Twentieth Color and Imaging Conference

Color Science and Engineering Systems, Technologies, and Applications

www.imaging.org/ist/conferences/cic

UPDATED VERSION (09/18/12) with SHORT COURSE TIME CHANGE

November 12-16, 2012
Los Angeles, California

Cooperating Societies
- Inter-Society Color Council (ISCC)
- Imaging Society of Japan (ISJ)
- Royal Photographic Society of Great Britain (RPS)
- Society of Motion Picture and Television Engineers (SMPTE)
- Society of Photographic Science and Technology of Japan (SPSTJ)

Sponsored by Society for Imaging Science and Technology and Society for Information Display
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Become part of the CIC online community!
Search LinkedIn groups for “color and imaging conference”

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©2012 Society for Imaging Science and Technology (IS&T) and Society for Information Display (SID)
Introducing CIC20!

The 20th IS&T/SID Color and Imaging Conference (CIC20) takes place in California. Its location in downtown Los Angeles provides an outstanding opportunity for leading color, graphics, and imaging professionals from Hollywood to interact with visiting industry colleagues and world-class academics involved in color science, vision science, materials appearance, and visual perception research and development.

The technical program features 3 keynote, 5 invited, 37 oral, and 26 interactive papers covering a broad range of color topics organized into sessions ranging from motion imaging and temporal color to communicating color, illuminant estimation, and color perception.

We are proud to announce three-highly distinguished keynote speakers:

• Paul Debevec, a research professor from the Institute for Creative Technologies at University of Southern California who has pioneered techniques for illuminating computer-generated objects using measurements of real-world illumination, will present “Creating Photoreal Digital Actors: Capturing Light and Reflectance.”

• Mark Fairchild, a professor in the Munsell Color Science Laboratory at Rochester Institute of Technology with an impressive record of achievement in the fields of color imaging and color vision, will review 20 years of research presented at CIC in “Progress and Poverty: An Inquiry into Color Appearance Modelling and Increase of Want with Increase of Wealth.”

• Robert W.G. Hunt, the elder statesman of color well-known to regular CIC attendees, will conclude his recent trilogy of keynote presentations with a final CIC keynote “The Challenge of our Unknown Unknowns.”

Wednesday evening will feature a highly anticipated special event hosted by the Academy of Motion Pictures that is not to be missed (see page 4 for details), and Thursday evening will feature Phil Tippett a movie director and an award-winning visual effects supervisor and producer, who specializes in creature design and character animation.

We are celebrating 20 years of CIC and are delighted to include special presentations that look back upon the progress that has been made during the past 20 years and speculate on what the future may hold for color imaging. These invited presentations are given by some of the leaders in the field including Ronnier Luo, John McCann, Jan Morovic, Shoji Tominaga, and Joyce Farrell, who will look back at the late Lou Silverstein’s work with a presentation entitled “A Life in Color: Lou Silverstein’s Contributions to Color in Displays.”

—Stephen Westland and Xuemei Zhang, CIC20 General Chairs
Conference At-a-Glance

Monday, November 12
Registration open 7:00 – 9:00 am and 5:00 – 6:00 pm
• Color Science and Imaging: Day 1*
• ICC DevCon* (see page 8 for details)

Tuesday, November 13
Registration open 7:00 am – 6:00 pm
• Color Science and Imaging: Day 2*
• Short Course Program (see descriptions beginning page 9)
• Welcome Reception: Celebrating CIC@20 with Games and Trivia

Wednesday, November 14
Registration open 8:00 am to 4:15 pm
• Keynote: Paul Debevec—Creating Photoreal Digital Actors: Capturing Light and Reflectance
• Technical Sessions
  • Motion Imaging and Temporal Color
  • Communicating Color
  • Illuminant Estimation
  • Spotlight Session 1
  • Virtual Color
• Special Evening Event at the Academy of Motion Picture Arts and Sciences—see p. 4

Thursday, November 15
Registration open 8:30 am – 4:00 pm
• Keynote: Mark Fairchild—Progress and Poverty: An Inquiry into Color Appearance Modeling and Increase of Want with Increase of Wealth
• IS&T Honors and Awards Presentations
Technical Sessions
• Medical Color
• Colorimetry
• Spotlight Session 2
• Color Algorithms
• Interactive Paper Session
• Evening Talk: Phil Tippett—Title TBA

Friday, November 16
Registration open 8:30 am to 2:15 pm
• Keynote: Robert G.W. Hunt—The Challenge of our Unknown Unknowns
• Cactus Award Presentation
• Technical Sessions
  • Color Imaging
  • Color Perception
  • Printing
• Late Breaking News

*Separate registration fee required.

Conference Venue:
Doubletree by Hilton Hotel Los Angeles Downtown

CIC20 will take place in the Doubletree by Hilton Hotel Los Angeles Downtown (formerly the Kyoto Grand Hotel and Gardens). The Doubletree is located in downtown LA, in the heart of Japantown/Little Tokyo. It boasts a lovely rooftop Japanese garden and is within walking distance of many of LA’s local attractions. There are authentic Japanese restaurants just outside its doors.

The Little Tokyo Historic District is an ethnic Japanese American area and one of only three official Japantowns in the United States, all of which are in California.

The hotel is four blocks from Union Station and five from Olvera Street. Olvera Street, located in the oldest part of downtown LA is part of the El Pueblo de Los Angeles Historic Monument. The street is famous for its many Mexican restaurants and shops. Also near the hotel are the well-regarded Japanese American National Museum (two blocks away) and the Geffen Contemporary at MOCA (four blocks away), which features ultra-modern art from the Museum of Contemporary Art, Los Angeles.
Technical Program

Wednesday November 14, 2012

9:00 – 10:00 AM
WELCOME REMARKS AND KEYNOTE
Session Chair: Xuemei Zhang, Apple Inc.

Creating Photoreal Digital Actors: Capturing Light and Reflectance, Paul Debevec, University of Southern California’s Institute for Creative Technologies (USA)

10:00 – 11:00 AM
MOTION IMAGING AND TEMPORAL COLOR
Session Chairs: Joshua Pines, Technicolor, and Joseph Goldstone, ARRI, Inc.

Visual Attention based Surveillance Videos Compression, Fahad Fazal Elahi Guraya, Victor Medina, and Faaouzi Alaya Cheikh, University College Gjøvik (Norway)
Improved Video Compression using Perceptual Modeling, Mark Q. Shaw, Hewlett-Packard Company; Albert Parra and Jan P. Allebach, Purdue University (USA)
Boosting Luminance of a Colour-Sequential Display, M. Hammer, K.J.G. Hinnen, and E.H.A. Langendijk, TP Vision (the Netherlands)

11:45 AM – 12:55 PM
COMMUNICATING COLOR
Session Chair: Geoff Woolfe, Canon Information Systems Research Australia Pty. Ltd.

