

Color imaging has historically been treated as a phenomenon sufficiently described by three independent parameters. Recent advances in computational resources and in the understanding of the human aspects are leading to new approaches that extend the purely metrological view towards a perceptual approach describing the appearance of objects, documents, and displays. Part of this perceptual view is the incorporation of spatial aspects, adaptive color processing based on image content, and the automation of color tasks, to name a few. This dynamic nature applies to all output modalities, including hardcopy devices, but to an even larger extent to soft-copy displays.

Spatially adaptive gamut and tone mapping, dynamic contrast, and color management continue to support the unprecedented development of the display hardware covering everything from mobile displays to standard monitors, and all the way to large size screens and emerging technologies. The scope of inquiry is also broadened by the desire to match not only color, but complete appearance perceived by the user. This conference provides an opportunity to present, to interact, and to learn about the most recent developments in color imaging and material appearance researches, technologies, and applications. Focus of the conference is on color basic research and testing, color image input, dynamic color image output and rendering, color image automation, emphasizing color in context and color in images, and reproduction of images across local and remote devices.

In addition, the conference covers software, media, and systems related to color and material appearance. Special attention is given to applications and requirements created by and for multidisciplinary fields involving color and/or vision.

Conference Chairs: Reiner Eschbach, Norwegian University of Science and Technology (Norway) and Monroe Community College (US); **Gabriel G. Marcu**, consultant (US); and **Alessandro Rizzi**, Università degli Studi di Milano (Italy)

Program Committee: Jan P. Allebach, Purdue University (US); **Giordano B. Beretta**, consultant (US); **Vien Cheung**, University of Leeds (UK); **Scott J. Daly**, Dolby Laboratories, Inc. (US); **Philip J. Green**, Norwegian University of Science and Technology (Norway); **Mathieu Hebert**, Université Jean Monnet de Saint Etienne (France); **John J. McCann**, McCann Imaging (US); **Caterina Ripamonti**, Cambridge Research Systems Ltd. (UK); **Lionel Simonot**, Université de Poitiers (France); **Aditya Suneel Sole**, Norwegian University of Science and Technology (NTNU) (Norway); **Hyeon-Jeong Suk**, Korea Advanced Institute of Science and Technology (KAIST) (Republic of Korea); **Ingeborg Tastil**, HP Labs, HP Inc. (US); **Shoji Tominaga**, Norwegian University of Science and Technology (Norway) and Nagano University (Japan); and **Sophie Triantaphillidou**, University of Westminster (UK)

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.

Color Imaging XXVIII: Displaying, Processing, Hardcopy, and Applications

MONDAY 16 JANUARY 2023

Vision 1 (M2)

Session Chair: Reiner Eschbach, Norwegian University of Science and Technology (Norway) and Monroe Community College (United States)

11:05 AM – 12:30 PM

Mission II/III

11:05

Conference Welcome

11:10

COLOR-183

Pseudocolor visualizations of light patterns on retinal receptors after glare (Invited), John J. McCann, McCann Imaging (United States)

11:50

COLOR-184

Color blindness and modern board games, Alessandro Rizzi¹ and Matteo Sassi²; ¹Università degli Studi di Milano and ²consultant (Italy)

12:10

COLOR-185

Testing the role of vision spatial processing in color deficiency, Alice Plutino¹, Reiner Eschbach², Luca Armellin¹, Andrea Mazzoni³, Roberta Marcucci³, and Alessandro Rizzi¹; ¹Università degli Studi di Milano (Italy), ²Norwegian University of Science and Technology (Norway) and Monroe Community College (United States), and ³Aerospace Medical Institute - Italian Airforce (Italy)

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.

