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PROCEEDINGS

IS&T International Symposium on

Electronic Imaging

SCIENCE AND TECHNOLOGY

28 January 2018 – 1 February 2018 • Burlingame, CA, USA

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

Editors: **Reiner Eschbach,** Norwegian Univ. of Science and Technology (Norway) and Monroe Community College (United States)
Gabriel G. Marcu, Apple Inc. (United States)
Alessandro Rizzi, Univ. degli Studi di Milano (Italy)

These papers represent the program of Electronic Imaging 2018,
held 28 January – 1 February 2018, at the Hyatt Regency San Francisco Airport in Burlingame, CA.

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

Conference Overview

Color imaging has historically been treated as a constant phenomenon well 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, e.g., 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 for presenting, as well as getting acquainted with, the most recent developments in color imaging researches, technologies, and applications. The 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.

The conference covers also 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.

Astro Photography Highlight

On Tuesday, Color Imaging XXIII hosted a series of four sessions on Imaging and Astronomy. Of particular note, Professor Joel Primack presented insights into his work using supercomputers to simulate and visualize the evolution of the universe and the formation of galaxies under various assumptions, and compared the predictions of these theories to the latest observational data. The morning session in this series included presentation of selected images from NASA's library of astrophotographic images.

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

Monday January 29, 2018

Plenary Session

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

Overview of Modern Machine Learning and Deep Neural Networks - Impact on Imaging and the Field of Computer Vision, *Greg Corrado, Google, Inc. (United States)*

Dr. Greg Corrado, co-founder of Google Brain, principal scientist, and director of augmented intelligence research at Google, provides an overview of modern machine learning and deep neural networks, with particular attention to its impact on imaging and the field of computer vision.

Dr. Corrado is a senior research scientist interested in biological neuroscience, artificial intelligence, and scalable machine learning. He has published in fields ranging across behavioral economics, neuromorphic device physics, systems neuroscience, and deep learning. At Google he has worked for some time on brain inspired computing, and most recently has served as one of the founding members and the co-technical lead of Google's large scale deep neural networks project. Prior to joining Google, Dr. Corrado was a staff research scientist at IBM. He received his MS in computer science and PhD in neuroscience from Stanford University.

3:00 – 3:30 pm Coffee Break

Surface Appearance Modeling and Reproduction JOINT SESSION

Session Chairs: Reiner Eschbach, Norwegian University of Science and Technology (Norway) and Monroe Community College (United States) and Mathieu Hebert, Université Jean Monnet de Saint Etienne (France)

3:30 – 4:50 pm
Cypress A

This session is jointly sponsored by: Color Imaging XXIII: Displaying, Processing, Hardcopy, and Applications, and Material Appearance 2018.

3:30 MAAP-165
Color prediction based on individual characterizations of the ink layers and print support, *Théo Phan Van Song[1,2], Christine Andraud[2], Luis Sapaico[1], and Maria Ortiz Segovia[1]; [1]Océ Print Logic Technologies — Canon Group and [2]Museum National d'Histoire Naturelle (France)*

3:50 MAAP-166
Light interreflections and shadowing effects in a Lambertian V-cavity under diffuse illumination, *Dorian Saint-Pierre[1], Rada Deeb[1], Damien Muselet[1], Lionel Simonot[1,2], and Mathieu Hebert[1]; [1]Université Jean Monnet de Saint Etienne and [2]Institut Pprime (France)*

4:10 MAAP-167
Interactive RGB transparency: A color rendering tool for superimposed translucent layers in digital images, *Lionel Simonot[1,2] and Mathieu Hebert[3]; [1]Institut Pprime, [2]Laboratoire Hubert Curien, and [3]Université Jean Monnet de Saint Etienne (France)*

4:30 MAAP-168
General method for estimating fluorescent Donaldson matrices, *Shoji Tominaga, Keita Hirai, and Takahiko Horiuchi, Chiba University (Japan)*

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

Tuesday, January 30, 2018

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

Color & Displays

Session Chair: Gabriel Marcu, Apple Inc. (United States)

8:50 – 10:10 am
Cypress B

8:50 COLOR-185
High-quality imaging micro-LED display based on quantum dot CSP technology, *Dae-Sik Kim, Sung-Yeol Kim, Jong-Hun Jung, and Seung-Young Shin, Samsung Electronics (Republic of Korea)*

9:10 COLOR-186
Color and quality enhancement of videoconferencing white-boards (JPI-first), *Carlos Andrés Arango Duque, Mekides Assefa Abebe, Muhammad Shahid, and Jon Yngve Hardeberg, Norwegian University of Science and Technology (Norway)*

9:30 COLOR-187
Optical characterization of the emissive properties of HDR/WCG displays using ICtCp color space and Fourier optics viewing angle instruments, *Pierre Boher[1], Thierry Leroux[1], and Pierre Blanc[2]; [1]ELDIM and [2]Laboratoires d'Essai de la FNAC (France)*