CIC@20: The Continuing “Tale of Two Paradigms” (Invited), John McCann, McCann Imaging (USA)
A Large-Scale Multi-Lingual Color Thesaurus, Albrecht Lindner, Bryan Zhi Li, Nicolas Bonnier; École Polytechnique Fédérale de Lausanne (Switzerland) and Océ Print Logic Technologies S.A. (France)
Games with Hypotheses: Color, Text and Texture, Nathan Moroney, Hewlett-Packard

12:55 PM – 2:15 PM
LUNCH

2:15 – 3:15 PM
ILLUMINANT ESTIMATION
Session Chair: Graham Finlayson, University of East Anglia

The Role of Bright Pixels in Illumination Estimation, Hamid Reza Vaezi Joze and Mark S. Drew, Simon Fraser University (Canada); Graham D. Finlayson and Perla A. Troncoso Rey, University of East Anglia (UK)
Scene Illuminant Estimation of Multiple Light Sources, Shoji Tominaga, Takahiko Horiuchi, and Yu Kato, Chiba University (Japan)
Reducing Worst-Case Illumination Estimates for Better Automatic White Balance, Milan Mosny and Brian Funt, Simon Fraser University (Canada)

THURSDAY EVENING SPEAKER

Join colleagues to hear Phil Tippett, founder of Tippett Studio. Tippett’s career in visual effects has spanned more than 30 years and includes work on “Star Wars”, “RoboCop”, “Willow”, and “The Twilight Saga.” He has two Academy Awards (six nominations), one BAFTA, and two Emmys.
3:15 – 3:45 PM
SPOTLIGHT SESSION 1
Session Chairs: Vien Cheung, University of Leeds, and Yonghui (Iris) Zhao, Apple Inc.

Two-minute previews of papers that will be presented during the Interactive Paper Session Wednesday afternoon.

Spectral Representation of Object Colours, Yi-Fan Chou,¹,² Vien Cheung,¹ M. Ronnier Luo,¹ and San-Liang Lee²; ¹University of Leeds (UK) and ²National Taiwan University of Science and Technology (Taiwan)

Improvement of Camera Characterization Process for Different Capturing Geometries using Saunderson Equation, Farhad Moghareh Abed and Roy S. Berns, Rochester Institute of Technology (USA); Kenichiro Masaoka, NHK Science & Technology Research Laboratories (Japan)

Simulation of Image Appearance using Contrast Sensitivity Functions and Wavelets, Marius Pedersen and Ivar Farup, Gjøvik University College (Norway)

A Closed Form Solution for the Brightness Preserving Colour to Greyscale Image Conversion, Graham D. Finlayson and Toby N. Matheson, University of East Anglia (UK)

Webcam-based Display Calibration, Jean-Baptiste Thomas, University of Burgundy (France); and Jérémie Gerhardt, Fraunhofer FIRST (Germany)

A LUT-based Method for Recovering Color Signals from High Dynamic Range Images, Keita Hirai and Shoji Tominaga, Chiba University (Japan)

Ascertainment of Perceptual Classification for Material Appearance, Shoji Yamamoto, Tokyo Metropolitan College of Industrial Technology; Masashi Sawabe, Chiba University; Yasuki Yamauchi, Yamagata University; and Tsumura Norimichi, Chiba University (Japan)

Evaluation of Authenticity by using Perceptually-based Rendering for Reflection Image, Natsumi Hosokawa,¹ Mayu Yokoya,¹ Shoji Yamamoto,² and Norimichi Tsumura; ¹Chiba University and ²Tokyo Metropolitan College of Industrial Technology (Japan)

Removing Outliers in Illumination Estimation,

WEDNESDAY EVENING SPECIAL PROGRAM

COLOR IN MOTION: THE ART AND SCIENCE OF COLOR IN THE MOVIES

Join colleagues for a very special event
Wednesday, November 14, 2012

6:30 reception / 7:30 program

Presented by the Academy of Motion Picture Arts and Sciences’s Science and Technology Council, this program will highlight the significant advancements in color in the movies, from the transition from black-and-white all the way up to contemporary film and digital motion picture images.

Samual Goldwyn Theater
8949 Wilshire Boulevard  ●  Beverly Hills, California
www.oscars.org/events-exhibitions/venues-ticketing/goldwyn.html

Bus transportation to/from the conference hotel and the event will be provided.
Thursday November 15, 2012

9:00 – 10:00 AM
KEYNOTE
Session Chair: Stephen Westland, University of Leeds

Progress and Poverty: An Inquiry into Color Appearance Modeling and Increase of Want with Increase of Wealth, Mark Fairchild, Munsell Color Science Lab / RIT (USA)

10:00 – 11:00 AM
MEDICAL COLOR
Session Chair: TBA

Automated Pre-processing Method for Dermoscopic Images and its Application to Pigmented Skin Lesion Segmentation, Ali Madooei, Mark Drew, Maryam Sadeghi, and Stella Atkins, Simon Fraser University (Canada)

Color Hit-or-Miss Transform on Dermatological Images, Audrey Ledoux, Noël Richard, Anne-Sophie Capelle-Laiizé, and Christine Fernandez-Maloigne, University of Poitiers (France)

Rendering of Human Teeth and Restorative Bio Materials, Jin Woo Jung, Gary Meyer, and Ralph DeLong, University of Minnesota; and Brian N. Holmes, 3M (USA)

11:45 AM – 12:55 PM
COLORIMETRY
Session Chair: Gabriel Marcu, Apple Inc.

CIC@20: Multispectral Imaging, Shoji Tominaga, Chiba University (Japan)

Evaluation of Performance of Several Color-Difference Formulae using a New NCSU Black Experimental Dataset, Renzo Shamey, Juan Lin, Weethima Sawatwarakul, and Gang Fang, North Carolina State University (USA)

Analysis and Correction of the Joensuu Munsell Glossy Spectral Database, Maxim W. Derhak,¹, ² and Roy S. Berns;² ¹Onyx Graphics Corporation and ²Rochester Institute of Technology (USA)
Two-minute previews of papers that will be presented during the Interactive Paper Session later Wednesday afternoon.

CAT02 and HPE Triangles, Changjun Li, University of Science and Technology Liaoning (China); M. Ronnier Luo, University of Leeds (UK); and Manuel Melgosa University of Granada (Spain)

Visual Appearance of Printed Special Effect Colors, Katharina Kehren, Philipp Urban, and Edgar Dörsam, Technische Universität Darmstadt (Germany)

Multi-angle Analysis of Metallic Paint Appearance and the Visually Identifiable Sparkling Grades: From Microscopic to Macroscopic, Ming-Jiu Huang, Hung-Shing Chen, and Chao-hua Wen, National Taiwan University of Science and Technology (Taiwan); and M. Ronnier Luo, University of Leeds (UK)

Reproduction of Gloss Unevenness on Printed Paper by Reflection Model with Consideration of Mesoscopic Facet, Rui Takano,¹ Kaori Baba,¹ Shinichi Inoue,² Kimiyoshi Miyata,³ and Norimichi Tsumura¹;¹ Chiba University, ²Mitsubishi Paper Mills Limited, and ³National Museum of Japanese History (Japan)

Embedding Two-Dimensional Barcodes into Graphics, Yonghui Zhao and Zhigang Fan, Xerox Corporation (USA)

