



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

Conference Chairs

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

Gabriel G. Marcu, Apple Inc. (United States)

Alessandro Rizzi, Università degli Studi di Milano (Italy)

This document details the conference program, held as part of the 2022 IS&T International Symposium on Electronic Imaging, online 15–26 January 2022. Manuscripts of conference papers are reproduced from PDFs as submitted and approved by authors; no editorial changes were made.

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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 view of color in 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 spreading from mobile displays to large size screens and emerging technologies. This conference provides an opportunity to present, to interact, and to learn about the most recent developments in color imaging 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. Special attention is given to applications and requirements created by and for multidisciplinary fields involving color and/or vision.

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Program Committee: Jan P. Allebach, Purdue University (United States); **Giordano B. Beretta**, consultant (United States); **Vien Cheung**, University of Leeds (United Kingdom); **Scott J. Daly**, Dolby Laboratories, Inc. (United States); **Philip J. Green**, Norwegian University of Science and Technology (Norway); **Mathieu Hebert**, Université Jean Monnet de Saint Etienne (France); **John J. McCann**, McCann Imaging (United States); **Caterina Ripamonti**, Cambridge Research Systems Ltd. (United Kingdom); **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 Tastl**, HP Labs, HP Inc. (United States); **Shoji Tominaga**, Chiba University (Japan); and **Sophie Triantaphillidou**, University of Westminster (United Kingdom)

Paper authors listed as of 1 January 2022; refer to manuscript for final authors. Titles that are not listed with the proceedings files were presentation-only.

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

MONDAY 17 JANUARY 2022

PLENARY: Quanta Image Sensors: Counting Photons Is the New Game in Town

10:00 – 11:10

Eric R. Fossum, Dartmouth College (United States)

The Quanta Image Sensor (QIS) was conceived as a different image sensor—one that counts photoelectrons one at a time using millions or billions of specialized pixels read out at high frame rate with computation imaging used to create gray scale images. QIS devices have been implemented in a CMOS image sensor (CIS) baseline room-temperature technology without using avalanche multiplication, and also with SPAD arrays. This plenary details the QIS concept, how it has been implemented in CIS and in SPADs, and what the major differences are. Applications that can be disrupted or enabled by this technology are also discussed, including smartphone, where CIS-QIS technology could even be employed in just a few years.

Eric R. Fossum is best known for the invention of the CMOS image sensor “camera-on-a-chip” used in billions of cameras. He is a solid-state image sensor device physicist and engineer, and his career has included academic and government research, and entrepreneurial leadership. At Dartmouth he is a professor of engineering and vice provost for entrepreneurship and technology transfer. Fossum received the 2017 Queen Elizabeth Prize from HRH Prince Charles, considered by many as the Nobel Prize of Engineering “for the creation of digital imaging sensors,” along with three others. He was inducted into the National Inventors Hall of Fame, and elected to the National Academy of Engineering among other honors including a recent Emmy Award. He has published more than 300 technical papers and holds more than 175 US patents. He co-founded several startups and co-founded the International Image Sensor Society (IIS), serving as its first president. He is a Fellow of IEEE and OSA.

TUESDAY 18 JANUARY 2022

Color Management I

Session Chairs: Reiner Eschbach, Norwegian University of Science and Technology (Norway) and Monroe Community College (United States) and Gabriel Marcu, Apple Inc (United States)

10:00 – 11:20

10:00

COLOR-139

Estimating spectral reflectances using mobile phone cameras, Shoji Tominaga^{1,2}, Shogo Nishi³, and Ryo Ohtera⁴; ¹Norwegian University of Science and Technology (Norway), ²Nagano University (Japan), ³Osaka Electro-Communication University (Japan), and ⁴Kobe Institute of Computing (Japan)

10:20

COLOR-140

Non-standard colorimetry in ICC colour management, Peter Nussbaum, Milan Kresović, and Phil Green, Norwegian University of Science and Technology (Norway)