Vision 2 (M3)

Session Chair: John McCann, McCann Imaging (United States)

3:30 – 5:10 PM

Mission II/III

3:30

COLOR-186

Heterochromatic brightness matching experiments to evaluate brightness prediction model including Helmholtz-Kohlrausch effect, *Garam Seong¹, Youngshin Kwak¹, and Hyosun Kim²; ¹Ulsan National Institute of Science and Technology and ²Samsung Display Co., Ltd (Republic of Korea)*

3:50

COLOR-187

HyperspectrACE: A human vision inspired hyperspectral color and contrast adjustment, *Beatrice Sarti, Alice Plutino, and Alessandro Rizzi, Università degli Studi di Milano (Italy)*

4:10

COLOR-188

Spatiochromatic natural image statistics modelling: Applications from display analysis to neural networks, *Scott Daly, Timo Kunkel, Guan-Ming Su, and Anustup Choudhury, Dolby Laboratories, Inc. (United States)*

4:30

COLOR-189

Lessons from research in color science on the bleeding edge (Invited), *Giordano B. Beretta, consultant (United States)*

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 Park¹, Yuhyun Ji¹, Semin Kwon¹, Andrew R. O'Brien², Ying Wang², and Young L. Kim¹; ¹Purdue University and ²Indiana University School of Medicine (United States)*

AVM-118

Designing scenes to quantify the performance of automotive perception systems, *Zhenyi Liu¹, Devesh Shah², Alireza Rahimpour², Joyce Farrell¹, and Brian Wandell¹; ¹Stanford University and ²Ford Motor Company (United States)*

VDA-403

Visualizing and monitoring the process of injection molding, *Christian A. Steinparz¹, Thomas Mitterlehner², Bernhard Praher², Klaus Straka^{1,2}, Holger Stitz^{1,3}, and Marc Streit^{1,3}; ¹Johannes Kepler University, ²Moldsonics GmbH, and ³datavisyn 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 Chapiro¹, Nathan Matsuda¹, Maliha Ashraf², and Rafal Mantiuk³; ¹Meta (United States), ²University of Liverpool (United Kingdom), and ³University 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 Meena¹, Amir K. Ziabari¹, Singanallur Venkatakrishnan¹, Isaac R. Lyngaas¹, Matthew R. Norman¹, Balint Joo¹, Thomas L. Beck¹, Charles A. Bouman², Anuj Kapadia¹, and Xiao Wang¹; ¹Oak Ridge National Laboratory and ²Purdue 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 Rizzi¹ and Matteo Sassi²; ¹Università degli Studi di Milano and ²consultant (Italy)

TUESDAY 17 JANUARY 2023

Applications 1 (T1)

Session Chair: John McCann, McCann Imaging (United States)

9:10 – 10:30 AM

Mission II/III

9:10

COLOR-190

Influence of fluorescence on the color prediction of translucent samples of dental resin composites, Vincent Duveiller¹, Raphael Clerc¹, Anthony Cazier¹, Jean-Pierre Salomon^{2,3,4}, and Mathieu Hebert¹; ¹University Jean Monnet Saint-Etienne (France), ²Faculté d'Odontologie de Nancy (France), ³Institut de Science des Matériaux de Mulhouse IMR 7361 CNRS (France), and ⁴Oregon Health and Science University (United States)

9:30

COLOR-191

Can image cues explain the impact of translucency on perceived gloss?, Davit Gigilashvili and Akib J. Islam, Norwegian University of Science and Technology (Norway)

9:50

COLOR-192

A cross-polarization as a possible cause for color shift in illumination, Tarek Abu Haila^{1,2} and Davit Gigilashvili³; ¹Fraunhofer IGD, ²Technical university Darmstadt (Germany), and ³presenter only (Norway)

10:10

COLOR-193

Image color-based preset light matching algorithm for an electric vitrine, Byeongjin Kim¹, Ye Jin Kim², Myoung Suk Kim², Hong Seung Do², and Hyeon-Jeong Suk¹; ¹Korea Advanced Institute of Science and Technology (KAIST) and ²LG Electronics (Republic of Korea)

Applications 2 (T2)

Session Chair: Gabriel Marcu, consultant (United States)

11:10 AM – 12:10 PM

Mission II/III

11:10

COLOR-194

Active learning approaches to analysis of thin-film printed sensors for determining nitrate levels in soil, Xihui Wang, Bruno Ribeiro, Ali Shakouri, and Jan P. Allebach, Purdue University (United States)

11:30

COLOR-195

Simulation and estimation of printer media velocity variation, Runzhe Zhang^{1,2}, Yeri Nam³, Yousun Bang³, Ki-Youn Lee³, Mark Shaw³, and Jan P. Allebach⁴; ¹Purdue University (United States), ²Apple (United States), and ³HP (Republic of Korea)

11:50

COLOR-196

Analysis of food crystal images, Qiyue Liang, Ali Shakouri, and Jan P. Allebach, Purdue University (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.