9:50 COLOR-188
Visibility of natural scene of background when viewed through transparent display with on-screen content, *Chang-Mo Yang, Dong-Hyeok Lee, and Choon-Woo Kim; Inha University (Republic of Korea)*

10:00 AM – 7:30 pm Industry Exhibition

10:10 – 10:40 am Coffee Break

Imaging and Astronomy Morning Session

Session Chair: Daniele Marini, Università degli Studi di Milano (Italy)

10:40 AM – 12:40 pm
Cypress B

10:40 COLOR-221
Color characterization methods for a multispectral camera, *Haris Ahmad Khan[1,2] and Phil Green[1]; [1]Norwegian University of Science and Technology (Norway) and [2]University de Bourgogne (France)*

11:00 COLOR-222 [no paper]
NASA's astronomy picture of the day: Popular and innovative images in modern astrophotography, *Robert Nemiroff[1] and Jerry Bonnell[2]; [1]Michigan Technological University and [2]NASA's GSFC (United States)*

11:40 COLOR-223
Evaluation for faithful reproduction of star fields in a planetarium (JIST-first), *Midori Tanaka[1], Takahiko Horiuchi[1], Ken'ichi Otani[2], and Po-Chieh Hung[3]; [1]Chiba University, [2]Konica Minolta Planetarium Co., Ltd., and [3]Ex-Konica Minolta, Inc. (Japan)*

12:00 COLOR-224
Distributed fast radio burst detection: Algorithm and application, *Stephen Itschner, Kevin Bandura, and Xin Li, West Virginia University (United States)*

12:20 COLOR-225

Can Pop-Tart® wrappers be used to make safe eclipse glasses?, *Katherine Carpenter and Susan Farnand, Rochester Institute of Technology (United States)*

12:40 – 2:00 pm Lunch

Plenary Session

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

Fast, Automated 3D Modeling of Buildings and Other GPS Denied Environments, *Avideh Zakhor, University of California, Berkeley (United States)*

Professor Avideh Zahkor discusses fast, automated 3D modeling of buildings and other GPS denied environments with examples from her work in 3D reality capture, and visual and metric documentation of building interiors. Dr. Zakhor is a serial entrepreneur with startups in outdoor mapping, indoor mapping, and micro-lithography, currently CEO and founder of Indoor Reality, a Silicon Valley startup with products in 3D reality capture, and visual and metric documentation of building interiors.

Dr. Zakhor has been faculty member at University of California, Berkeley since 1994 where she holds the Qualcomm Chair in the electrical engineering and computer science department. She co-founded OPC technology in 1996, which was acquired by Mentor Graphics in 1998, and UrbanScan Inc. in 2005, acquired by Google in 2007. UrbanScan created the first fully automated 3D outdoor mapping system for 3D exterior models of buildings in urban environments. She has received a number of best paper awards in 3D computer vision, image processing, signal processing, is an IEEE fellow, and received the presidential young investigator award in 1992. Dr. Zakhor received her BSc in electrical engineering, from the California Institute of Technology (1983), and her MS (1985) and PhD (1987) in electrical engineering and computer science from MIT.

3:00 – 3:30 am Coffee Break

Keynote: Imaging and Astronomy, Prof. Joel Primack Joint Session
Session Chairs: Susan Farnand, Rochester Institute of Technology (United States) and Kurt Niel, University of Applied Sciences Upper Austria (Austria)

3:30 – 4:30 pm
Cypress B

This session is jointly sponsored by: Color Imaging XXIII: Displaying, Processing, Hardcopy, and Applications, and Image Quality and System Performance XV.

COLOR-259 [no paper]

Computer vision and deep learning applied to simulations and imaging of galaxies and the evolving universe, *Joel Primack, University of California, Santa Cruz (United States)*

The keynote speaker is Dr. Joel R. Primack, Distinguished Professor of Physics Emeritus, University of California, Santa Cruz. Dr. Primack specializes in the formation and evolution of galaxies and the nature of the dark matter that makes up most of the matter in the universe. After helping to create what is now called the "Standard Model" of particle physics, Dr. Primack began working in cosmology in the late 1970s, and he became a leader in the new field of particle astrophysics. His 1982 paper proposed that a natural candidate for the dark matter is the lightest supersymmetric particle, still perhaps the leading candidate. He is one of the principal originators and developers of the theory of Cold Dark Matter, which has become the basis for the standard modern picture of structure formation in the universe. With support from NASA, NSF, and DOE, he has been using supercomputers to simulate and visualize the evolution of the universe and the formation of galaxies under various assumptions, and comparing the predictions of these theories to the latest observational data. He organized and led the University of California systemwide Center for High-Performance Astro-Computing, 2010-2015. Dr. Primack was one of the main advisors for the Smithsonian Air and Space Museum's 1996 IMAX film Cosmic Voyage, and he has worked with leading planetariums to help make the invisible universe visible.