10:40

COLOR-141

Camera response function assessment in multispectral HDR imaging, Majid Ansari-Asl, Jean-Baptiste Thomas, and Jon Yngve Hardeberg, Norwegian University of Science and Technology (Norway)

11:00

COLOR-142

Problems in image target-based color correction, Gabriele Simone¹, Marco Gaiani², Andrea Bellabeni², and Alessandro Rizzi¹; ¹Università degli Studi di Milano and ²University of Bologna (Italy)

AI Applications for Color

Session Chair: Jan Allebach, Purdue University (United States)

11:50 – 13:10

11:50

COLOR-156

Effect of hue shift towards robustness of convolutional neural networks, Kanjar De^{1,2} and Marius Pedersen²; ¹Lulea University of Technology (Sweden) and ²Norwegian University of Science and Technology (Norway)

12:10

COLOR-157

Deep learning approach for classifying contamination levels with limited samples, Min Zhao¹, Susana Diaz-Amaya^{1,2}, Amanda J. Deering¹, Lia Stanciu¹, George T.-C. Chiu¹, and Jan Allebach¹; ¹Purdue University and ²Bayer at Convergence - Bayer Crop Science (United States)

12:30

COLOR-158

Mimicking DBS halftoning via a deep learning approach, Baekdu Choi and Jan P. Allebach, Purdue University (United States)

12:50

COLOR-159

Improvements to color image and machine learning based thin-film nitrate sensor performance prediction: New texture features, repeated cross-validation, and auto-tuning of hyperparameters, Xihui Wang, Jan Allebach, George T.-C. Chiu, Ali Shakouri, and Ye Mi, Purdue University (United States)

Color Management II

Session Chairs: Phil Green, Norwegian University of Science and Technology (NTNU) (Norway) and Shoji Tominaga, Norwegian University of Science and Technology (Norway) and Nagano University (Japan) (Japan)

19:15 – 19:55

19:15

COLOR-180

An exploration of color reproduction for inkjet FDM color 3D printing, Piyaat Silapasuphakornwong¹, Chulapong Panichkriangkrai², Parinya Punpongson³, Masahiro Suzuki⁴, and Kazutake Uehira¹; ¹Kanagawa Institute of Technology (Japan), ²Chulalongkorn University (Thailand), ³Osaka University (Japan), and ⁴Seisen University (Japan)

19:35

COLOR-181

Considering chromatic adaptation in camera white balance, Minchen Wei¹, Yiqian Li¹, and Xiandou Zhang²; ¹The Hong Kong Polytechnic University (Hong Kong) and ²Huawei Tech (China)

WEDNESDAY 19 JANUARY 2022

PLENARY: In situ Mobility for Planetary Exploration: Progress and Challenges

10:00 – 11:15

Larry Matthies, Jet Propulsion Laboratory (United States)

This year saw exciting milestones in planetary exploration with the successful landing of the Perseverance Mars rover, followed by its operation and the successful technology demonstration of the Ingenuity helicopter, the first heavier-than-air aircraft ever to fly on another planetary body. This plenary highlights new technologies used in this mission, including precision landing for Perseverance, a vision coprocessor, new algorithms for faster rover traverse, and the ingredients of the helicopter. It concludes with a survey of challenges for future planetary mobility systems, particularly for Mars, Earth's moon, and Saturn's moon, Titan.

Larry Matthies received his PhD in computer science from Carnegie Mellon University (1989), before joining JPL, where he has supervised the Computer Vision Group for 21 years, the past two coordinating internal technology investments in the Mars office. His research interests include 3-D perception, state estimation, terrain classification, and dynamic scene analysis for autonomous navigation of unmanned vehicles on Earth and in space. He has been a principal investigator in many programs involving robot vision and has initiated new technology developments that impacted every US Mars surface mission since 1997, including visual navigation algorithms for rovers, map matching algorithms for precision landers, and autonomous navigation hardware and software architectures for rotorcraft. He is a Fellow of the IEEE and was a joint winner in 2008 of the IEEE's Robotics and Automation Award for his contributions to robotic space exploration.