Simulation of Paper Gloss by Point Spread Function of Specular Reflection, Kaori Baba,¹ Rui Takano,¹ Shinichi Inoue,² Kimiyoshi Miyata,³ and Norimichi Tsumura¹;¹ Chiba University, ²Mitsubishi Paper Mills Limited, and ³National Museum of Japanese History (Japan)

Color Correction in Whole Slide Digital Pathology, Yuri Murakami, Hikaru Gunji, Fumikazu Kimura, and Masahiro Yamaguchi, Tokyo Institute of Technology (Japan); Yoshiko Yamashita and Akira Saito, NEC Corporation (Japan); Tokiya Abe and Michie Sakamoto, Keio University (Japan); Pinky A. Bautista and Yukako Yagi, Massachusetts General Hospital and Harvard University Medical School (USA)

Model-based Local Contrast Enhancement for Magnified Images, Youn Jin Kim and Seung Ran Park, Samsung Electronics Company (Korea)

How do Major Color-Difference Formulae Perform in the High Chroma Blue Region?, Renzo Shamey, Renbo Cao, Syed Shahzad Hussain Zaidy, Juan Lin, and Seung Geol Lee, North Carolina State University (USA)

Angular Variations of Reflectance and Fluorescence from Paper—the Influence of Fluorescent Whitening Agents and Fillers, Niklas Johansson and Mattias Andersson, Mid Sweden University (Sweden)

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2:45 – 3:55 PM
COLOR ALGORITHMS
Session Chair: Mike Brill, Datacolor

CIC@20: 20 Years of Colour Appearance Research at CIC, Ronnier M. Luo, University of Leeds (UK)

Making the Calculation of Logvinenko’s Coordinates Easy, Graham D. Finlayson and Michal Mackiewicz, University of East Anglia; and Anya Hurlbert, Newcastle University (UK)

Analysis of Irregular Sampling for Local Interpolation, Kok-Wei Koh, Nathan Moroney, and Melanie Gottwals, Hewlett-Packard Laboratories (USA)
3:55 – 5:55 PM
INTERACTIVE PAPERS

8:00 – 8:50 PM
EVENING LECTURE
Session Chair: Alex Forsythe, Academy of Motion Picture Arts and Sciences

Title TBA, Phil Tippett, Phil Tippett Studio [USA]

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Friday November 16, 2012

9:00 – 10:00 AM
KEYNOTE
Session Chair: Geoff Woolfe, Canon Information Systems Research Australia Pty. Ltd.

The Challenge of our Unknown Unknowns,
Robert G. W. Hunt, consultant [UK]

10:00 – 11:00 AM
COLOR IMAGING
Session Chair: Sabine Süsstrunk, École Polytechnique Fédérale de Lausanne

Deriving Appearance Scales, Mark D. Fairchild and Rodney L. Heckaman, Rochester Institute of Technology [USA]
The Number of Discriminable Object Colors is Unknown, Kenichiro Masaoka, NHK Science & Technology Research Laboratories [Japan]; Roy S. Bems, Mark D. Fairchild, and Farhad Moghareh Abed, Rochester Institute of Technology [USA]
Two-Color System by Red/Cyan Projections Not Land, Hiroaki Kotera, Kotera Imaging Laboratory [Japan]

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11:45 AM – 12:55 PM
COLOR PERCEPTION
Session Chair: Caterina Ripamonti, University College London

CIC@20: A Life in Color: Lou Silverstein’s Contributions to Color in Displays,
Joyce Farrell, Stanford University [USA]

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2:15 PM – 4:05 PM
PRINTING
Session Chair: Jan Allebach, Purdue University

CIC@20: To Predictability and Beyond: 20 years of Color Printing at CIC, Ján Morovic, Hewlett-Packard Española S.L. (Spain)
Revisiting Spectral Printing: A Data Driven Approach, Peter Morovic, Ján Morovic, Jordi Arnabat, and Juan Manuel Garcia-Reyero, Hewlett-Packard Company [UK]
Spectral Vector Error Diffusion – Promising Road or Dead End?, Ole Norberg, Voxvil AB, and Daniel Nyström, Linköping University [Sweden]
Gamut Expanded Halftone Prints, Romain Rossier and Roger D. Hersch, École Polytechnique Fédérale de Lausanne [Switzerland]
Automatic Semantic-Driven Selection of Printer Color Workflows, Kristyn Falkenstern,¹,² Albrecht Lindner,³ Sabine Süsstrunk,³ and Nicolas Bonnier;¹ ¹Océ Print Logic Technologies S.A. (France), ²Institut Telecom (France), and ³École Polytechnique Fédérale de Lausanne (Switzerland)

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4:05 PM – 5:05 PM
LATE BREAKING NEWS AND MERL BEST STUDENT PAPER AWARD PRESENTATION
Session Chairs: Jennifer Gille, Qualcomm QMT, and Clément Fredembach, Canon Information Systems Research Australia Pty. Ltd. [CISRA]

See page 22 for details on how to submit a LBN paper.
The ICC DevCon 2012 Developers Conference is being held on November 12th in conjunction with the ICC Meetings and CIC20. The meeting will focus on presenting current best color management practices in the areas of graphic arts, motion picture, mobile, and web. Individual use cases, examples, and ways to assure consistency in workflows will be discussed. The “Vision” and the next generation efforts for color management is presented. DevCon 2012 includes discussion of testing and certification of implementations and an introduction into ICC Labs open source efforts.

Confirmed speakers include:
- Chris Cox and Leonard Rosenthal (Adobe)
- Max Derhak (ONYX)
- James Vogh, Jeremiah Snader, and Tom Lianza (X-Rite)
- Bob Hallam (Quad/Graphics)
- Nathan Moroney (Hewlett-Packard)
- Joseph Slomka (FotoKem)
- Jeremy Selan (OpenColorIO)
- Rod Bogart (Pixar)

ICC DevCon 2012 is your opportunity to learn from the experts—experienced developers and users in the imaging, printing and publishing color community. Visit the website noted above to view the preliminary program.

Fees*
- $300 IS&T/SID/ICC members
- $200 each additional registration from the same company
- $400 non-members
- $300 each additional registration from the same company
- $25 students

Early bird special
Register by October 15, 2012 and get $50 off (does not apply to students).

Special Offer
New member companies who join ICC during the DevCon 2012 will receive a reduction of membership fees for the first year in the amount of conference fees paid by the company.

*rates reduced from previous years; you may register for ICC DevCon 2012 when you register for CIC—see page 24
Special Two-Day Class:
Color Science and Imaging
8:30 am – 5:30 pm
Instructor: Geoff Woolfe, Canon Information Systems Research Australia Pty. Ltd. (CISRA)

This intensive two-day course provides comprehensive coverage of the principles of color vision and perception, and color measurement, management, and reproduction. It allows researchers, engineers, and computer graphics specialists to confidently undertake color control, modeling, and design problems.

The course consists of four 3-hour modules with opportunities for questions and discussion. A comprehensive set of course notes is included.