Imaging and Astronomy Afternoon Session Joint Session

Session Chairs: Susan Farnand, Rochester Institute of Technology (United States) and Alessandro Rizzi, Università degli Studi di Milano (Italy)

4:30 – 5:10 pm
Cypress B

This session is jointly sponsored by: Color Imaging XXIII: Displaying, Processing, Hardcopy, and Applications, and Image Quality and System Performance XV.

4:30 COLOR-285

About color correction in astrophotography, *Daniele Marini, Cristian Bonanomi, and Alessandro Rizzi, Università degli Studi di Milano (Italy)*

4:50 SD&A-286

TileViz: Tile visualization for astro-chemistry, *Martial Mancip[1], Riccardo Spezia[2,3], Yannick Jeanvoine[2], and Cécile Balsier[1]; [1]Maison de la Simulation, CEA, CNRS, UVSQ, UPSud, [2]LAMBE, Univ Evry, CNRS, CEA, Université Paris-Saclay, and [3]Sorbonne Université, CNRS, Laboratoire de Chimie Théorique (France) [Included in this COLOR proceedings.]*

Imaging and Astronomy Discussion JOINT SESSION
Session Chairs: Susan Farnand, Rochester Institute of Technology (United States) and Daniele Marini, Università degli Studi di Milano (Italy)

5:10 – 5:30 pm
Cypress B

This session is jointly sponsored by: Color Imaging XXIII: Displaying, Processing, Hardcopy, and Applications, and Image Quality and System Performance XV.

Symposium Demonstration Session

5:30 – 7:30 pm
Grand Peninsula Ballroom E

Wednesday January 31, 2018

Color Modeling Applications

Session Chair: Phil Green, Norwegian University of Science and Technology (Norway)

8:50 – 9:50 am
Cypress B

8:50 COLOR-295
Illuminant color estimation in an image under several illuminants based on gray-world assumption, *Harumi Kawamura, Salesian Polytechnic (Japan)*

9:10 COLOR-296
Explanation of color lines based on a simple color image model, *Megan Fuller and Jae Lim, Massachusetts Institute of Technology (United States)*

9:30 COLOR-297
Detection of color fading in printed customer content, *Zuguang Xiao[1], Shaoyuan Xu[1], Eric Maggard[2], Mark Shaw[2], Katie Morse[2], and Jan Allebach[1]; [1]Purdue University and [2]HP Inc. (United States)*

10:00 AM – 4:00 pm Industry Exhibition

10:10 – 10:40 am Coffee Break

Color Appearance

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

10:40 AM – 11:40 am
Cypress B

10:40 COLOR-321
Near-Infrared fusion for photorealistic image dehazing, *Frederike Dümbgen, Majed El Helou, Natalija Gucevska, and Sabine Süsstrunk, Ecole Polytechnique Fédérale de Lausanne (Switzerland)*

11:00 COLOR-323
Color appearance processing using iccMAX, *Max Derhak[1], Phil Green[2], and Michele Conni[3]; [1]Onyx Graphics (United States), [2]Norwegian University of Science and Technology (Norway), and [3]Barbieri Electronic (Italy)*

11:20 COLOR-324
Chromaticity matrix to tristimulus matrix conversion for RGB color spaces – even in the dark, *J. A. Stephen Viggiano, Nanette Salvaggio, and Nitin Sampat, Rochester Institute of Technology (United States)*

11:40 am – 2:00 pm Lunch

Plenary Session

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

Ubiquitous, Consumer AR Systems to Supplant Smartphones, *Ronald T. Azuma, Intel, Corp. (United States)*

Dr. Ronald T. Azuma, researcher and augmented reality pioneer, shares his vision for achieving ubiquitous, consumer AR systems. Recent large investments in augmented reality reflect the commercial interest in its inherent potential to replace current smartphone technology, but much remains to be done. In his talk, Dr. Azuma gives a vision for achieving this goal, which requires not just solving numerous technical challenges but also determining new, compelling AR experiences that will establish AR as a new platform and novel form of media.

Dr. Azuma leads a team in Intel Labs that designs and prototypes novel experiences and key enabling technologies to enable new forms of media. These technology areas include computational imaging and photography, computational displays, and head-worn displays. Dr. Azuma is recognized as a pioneer and innovator in augmented reality, and has held prominent leadership roles in that research area, including leading and implementing research projects and demonstrations in areas such as AR, visualization, and mobile applications. Dr. Azuma received his BSc (1988) in electrical engineering from University of California, Berkeley, and MS (1990) and PhD (1995) in computer science from University of North Carolina, Chapel Hill. Prior to joining Intel, he was a research leader at Nokia Research Center Hollywood, and a senior researcher at Hughes Research Laboratories.