Material Appearance I

Session Chairs: Mathieu Hebert, Université Jean Monnet de Saint Etienne (France) and Lionel Simonot, Université de Poitiers (France)

12:40 – 13:20

12:40

COLOR-221

Light scattering in translucent layers: Angular distribution and internal reflections at flat interfaces, Arthur Gautheron^{1,2}, Raphael Clerc^{3,4}, Vincent Duveiller^{3,4}, Lionel Simonot⁵, Bruno Montcel^{1,2}, and Mathieu Hebert^{3,4}; ¹CREATIS, ²Université Claude Bernard Lyon 1, ³Université Jean Monnet de Saint Etienne, ⁴Institut d'Optique Graduate School, and ⁵University de Poitiers (France)

13:00

COLOR-222

Exploring the role of caustics in translucency perception — An eye tracking approach, Davit Gigilashvili, Aditya Sole, Shaikat Deb Nath, and Marius Pedersen, Norwegian University of Science and Technology (Norway)

Imaging I

Session Chairs: Vien Cheung, University of Leeds (United Kingdom) and Alessandro Rizzi, Università degli Studi di Milano (Italy)

13:55 – 14:35

13:55

COLOR-233

Smartphones' skin colour reproduction analysis for neonatal jaundice detection (JIST-first), Mekides A. Abebe¹, Jon Yngve Hardeberg¹, and Gunnar Vartdal²; ¹Norwegian University of Science and Technology and ²Picterus AS (Norway)

14:15

COLOR-234

Motion detection in a color video sequence with an application to monitoring a baby, Yang Yan, Purdue University (United States)

Appearance and Perception I

Session Chairs: John McCann, McCann Imaging (United States) and HyeonJeong Suk, Korea Advanced Institute of Science and Technology (KAIST) (Republic of Korea)

18:20 – 19:00

18:20

COLOR-245

A measurement of the overall vividness of a color image based on RGB color model, Tieling Chen, University of South Carolina (United States)

18:40

COLOR-246

Experimental methods to investigate time-course of chromatic adaptation, Seonyoung Yoon¹, Youngshin Kwak¹, and Hyosun Kim²; ¹Ulsan National Institute of Science and Technology and ²Samsung Display Co., Ltd. (Republic of Korea)

Material Appearance II

Session Chairs: Mathieu Hebert, Université Jean Monnet de Saint Etienne (France) and Ingeborg Tastl, HP-Labs (United States)

19:15 – 20:15

19:15

COLOR-252

Modeling the 3D shape of a fingernail and pre-distorting an image to be printed on the fingernail to yield the correct appearance, Marshia A. Seto¹, Rain Guo², White He², Davi He², George T.-C. Chiu¹, and Jan P. Allebach¹; ¹Purdue University (United States) and ²SunValley (China)

19:35

COLOR-253

Glossy appearance editing for heterogeneous material objects (JIST-first), Yusuke Manabe, Midori Tanaka, and Takahiko Horiuchi, Chiba University (Japan)

THURSDAY 20 JANUARY 2022

Imaging II

Session Chairs: Alessandro Rizzi, Università degli Studi di Milano (Italy) and Sophie Triantaphillidou, University of Westminster (United Kingdom)

10:00 – 11:00

10:00

COLOR-259

Measuring colorant fading within raster regions of printed scanned customer content using a novel unsupervised clustering method, Runzhe Zhang¹, Yousun Bang², Minki Cho², Mark Shaw³, and Jan P. Allebach¹; ¹Purdue University (United States), ²HP Printing Korea Co., Ltd. (Republic of Korea), and ³HP Inc. (United States)

10:20

COLOR-260

Colorization of monochrome night vision videos for a baby monitor based on a reference daylight image of the same scene, Yang Yan, Purdue University (United States)