**Module 1** covers the human visual system, mechanisms and models of color vision, and the impact of visual characteristics on the design and optimization of color imaging systems.

**Module 2** introduces the science of colorimetry. It then describes a range of color appearance phenomena and discusses the relationship between spatial and color vision. Several widely used color appearance models are discussed.

**Modules 3 and 4** cover color devices including cameras, displays, projectors and printers. Color measurement, necessary to characterize and model such devices, is discussed. Color device modeling techniques are presented before moving on to discuss color management systems.

**Prerequisites**
A basic education in college science and math is useful. Some experience with color systems is helpful, but not mandatory.

**Benefits**
Attendees will be able to:
- Understand color vision and color appearance and their impact on the design of color imaging and graphics systems.
- Explain luminance and chromatic adaptation mechanisms of the human visual system and how to model them.
- Have an awareness of light sources including incandescent, fluorescent, discharge, and LED lamps and the impact they have on color capture and rendering.
- Understand standard illuminants including daylight, blackbody, and fluorescent.
- Know what is meant by correlated color temperature.
- Understand the principles of color measurement, including the geometry of illumination and viewing.
- Explain the experimental basis of colorimetry.
- Have a working knowledge of color matching functions, CIE XYZ colorimetry and other color spaces, such as CIELAB and CIELUV, derived from it.
- Understand the concept of chromaticity and use and interpret chromaticity diagrams.
- Understand the meaning of perceptually uniform color spaces and know when to use them for modeling and computation.
- Understand the difference between colorimetry and color appearance and have a working knowledge of widely used color appearance models.
- Understand and use a number of color difference formulae.
- Be able to confidently undertake colorimetric calculations and build color models.
- Explain primaries, chromaticity, the effects of changing primaries, and color matching functions.
- Understand illuminant and observer metamamerism and their implications in imaging system design.
• Model color reproduction of both additive and subtractive devices.
• Explain color gamuts and gamut mapping.
• Understand the principles of color image capture and color.
• Have a working knowledge of color management.
• Appreciate the factors that affect the quality of images including aspects of tone and color reproduction.

Geoff Woolfe is the Publications Vice President for IS&T and general manager of Image and Video Research at Canon Information Systems Research Australia. Previously he was principal research scientist in the Xerox Innovation Group (US) and senior principal research scientist at the Kodak Research Laboratories (US). He has been involved in commercial color imaging research for more than 25 years.

Woolfe received his BSc (Honors) and PhD in physical chemistry from the University of Melbourne (Australia) and MS in imaging science from the Rochester Institute of Technology. He was awarded the Mees Award, Kodak’s highest honor for scientific achievement, is a member of the Honor Society of Phi Kappa Phi, and has previously served on the steering committee of the International Color Consortium. He is the author of 28 scientific papers and 45 US and international patents and patent applications in the fields of color and imaging science.

Fee before/after October 15th:

$675/$725 IS&T/SID members
$850/$900 non-members
$265/$315 student member
$290/$340 student non-member

TUESDAY NOVEMBER 13, 2012

Color Science and Imaging Con’t.
8:30 am – 5:30 pm
Instructor: Geoff Woolfe,
Canon Information Systems Research
Australia Pty. Ltd. (CISRA)
See page 9 for description.

8:00 – 10:00 AM COURSES

SC1A: Color Difference Perception for Images
8:00 – 10:00 am (2 hours)
Instructor: M. Ronnier Luo, University of Leeds

This course is divided into two parts: color difference evaluation for color patches and images, respectively. The former covers the fundamentals in understanding color difference assessments such as visual assessment methods, reference viewing condition, and evaluation and development of color difference formulas using visual results. The latter introduces the way and theory to extend the formulae based on patches for evaluating images such as conventional formula with add-on spatial filters, color appearance model based formula, and image appearance model. Furthermore, some experiments conducted and associated with CIE TC8-02 Colour Difference Evaluation for Images will be introduced. The visual results were used to evaluate the performance of various types of formulae.

Benefits: Attendees will be able to:
• Explain the techniques for visually assessing color difference.
• Understand different types of color difference formulae and evaluate their performances.
• Apply color difference formula in the imaging industry.
Intended Audience: color engineers and research scientists involved with color reproduction, imaging device developers, computer software developers. Knowledge of fundamental colorimetry is assumed.

Ming Ronnier Luo is a global expert professor at Zhejiang University (China) and professor of colour and imaging science at University of Leeds (UK). He is also the director of the International Commission on Illumination (CIE) Division 1 (Colour and Vision). Luo received his PhD at the University of Bradford (1986) in the field of colour science. He has more than 370 publications in the field of colour appearance modelling, colour difference evaluation, and colour management of digital imaging products. He is a Fellow of IS&T and the Society of Dyers and Colourists. He is also the chief editor of the Encyclopaedia of Colour Science and Technology to be published by Springer.

SC1B: Role of Color in Human Vision
8:00 – 10:00 am (2 hours)
Instructor: Kathy Mullen, McGill University

This course presents an introduction to two fundamental and linked factors of color vision: the neural systems of the brain that undertake the computation of color, and the function of color for human vision. The first part of the course covers an overview of the aspects of the physical world our color vision informs us about. It discusses how we are able to see color, the basic neural mechanisms of our color vision from the cones in the retina to the cone opponent processes, and the visual cortex of the brain. The second addresses the question “why have color vision” by defining what color vision is good at, and what it is bad at. Experimental approaches are discussed that have allowed the measurement of the spatial contrast-sensitivity function for color and color resolution, and that have revealed the role of color in defining shape and forms in the visual scene and in disambiguating shape and shading. The type of information that human color vision filters out, the temporal contrast-sensitivity function, and the sensitivity of color vision to motion is also be discussed.

Benefits: Attendees will be able to:
• Understand the neural mechanisms of color vision.
• Design psychophysical experiments in color vision.
• Understand the limitations of color vision: the modulation transfer functions of human vision compared for color and luminance information.
• Understand the role of color vision for the analysis of shape and form in an image.

Intended Audience: color engineers, scientists and designers. Those who wish to understand techniques for measuring vision thresholds of contrast sensitivity. Those interested in understanding perceptual metrics or the design of image analyses for chromatic and achromatic components.

Kathy Mullen received her Bachelor Degree in physiology from Oxford University and a PhD in neuroscience from the University of Cambridge. Her PhD supervisor, Horace Barlow, was the great-grandson of Charles Darwin. She remained at the University of Cambridge, where she received a Royal Society University Research Fellowship and a College Fellowship from New Hall, Cambridge. She moved to McGill University in 1990 and is currently a professor of neuroscience, and a world authority on human color vision.
SC1C: LED Lighting: Characterization and Visual Quality
8:00 – 10:00 am (2 hours)
Instructor: Wendy Davis, University of Sydney

Light-emitting diodes (LEDs) promise to reduce the energy consumed by lighting, but will only fulfill this potential if they produce illumination that meets the needs of the users of electric lighting. Since many of the characteristics of LEDs vary significantly from incumbent lighting technologies, their quality considerations also differ. Some of the noteworthy properties of LEDs, such as spectral output and spatial distribution of emitted light, can pose challenges in certain lighting applications, but can be advantageous if applied in new ways. This course explores the way lighting is evolving, how photometry and colorimetry are changing accordingly, and the impact of lighting quality on energy consumption.