DISCUSSION: Dark Side of Color (T3)

Session Chair: Alessandro Rizzi, Università degli Studi di Milano (Italy)

3:30 – 4:30 PM

Mission II/III

A session for unexpected topics, including: "Music and Color and Noise with a splash of Synaesthesia", "A view from the dark side", and "What you see is what you get and beyond".

COLOR-460

Music and color and noise, with a splash of synaesthesia (Invited), *Scott Daly, Dolby Laboratories, Inc. (United States)*

COLOR-461

A view from the dark side (Invited), *Alessandro Rizzi, Università degli Studi di Milano (Italy)*

COLOR-462

What you see is what you get and beyond (Invited), *Gabriel Marcu, consultant (United States)*

WEDNESDAY 18 JANUARY 2023

Processing (W1)

Session Chair: Gabriel Marcu, consultant (United States)

9:10 – 10:10 AM

Mission II/III

9:10

COLOR-198

Hue-preserving color enhancement under a cylindrical model without geometric deformation of the RGB color cube, *Tieling Chen and Onan Chew, University of South Carolina Aiken (United States)*

9:30

COLOR-199

Machine learning estimation of camera spectral sensitivity functions with non-RGB color filters, *Abraham Sachs^{1,2} and Ramakrishna Kakarala¹; ¹Omnivision and ²UC Davis (United States)*

9:50

COLOR-201

Towards a colorimetric camera, *Tripurari Singh and Mritunjay Singh, Image Algorithmics (United States)*

Halftoning 1 (W2)

Session Chair: Reiner Eschbach, Norwegian University of Science and Technology (Norway) and Monroe Community College (United States)

11:10 AM – 12:30 PM

Mission II/III

11:10

COLOR-202

A career retrospective and lessons learned: From digital holography and digital halftoning to printed thin film sensors (Invited), *Jan P. Allebach, Purdue University (United States)*

11:50

COLOR-203

Descreening of halftone images using generative adversarial network, Baekdu Choi and Jan P. Allebach, Purdue University (United States)

12:10

COLOR-204

Simulation of the impact of a coating layer on the appearance of various halftone patterns., Fanny Dailliez^{1,2}, Mathieu Hebert², Lionel Chagas¹, Thierry Fournel², and Anne Blayo¹; ¹LGP2 and ²Université Jean Monnet de Saint Etienne (France)

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.

Halftoning 2 (W3)

Session Chair: Reiner Eschbach, Norwegian University of Science and Technology (Norway) and Monroe Community College (United States)

3:30 – 4:50 PM

Mission II/III

3:30

COLOR-205

Structure-aware color halftoning with adaptive sharpness control (JIST-first), Fereshteh Abedini¹, Sasan Gooran¹, and Abigail Trujillo-Vazquez²; ¹Linköping University (Sweden) and ²presenter only (United States)

3:50

COLOR-206

Effect of halftones on printing iridescent colors, *Fereshteh Abedini¹, Abigail Trujillo-Vazquez², Sasan Gooran¹, and Susanne Klein²; ¹Linköping University (Sweden) and ²University of the West of England (United Kingdom)*

4:10

COLOR-207

Three-dimensional adaptive digital halftoning (JIST-first), *Sasan Gooran¹, Fereshteh Abedini¹, and Abigail Trujillo-Vazquez²; ¹Linköping University (Sweden) and ²presenter only (United States)*

4:30

COLOR-208

Dot profile model-based direct binary search, *Yafei Mao¹, Utpal Sarkar², Isabel Borrell², Lluís Abello², and Jan P. Allebach³; ¹Purdue University (United States) and ²HP Inc (Spain)*