10:40

COLOR-261

Image segmentation based on content-color-dependent screening (CCDS) using U-net, Altyngul Jumabayeva and Adnan Yazici, Nazarbayev University (Kazakhstan)

Print I

Session Chairs: Reiner Eschbach, Norwegian University of Science and Technology (Norway) and Monroe Community College (United States) and Gabriel Marcu, Apple Inc (United States)

11:35 – 12:35

11:35

COLOR-277

Printer spectral color characterization adjustment for change in substrates, Anastasiia Gudzenchuk¹, Phil Green², and Hans Don³; ¹Norwegian University of Science and Technology (Norway), ²London College of Communication (United Kingdom), and ³Wageningen University & Research (the Netherlands)

11:55

COLOR-278

Structure-aware halftoning using the iterative method controlling the dot placement (JIST-first), Fereshteh Abedini¹, Sasan Gooran¹, Vlado Kitanovski², and Daniel Nyström¹; ¹Linköping University (Sweden) and ²Norwegian University of Science and Technology (Norway)

12:15

COLOR-279

Improving an inkjet printer: Removing stray-dots by constraining error diffusion in highlight regions, Sige Hu¹, George T.-C. Chiu¹, Davi He², Rain Guo², White He², and Jan P. Allebach¹; ¹Purdue University (United States) and ²SunValley Tek (China)

Print II

Session Chairs: Mathieu Hebert, Université Jean Monnet de Saint Etienne (France) and Gabriel Marcu, Apple Inc (United States)

13:00 – 14:00

13:00

COLOR-284

Developing a gamut mapping method for a novel inkjet printer, Baekdu Choi¹, Sige Hu¹, Rain Guo², White He², Davi He², George T.-C. Chiu¹, and Jan P. Allebach¹; ¹Purdue University (United States) and ²Sunvalley Tek (China)

13:20

COLOR-285

Measuring margin and skew errors in scanned printed customer content, Runzhe Zhang¹, Ki-Youn Lee², Yousun Bang², Mark Shaw³, and Jan P. Allebach¹; ¹Purdue University (United States), ²HP Printing Korea Co., Ltd. (Republic of Korea), and ³HP Inc. (United States)

13:40

COLOR-286

Measuring CMYK color plane misregistration from scanned printed customer content image, Yi Yang¹, Ki-Youn Lee², Yousun Bang², Mark Shaw³, and Jan P. Allebach¹; ¹Purdue University (United States), ²HP Printing Korea Co., Ltd. (Republic of Korea), and ³HP Inc. (United States)

TUESDAY 25 JANUARY 2022

PLENARY: Physics-based Image Systems Simulation

10:00 – 11:00

Joyce Farrell, Stanford Center for Image Systems Engineering, Stanford University, CEO and Co-founder, Imgeval Consulting (United States)

Three quarters of a century ago, visionaries in academia and industry saw the need for a new field called photographic engineering and formed what would become the Society for Imaging Science and Technology (IS&T). Thirty-five years ago, IS&T recognized the massive transition from analog to digital imaging and created the Symposium on Electronic Imaging (EI). IS&T and EI continue to evolve by cross-pollinating electronic imaging in the fields of computer graphics, computer vision, machine learning, and visual perception, among others. This talk describes open-source software and applications that build on this vision. The software combines quantitative computer graphics with models of optics and image sensors to generate physically accurate synthetic image data for devices that are being prototyped. These simulations can be a powerful tool in the design and evaluation of novel imaging systems, as well as for the production of synthetic data for machine learning applications.

Joyce Farrell is a senior research associate and lecturer in the Stanford School of Engineering and the executive director of the Stanford Center for Image Systems Engineering (SCIEN). Joyce received her BS from the University of California at San Diego and her PhD from Stanford University. She was a postdoctoral fellow at NASA Ames Research Center, New York University, and Xerox PARC, before joining the research staff at Hewlett Packard in 1985. In 2000 Joyce joined Shutterfly, a startup company specializing in online digital photofinishing, and in 2001 she formed Imgeval Consulting, LLC, a company specializing in the development of software and design tools for image systems simulation. In 2003, Joyce returned to Stanford University to develop the SCIEN Industry Affiliates Program.