Benefits: Attendees will be able to:
• Identify the illumination properties that influence perceptions of visual quality.
• Understand the basic ways that light sources and illumination are quantified.
• Differentiate the characteristics of LEDs from other light sources.
• Evaluate the interactions between various quality measures and light source efficacy.
• Discuss the future of lighting and predict major changes in the application of light.

Intended Audience: assumes minimal prior knowledge; the content is accessible to a wide range of interested persons. This course is of particular interest to lighting designers and specifiers, lighting product manufacturers and developers, architects and other design professionals, color and lighting scientists, and others interested in emerging light technologies.

Wendy Davis is an associate professor in the Faculty of Architecture, Design and Planning at the University of Sydney, where she is the director of the Illumination Design Program. She was previously employed as a vision scientist in the Lighting and Color Group at the National Institute of Standards and Technology (NIST) for more than seven years. Davis earned her PhD (2004) and MS (2001) in vision science from the University of California, Berkeley.

SC1D: The Digital Camera Image Processing Pipeline – From Pixels to Picture
8:00 – 10:00 am (2 hours)
Instructor: Matt Whalen, Applied Color Science Inc.

The collection of image processing elements (Bayer de-mosaic, color matrix, exposure control, gamma, white balance, sharpening, hue/saturation control etc.) in digital cameras and image sensors that transform raw pixel output from an image sensor into full color video or still images is described in this course. It also explains the function of each processing element and discusses various implementations and tradeoffs for each with examples.

Benefits: Attendees will be able to:
• Understand the elements of a digital camera image processing pipeline (IPP).
• See the relationship between imaging system design and the IPP.
• Appreciate the system tradeoffs among image processing algorithms.
• Analyze image processing problems from evaluation of output images.
• Learn how new 3D and High Dynamic Range cameras affect the IPP.

Intended Audience: digital camera designers, imaging engineers, and managers involved or interested in developing or improving an image processing pipeline.

Matt Whalen is the founder and chief imaging scientist for Applied Color Science, Inc. He has been actively involved in CMOS image sensor applications and digital image processing for more than 15 years. His work in image sensor evaluation and image processing development
has ranged from consumer products (Kodak CMOS sensors, Cisco Telepresence) to medical (True-Vision 3D surgery camera) and professional (RED digital cinema). He currently holds more than 10 patents in the areas of lightwave and digital camera technology and has published numerous technical articles and conference papers. Whalen has a BS/MS in physics from Rutgers University. He is a member of IS&T.

10:15 AM – 12:15 PM COURSES

SC2A: Color Optimization for Displays
10:15 am – 12:15 pm (2 hours)
Instructor: Gabriel Marcu, Apple Inc.

This course introduces color optimization techniques for various display types, covering LCD (transmissive, reflective, and transflective), plasma, OLED, and projection systems (DLP, LCD, LcoS), and ranging from mobile devices to large LCD TV screens. Factors such as technology, luminance level, dynamic/static contrast ratio, linearization and gamma correction, gray tracking, color gamut, white point, response time, viewing angle, uniformity, color model, calibration, and characterization are discussed and color optimization methods for displays are presented.

Benefits: Attendees will be able to:
• Identify the critical color parameters for displays and their impact on display quality for smart phones, tablets, notebooks, desktops, LCD TV, and projectors.
• Understand color performances and limitations for various LCD modes (TN, IPS, MVA, FFS and OCB).
• Select the optimal color model for a display and highlight its dependency on display technology.
• Follow a live calibration and characterization of an LCD screen and of the projector used in the class, using tools varying from visual calibrator to instrument based ones.
• Apply the knowledge from the course to practical problems of color optimization for displays.

Intended Audience: engineers, scientists, managers, pre-press professionals, and those confronting display related color issues.

Gabriel Marcu is senior scientist in the ColorSync Group at Apple Inc. His achievements are in color reproduction on displays and desktop printing (characterization/ calibration, halftoning, gamut mapping, ICC profiling, HDR imaging, RAW color conversion). Marcu is responsible for color calibration and characterization of Apple display products. He has taught seminars and courses on color topics for UC Berkeley, IMI London, and various IS&T, SPIE, and SID conferences. He was co-chair of the 2006 SPIE/IS&T Electronic Imaging Symposium and of CIC11; he is co-chair of the El Color Imaging Conference: Displaying, Hardcopy, Processing, and Applications. Marcu is a IS&T and SPIE Fellow.

SC2B: Image Appearance
10:15 am – 12:15 pm (2 hours)
Instructor: Mark Fairchild, Rochester Institute of Technology

This course provides an introduction to image appearance specification and modeling, as well as describes some fundamental phenomena and techniques. Concepts for extending current color appearance models such as CIECAM02 into image appearance models dealing with complex spatial and temporal interactions are discussed, including an introduction of one image appearance framework called iCAM. Digital imaging systems can benefit from accurate and efficient image appearance models to allow rendering of image data on various displays and the specification of image differences and quality.

Benefits: Attendees will be able to:
• Describe the extension of color appearance to image appearance.
• Summarize the framework of image appearance models.
• Develop, implement, and use image difference/quality metrics.
• Understand HDR image/video rendering issues.
• Consider future directions in color and image appearance.
• Judge the utility of image appearance models in their application.

Intended Audience: scientists and engineers involved in either designing or working with systems that produce or reproduce images/video in various media and/or are observed under varying viewing conditions. Knowledge of the fundamentals of colorimetry and color appearance is assumed.

Mark Fairchild is the associate dean of Research and Graduate Education for the College of Science at the Rochester Institute of Technology and professor in RIT's Munsell Color Science Laboratory and Carlson Center for Imaging Science. He received his BS and MS in imaging science from RIT and PhD in vision science from the University of Rochester. He is author of the book Color Appearance Models, 2nd Ed., which serves as a reference to the fundamentals of color appearance and the formulation of specific models. He is a Fellow of IS&T and OSA.

Benefits: Attendees will be able to:
• Identify the components of spectrophotometers and spectroradiometers and the functions of each.
• Define the standardization process of spectrophotometers and understand the implications of standardization upon the measurement process.
• Interpret measurement requirements and select appropriate measurement parameters and geometries for various applications.
• Understand the point of “hand-off” from spectral measurements to colorimetric calculations.

Intended Audience: color engineers and technologists responsible for making and interpreting color measurements of any type. A technical background is not required, although an understanding of basic scientific principles will be very helpful.

Danny Rich has a BS and MS in optical physics and PhD in color science from the Rensselaer Color Measurement Laboratory, working under the direction of the late Fred W. Billmeyer, Jr. He has been published on all aspects of color science and technology and is active in color measurement standards organization such as ASTM E12 on Color & Appearance, ISO TC130 on Graphic Arts, and in CIE Division 2 on Measurement of Optical Radiations. Rich is currently head of the Color Research Laboratory at the Sun Chemical Corp., the world’s largest producer of printing inks.