3:00 – 3:30 pm Coffee Break

Multispectral Analysis

Session Chair: Ivar Farup, Norwegian University of Science and Technology (Norway)

3:30 – 4:50 pm
Cypress B

3:30 COLOR-361
Assessing the useful of similarity measures for multispectral face recognition, *Mamadou Diarra[1,2], Pierre Gouton[1], and Jerome Kablan Adou[2]; [1]Université de Bourgogne (France) and [2]Université Félix Houphouët-Boigny Cocody (Côte d'Ivoire)*

3:50 COLOR-362
Comparative study of biorthogonal wavelets accuracy in demosaicing algorithm based on wavelet analysis of luminance component, *Norbert Hounsou[1,2], Amadou Tidjani Sanda Mahama[1,2], Pierre Gouton[3], and Jean-Baptiste Thomas[4]; [1]University de Abomey-Calavi (Benin), [2]Institut de Mathématiques et de Sciences Physiques (Benin), [3]Université de Bourgogne (France), and [4]Norwegian University of Science and Technology (Norway)*

4:10 COLOR-363
Optimal color multiplexing for low-cost structured light 3D capture system with two projectors, *Yang Lei[1] and Jan Allebach[2]; [1]HP Labs and [2]Purdue University (United States)*

4:30 COLOR-364
Colorful insights supporting the modeling of creative processes across language, music, and emotion, *Fritz Lebowsky[1] and Mónica López-González[2]; [1]STMicroelectronics (France) and [2]La Petite Noiseuse Productions (United States)*

Color Discussion
4:50 – 5:30 pm
Cypress B

Symposium Interactive Papers (Poster) Session

5:30 – 7:30 pm
The Grove

Meet the Future: A Showcase of Student and Young Professionals Research

5:30 – 7:30 pm
The Grove

Thursday February 1, 2018

Color Gamuts and More

Session Chair: Robert Ulichney, HP Labs, HP Inc. (United States)

9:10 – 10:10 am
Cypress B

9:10 COLOR-416
New gamut boundary target for defining the colour gamut of a printing system, *W. Craig Revie[1] and Phil Green[2]; [1]FFEI Ltd. (United Kingdom) and [2]Norwegian University of Science and Technology (Norway)*

9:30 COLOR-417
Media color adaptive gamma correction, *Jaemin Shin, Hyunsoo Oh, Kyeongman Kim, and Seong-Wook Han, S-Printing Solutions (Republic of Korea)*

9:50 COLOR-418
Recent advances in detection and healing of streaks caused by dust in a sheetfed scanner, *Daulet Kenzhebalin[1], Ni Yan[1], Peter Bauer[2], Jerry Wagner[2], and Jan Allebach[1]; [1]Purdue University and [2]HP Inc. (United States)*

10:10 – 10:40 am Coffee Break

Halftoning, Watermarking, Barcodes

Session Chair: Robert Ulichney, HP Labs, HP Inc. (United States)

10:40 am – 12:20 pm
Cypress B

10:40 COLOR-427
Color CLU-DBS halftoning based on Neugebauer primary area coverage: Improving the breed, *Weijuan Xi[1], Tal Frank[2], Yotam Ben-Shoshan[2], Robert Ulichney[3], and Jan Allebach[1]; [1]Purdue University (United States), [2]HP Inc. (Israel), and [3]HP Labs, HP Inc. (United States)*

11:00 COLOR-428
Monochrome hybrid, multilevel, halftone screen with unequal spatial resolution for a low-cost electrophotographic printer, *Wan-Eih Huang[1], Tongyang Liu[1], Kurt Bengtson[2], and Jan Allebach[1]; [1]Purdue University and [2]HP Inc. (United States)*

11:20 COLOR-429
Novel color halftoning algorithm for ink savings, *Wanling Jiang[1], Alex Veis[2], Robert Ulichney[3], and Jan Allebach[1]; [1]Purdue University, [2]HP Scitex (Israel), and [3]HP Labs, HP Inc. (United States)*

11:40 COLOR-430
Analysis of a visually significant bar code system based on circular coding, *Yufang Sun[1], Robert Ulichney[2], Matthew Gaubatz[2], Stephen Pollard[3], Steven Simske[2], and Jan Allebach[1]; [1]Purdue University, [2]HP Labs, HP Inc. (United States), and [3]HP Labs, United Kingdom (United Kingdom)*

12:00 COLOR-431
UV watermarking of images in clustered dot scenarios, *Vlado Kitanovski[1], Reiner Eschbach[1,2], Marius Pedersen[1], and Jon Yngve Hardeberg[1]; [1]Norwegian University of Science and Technology (Norway) and [2]Monroe Community College (United States)*