PANEL: The Brave New World of Virtual Reality

11:00 – 12:00

Advances in electronic imaging, computer graphics, and machine learning have made it possible to create photorealistic images and videos. In the future, one can imagine that it will be possible to create a virtual reality that is indistinguishable from real-world experiences. This panel discusses the benefits of this brave new world of virtual reality and how we can mitigate the risks that it poses. The goal of the panel discussion is to showcase state-of-the-art synthetic imagery, learn how this progress benefits society, and discuss how we can mitigate the risks that the technology also poses. After brief demos of the state-of-the-art, the panelists will discuss: creating photorealistic avatars, Project Shoah, and digital forensics.

Panel Moderator: Joyce Farrell, Stanford Center for Image Systems Engineering, Stanford University, CEO and Co-founder, ImagEval Consulting (United States)

Panelist: Matthias Neissner, Technical University of Munich (Germany)

Panelist: Paul Debevec, Netflix, Inc. (United States)

Panelist: Hany Farid, University of California, Berkeley (United States)

Invited: Postmodernism

Session Chairs: Reiner Eschbach, Norwegian University of Science and Technology (Norway) and Monroe Community College (United States) and Gabriel Marcu, Apple Inc (United States)

12:50 – 13:30

COLOR-353

Postmodernism (Invited), Scott Daly, Dolby Laboratories, Inc. (United States)

Appearance and Perception II

Session Chairs: Phil Green, Norwegian University of Science and Technology (NTNU) (Norway) and John McCann, McCann Imaging (United States)

13:55 – 14:35

13:55

COLOR-363

Initial findings on changing the background in pseudo-isochromatic charts, Reiner Eschbach^{1,2} and Peter Nussbaum¹;

¹Norwegian University of Science and Technology (Norway) and ²Monroe Community College (United States)

14:15

COLOR-364

Similarity between two color areas, Tieling Chen, University of South Carolina (United States)

Beauty

Session Chairs: Jan Allebach, Purdue University (United States) and Scott Daly, Dolby Laboratories, Inc. (United States)

18:20 – 19:00

18:20

COLOR-373

A color image analysis tool to help users choose a makeup foundation color, Yafei Mao¹, Christopher Merkle², and Jan P.

Allebach¹; ¹Purdue University and ²MIME Inc. (United States)

18:40

COLOR-374

New image processing algorithm towards more realistic expression on hair coloring, Boram Kim and Hyeon-Jeong Suk, Korea Advanced Institute of Science and Technology (KAIST) (Republic of Korea)

Applications

Session Chairs: Scott Daly, Dolby Laboratories, Inc. (United States) and Reiner Eschbach, Norwegian University of Science and Technology (Norway) and Monroe Community College (United States)

19:15 – 20:15

19:15

COLOR-375

Printed paper-based devices for detection of food-borne contaminants: New device design and new colorimetric image analysis methods, Qiyue Liang, Min Zhao, Ana M. Ulloa Gomez, George T.-C. Chiu, Lia Stanciu, Amanda J. Deering, and Jan P.

Allebach, Purdue University (United States)

19:35

COLOR-376

Prototyping of low-cost color enhancement lighting using multicolor LEDs, *Camille Kabore¹, Masaru Tsuchida², Ikunori Suzuki¹, Satoshi Sugaya¹, Akisato Kimura², and Noboru Harada²; ¹Institute of Technologists and ²NTT Communication Science Laboratories (Japan)*

19:55

COLOR-377

Pokemon color adjustments for augmented reality contents, *Taesu Kim, Donggun Lee, and Hyeon-Jeong Suk, Korea Advanced Institute of Science and Technology (KAIST) (Republic of Korea)*