SC2C: Fundamentals of Spectral Measurements for Color Science
10:15 am – 12:15 pm (2 hours)
   Instructor: Danny Rich,
   Sun Chemical Corporation

This short course begins by defining the basic terms surrounding the instruments and quantities used in spectral measurements in the color field. It covers the operation and construction of spectrophotometers and spectroradiometers by discussing the function of each of the various subsystems present in the devices. Instrument standardization and the application of CIE geometries for reflectance and transmittance will be covered. To evaluate instruments, the concepts of precision and accuracy of measurement devices is introduced along with practical suggestions for the analysis of instrument performance. The overall goal is to fully understand the procedures and concepts that lead to proper spectral measurements that are the basis for colorimetric calculations.
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**SC2D: An Introduction to Motion Picture Color Pipelines**

10:15 am – 12:15 pm (2 hours)

Instructors: Jeremy Selan, Sony Pictures Imageworks, Stefan Luka, Walt Disney Feature Animation, and Rod Bogart, Pixar

This course serves as an introduction to color pipelines used in modern feature-film, visual-effects, and animation. Topics covered include image acquisition, VFX and animation lighting, rendering, shading, feature-film post-production including color correction, and mastering in a color-managed environment. Case studies follow recent productions at Pixar and Disney Animation Studios as well as offer a look into future developments considering industry trends. An examination of the impact of authoring color spaces, desktop displays, and audience presentation environments are discussed.

**Benefits:** Attendees will be able to:
- List the stages in feature production and mastering.
- Describe the basic concepts, tools, and transforms used in motion picture production color pipeline.
- Define terms related to motion picture pipelines and tools.
- List common misconceptions and misunderstandings.
- Identify common color encodings used in motion picture production.

**Intended Audience:** motion picture professionals who wish to gain a more complete technical understanding of motion picture pipelines, engineers, software developers, technical directors involved or interested in motion picture production. A basic understanding of colorimetry and image processing is expected.

Jeremy Selan has been the color pipeline lead at Sony Pictures Imageworks since 2003, focusing on the areas of compositing, color, and lighting. He is one of the founders of the Katana project, Imageworks’s in-house lighting and compositing tool. His work on colorimetry has been featured in GPGPU Gems 2 and Siggraph 2005’s Electronic Theater. Outside of Sony, Selan is a contributor to industry standards committees including the Academy of Motion Picture Art and Science’s Academy Color Encoding System, and previously with the Digital Cinema Initiative (DCI) and SMPTE.
Stefan Luka is a senior software engineer and color scientist at Walt Disney Feature Animation, where he oversees the production and mastering color pipelines. His work in the motion picture industry has also included film restoration, digital cinema systems, and display development. He received a BS in engineering and applied science from Caltech and a MS in color science from RIT.

Rod Bogart, whose initials are RGB, joined Pixar in 2005 after spending ten years as a software engineer at Industrial Light & Magic. He has a MS from the University of Utah, where he specialized in computer graphics. At Pixar, he is in charge of color science at the studio, overseeing the technology for creating the final distributed masters of the movies.

1:30 – 3:30 PM COURSES

SC3A: HDR Dynamic Range and Color in Cameras, Displays, and Human Vision
1:30 – 3:30 pm (2 hours)
Instructors: Alessandro Rizzi, University of Milano, and John McCann, McCann Imaging

High-dynamic range (HDR) imaging is a significant improvement over conventional imaging. After a description of the dynamic range problem in image acquisition, this course focuses on standard methods of creating and manipulating HDR images, replacing myths with measurements of scenes, camera images, and visual appearances. The course presents measurements about the limits of accurate camera acquisition (range and color) and the usable range of light for displays by human vision. The course discusses the role of accurate vs. non-accurate luminance recording for the final appearance of a scene, presenting the quality and the characteristics of visual information actually available on the retina. Finally, there will be a discussion of the principles of tone rendering and the role of HDR spatial comparison.

Benefits: Attendees will be able to:
• Explore the history of HDR imaging.
• Understand dynamic range and quantization: the “salame” metaphor.
• Compare single and multiple-exposure for scene capture.
• Measuring optical limits in acquisition and visualization.
• Discover relationship between HDR range and scene dependency; the effect of glare.
• Explore the limits of our vision system on HDR.
• Calculate retinal luminance.
• Put in relationship the HDR images and the visual appearance.
• Identify tone-rendering problems and spatial methods.
• Verify the changes in color spaces due to dynamic range expansion.

Intended Audience: color scientists, software and hardware engineers, photographers, cinematographers, production specialists, and students interested in using HDR images in real applications.

Since 1990, Alessandro Rizzi has been researching in the field of digital imaging and vision. His main research topic is the use of color information in digital images with particular attention to color perception mechanisms. He is associate professor at the Department of Information Science and Communication at the University of Milano, teaching Fundamentals of Digital Imaging, Multimedia Video and Human-Computer Interaction. He is one of the founders of the Italian Color Group and a member of several program committees of conferences related to color and digital imaging.

John McCann received a degree in biology from Harvard College (1964). He worked in and managed the Vision Research Laboratory at Polaroid from 1961 to 1996. He has studied human color vision, digital image processing, large format instant photography, and the reproduction of fine art. His publications and patents have studied Retinex theory, color constancy, color from rod/cone interactions at low light...
levels, appearance with scattered light, and HDR imaging. He is a Fellow of IS&T and the Optical Society of America. He is a past President of IS&T and the Artists Foundation, Boston. He is the IS&T/OSA 2002 Edwin H. Land Medalist and IS&T 2005 Honorary Member.

Image quality assessment is a topic of growing interest that has also been the subject of much recent research. In this short course, we examine the current thinking about color image quality from several different vantage points. First, the course examines models that are inspired by the spatio-chromatic properties of the human visual system, or by thinking about the visually relevant structural characteristics of images. These approaches typically lead to a processed image that reflects visual significance of image errors on a pixel-by-pixel basis. Such pixel maps may be converted to a single number that summarizes overall image quality by various approaches to spatial summation, including the accounting for visual saliency. Some of these approaches are described. Next is an examination of how the resulting summary metrics perform in comparison to observer ratings of the images in several different online image databases. A second major thread for image quality investigations is to identify a set of key image quality attributes, such as tone reproduction, sharpness, contrast, graininess, color fidelity, and artifacts; and to compute these as a set of distinct metrics for evaluating image quality. These metrics may be meaningfully examined together through the use of spider plots. Finally, the course illustrates the use of these image quality concepts in the context of several different applications, including color digital halftoning, especially for ink-savings, assessment of the visibility of image defects in the presence of masking image content, and evaluation of printer workflows.

Benefits: Attendees will be able to:
- Understand the basic spatiochromatic characteristics of the human visual system.
- Be familiar with the major image quality metrics in use today.
- Understand methods for pooling the results of spatial image quality maps to yield a single-number assessment of overall image quality.
- Know what is the current state-of-the-art in terms of the ability of these metrics to predict observer ratings of image quality.
- Understand what are the major image quality attributes, what they measure, and how they are computed.
- Know how to generate and interpret spider-plots that provide an integrated view of how a given image performs across a set of image quality attributes.
- Gain insight into the application of the concepts introduced in this course to the solution of real-world problems in imaging systems development.

Intended Audience: scientists, engineers, analysts, and managers involved in the design, engineering, manufacturing, marketing, or evaluation of imaging and printing products, algorithms, or systems. Participants should be familiar with the function and
basic properties of imaging systems. A rudimentary knowledge of color science, linear systems, and image processing will be helpful, but is not essential.

Jan P. Allebach is Hewlett-Packard Distinguished Professor of Electrical and Computer Engineering at Purdue University. His work on digital halftoning and image rendering algorithms has been licensed by major vendors in the printing industry and are used in products, some of which have sold 100s of millions of units worldwide. His current research interests include image rendering, image quality, color imaging and color measurement, printer and sensor forensics, and digital publishing. Allebach is a Fellow of IS&T, IEEE, and SPIE. He served as editor for the IS&T/SPIE Journal of Electronic Imaging (2000 to 2010). Allebach has received many awards including Senior (best paper) Award (IEEE Signal Processing Society), IS&T Bowman and Itek Awards, and the 2004 IS&T/SPIE Electronic Imaging Scientist of the Year. Allebach is an Honorary Member of IS&T. At Purdue, Allebach has received the College of Engineering Mentoring Excellence Award, the Sigma Xi Faculty Research Award, the Eaton Faculty Award, and five teaching awards, among others.

Marius Pedersen is a researcher in the Norwegian Color Research Laboratory at Gjøvik University College, Norway. His work is centered on image quality assessment. He received his BSc in computer engineering (2006), and MiT in media technology (2007), both from Gjøvik University College, Norway. He received his PhD in color imaging (2011) from the University of Oslo, Norway, with a dissertation on image quality metrics for the evaluation of printing workflows. He is currently head of the Norwegian Color Research Laboratory at Gjøvik University College.

SC4C: Introduction to Multispectral Color Imaging
1:30 – 3:30 pm (2 hours)
Instructor: Jon Y. Hardeberg,
Gjøvik University College

Conventional color imaging science and technology is based on the paradigm that three variables are sufficient to characterize a color. However, in particular due to the effect of metamerism, three color channels are often insufficient for high quality imaging e.g., for museums and digital archives. This course introduces the concept of multispectral color imaging, and shows how increasing the number of color channels beyond three can resolve limitations of conventional image capture and reproduction systems. Several practical systems for multispectral color image capture and reproduction are described, along with their strengths and weaknesses. It discusses the calibration and characterization of multispectral color imaging systems, and briefly introduces some of the current research topics in the field.

Benefits: Attendees will be able to:
• Understand the basics of color science, in particular metamerism.
• Decide between 3-color and multispectral approaches.
• Understand the issues and tradeoffs involved in the design and practical realization of multispectral color imaging systems.
• Learn methods to evaluate the performance of multispectral acquisition systems.
• Know where to find more information about this subject, equipment, and tools.

Intended Audience: image scientists, archivists, quality engineers, and others charged with choosing, developing, and managing imaging systems that may require multispectral color image capture and reproduction.

Jon Y. Hardeberg received his PhD from Ecole Nationale Supérieure des Télécommunications, Paris (1999). After a short, but extremely valuable industry career near Seattle, Washington, where
he designed, implemented, and evaluated color imaging system solutions for multifunction peripherals and other imaging devices and systems, he joined Gjøvik University College (2001). He is professor of color imaging in the Faculty of Computer Science and Media Technology, and director of the Norwegian Color Research Laboratory. His current research interests include multispectral color imaging, print and image quality, colorimetric device characterization, and color management. His book, Acquisition and Reproduction of Color Images: Colorimetric and Multispectral Approaches is considered a reference title in the area of multispectral color imaging.

SC3D: An Introduction to the Academy Color Encoding System (ACES)
1:30 – 3:30 pm (2 hours)
Instructors: Nicholas Bonnier, CISRA, and Alex Forsythe, Academy of Motion Picture Arts and Sciences

This course serves as an introduction to the Academy Color Encoding System. The course will introduce the basics image state based color process frameworks and color encodings. The fundamental transforms used in the Academy Color Encoding System will be defined and their functions described. Case studies follow recent production ACES implementations. Highlighted will be common challenges to implementation and solutions to those challenges.

Benefits: Attendees will be able to:
• Describe basic concepts related to image states and their application to motion picture production.
• List the key transforms and color encodings of the ACES framework.
• Name international standards related to the ACES framework.
• Describe recent implementation of the ACES framework.
• Summarize common challenges in implementing ACES and describe solutions to those challenges.

Intended Audience: motion picture professionals who wish to gain a more complete technical understanding of the Academy Color Encoding system, engineers, software developers, technical directors involved or interested in the future of motion picture production. A basic understanding of colorimetry and image processing is expected.

Nicolas Bonnier is a senior research engineer at Canon Information Systems Research Australia (CISRA). Prior to this, he was a color scientist at Océ (2005 to 2012), where he co-supervised PhD students and was involved in ICC and ISO activities. He was also a lecturer at the ENS Louis-Lumiere (Paris) from which he graduated in 2000, with a major in photography. Bonnier received his MS in electronic imaging from University Pierre & Marie Curie, Paris 6 (2001). He was then research engineer in the Laboratory for Computational Vision at New York University. He later completed his PhD in 2008.

Alex Forsythe is the imaging engineer manager at the Academy of Motion Picture Arts and Sciences. He received his BS in biomedical photographic communications and MS in printing technology from Rochester Institute of Technology. He is an imaging scientist with broad experience in research and product development in motion picture, medical, consumer, and professional imaging industries. His specialties include color systems engineering, imaging systems architecture, color science and management, film and digital motion picture systems, algorithm development, and digital camera systems engineering.

3:45 – 5:45 PM COURSES
SC4A: Color in High Dynamic Range Imaging
3:45 – 5:45 pm (2 hours)
Instructor: Greg Ward, Dolby Laboratories

The short course describes the techniques and technologies behind high dynamic range imaging, covering methods for HDR capture, representation, editing, and dis-
play. Live demonstrations of HDR image capture using a standard digital camera, and image-based lighting techniques for rendering synthetic objects into a real environment are featured. The course also addresses tone-mapping and gamut-mapping issues for low dynamic range output and printing.

Benefits: Attendees will be able to:
- Compare low dynamic range to high dynamic range imaging.
- Outline basic methods for HDR image capture.
- List major HDR image formats, their strengths and weaknesses.
- Describe the dual-modulation method for HDR image display.
- Summarize the tone-mapping problem as it applies to HDR image printing.
- Define image-based lighting and give examples from recent movies.

Intended Audience: color scientists, software and hardware engineers, photographers, cinematographers, production specialists, and students interested in the means and rewards of extending the dynamic range of their pipeline. By taking the audience from the basics of HDR to more advanced techniques such as image-based lighting, the course hopes to convey the simplicity and power of this exciting new trend in digital imaging.

Greg Ward, a leader in the HDR space, developed the first widely-used high dynamic range image file format in 1986 as part of the RADIANCE lighting simulation system. He developed the LogLuv TIFF HDR image format, the JPEG-HDR format, and authored the application Photosphere, an HDR image builder and browsing program. He’s been involved with Dolby Laboratories’ HDR display developments, which employ dual modulators to show colors 30 times as bright and ten times as dark as conventional monitors. Working in the computer graphics research community for more than 20 years, he has developed rendering algorithms, reflectance models, and measurement systems, tone reproduction operators, HDR image processing techniques, and photo printer calibration methods.

SC4B: Color Gamut Mapping
3:45 – 5:45 pm (2 hours)
Instructor: Ján Morovic, Hewlett-Packard Company

Attempting the reproduction of a displayed color image using a printer quickly runs into issues of not being able to match some of the original’s colors. The underlying cause of this, and many other color reproduction scenarios, is the fact that different color reproduction media are capable of reproducing different ranges (gamuts) of colors. To address color gamut differences, it is necessary to assign reproducible colors to all original ones, which is called gamut mapping. This short course, based on the instructor’s Color Gamut Mapping book, provides an introduction to color reproduction, making the role of gamut mapping explicit in its context, discusses how it is implemented in actual color management systems, and focus on sketching out the variety of gamut mapping solutions proposed over the last 30 years. Understanding the nature of gamut mapping provides a basis for making informed choices about it when setting up color reproduction solutions.

Benefits: Attendees will be able to:
- Understand the theory of color reproduction.
- Identify the role and position of color gamut mapping within color reproduction.
- Evaluate the performance of a color gamut mapping solution.
- Choosing from among the multitude of existing gamut mapping approaches.
- Trace color’s progress through a color reproduction workflow, with particular emphasis on the gamut mapping stage.
- Consider future trends in color gamut mapping.
Intended Audience: scientists, engineers and creative content creators either designing or working with systems that reproduce color image content in various media; students on courses involving color and imaging components. Knowledge of the fundamentals of colorimetry, color appearance, and color management is assumed, but a brief introduction will be given.

Ján Morovic is a senior color scientist and master technologist at Hewlett-Packard’s Large Format Printing division in Spain. He has a BA (Hons) in print management from the London College of Printing and a PhD in color science from the University of Derby. From 1998-2003 he was lecturer in digital color reproduction at the University of Derby’s Colour and Imaging Institute; he also chaired the CIE’s technical committee on gamut mapping during this period. Since 2003, he has worked on a variety of color reproduction technologies used in current products across HP’s printer portfolio. He is the director of CIE Division 8 on Image Technology and is the recipient of the RPS 2003 Selwyn Award.

SC3C: Spectral Printing
3:45 – 5:45 pm (2 hours)
Instructor: Philipp Urban,
Technische Universität Darmstadt

Conventional hardcopy reproduction (e.g., ICC) can have a wide range of colorimetric accuracy and is always constrained by metamericism. For color-critical, scientific, and archival applications, metameric reproduction is often insufficient. Spectral reproduction alleviates these limitations. This short course overviews spectral printer modeling, spectral separation, and spectral gamut mapping.

Benefits: Attendees will be able to:
• Understand the advantages and disadvantages of spectral reproduction compared to metameric reproduction.
• List and compare different spectral printer halftone models.
• Learn about separation techniques for spectral reproduction.
• Become familiar with the foundations of spectral gamut mapping.
• Comprehend the applications of spectral printing and spectral color management.

Intended Audience: for those wishing to become more familiar with the opportunities and challenges within the emerging field of spectral color reproduction, which may include color and imaging scientists, printer designers, and image processing specialists.

Philipp Urban has been the head of the Color Research Group, Institute of Printing Science and Technology, Technische Universität Darmstadt, Germany, since 2009. His research focuses on spectral-based acquisition, processing, and reproduction of color images considering the limited metameric and spectral gamut and low dynamic range of output devices. From 2006-2008 he was a visiting scientist at RIT Munsell Color Science Laboratory, where he developed the first spectral-based copying system especially designed for artwork reproduction. He holds an MS in mathematics from the University of Hamburg and a PhD from the Hamburg University of Technology.

SC4D: Spaces and Formats for Color and Images
3:45 – 5:45 pm (2 hours)
Instructor: Robert Buckley,
University of Rochester/ NewMarket Imaging

Exchanging, storing, sharing, and even experimenting with digital color images means packaging color image data in a format and attaching a color description to it. This course examines the choices technologists and applications have today for image formats and color spaces, covering their origins, the rationale behind them, and how they fit together. Some formats can support multiple color spaces, either directly or via ICC profile tagging; others are designed around a specific space. The implications for color work-
flows and transformations are illustrated with examples drawn from color reproduction, digital cinema, and image preservation.

Benefits: Attendees will be able to:
• List the two main types of color spaces, four main RGB color spaces, seven most commonly used image formats and three building blocks for color image workflows.
• Differentiate between a color space and a color encoding for XYZ, RGB and CIELAB.
• Understand the dynamic range, tone scale resolution and gamut options offered by different color encoding options.
• Know which combinations of formats and spaces are possible, and which aren’t.
• Understand where transformations and profiles fit in.
• Appreciate the need for specialized formats and where they are used.

Intended Audience: those who want an introduction or a refresher on the approaches used for communicating color images in different workflows and the reasons for the different choices available to users and technologists.

Robert Buckley is a senior scientist in the Dept. of Electrical and Computer Engineering at the University of Rochester and the founder of New-Market Imaging, which works with clients on the capture, preservation, and interchange of digital color images. He chairs the CIE Committee on Archival Color Imaging and is on the Advisory Board of the US Federal Agencies Digitization Guidelines Initiative.

As in the past, this year’s Color and Imaging Conference (CIC20) is accepting Late Breaking News (LBN) papers, which will either be included in a session to be held Friday afternoon or incorporated into the Interactive Paper Session. LBN papers offer researchers the opportunity to provide the latest technical results on recent research, i.e., results that were not available at the time of the deadline for regular paper submissions. Oral presentations are 15 minutes in length; interactive presenters will be allowed a two-minute oral preview and will participate in the two-hour poster session. If you have a topic you would like to present at CIC20, please submit a full length paper (2,000-3,000 words) by September 15, 2012 that:
• is ready for publication,
• is in MS-Word or PDF format,
• uses the US letter-size template and follows the guidelines found at www.imaging.org/ist/conferences/guide_author/index.cfm

Paper should be sent to cic@imaging.org. Your paper will be reviewed promptly and you will be expected to submit the final version (with any requested revisions) by September 28, 2012 so that the paper may be included in the conference proceedings.
CIC20 Hotel Information

Reservations Deadline: October 19, 2012

The Doubletree by Hilton Hotel Los Angeles Downtown
http://doubletree3.hilton.com
120 South Los Angeles Street, Los Angeles, CA 90012
Telephone +1- 213-629-1200; toll free reservations +1- 800-222-8733

Reservations may be made online by going to www.imaging.org/ist/Conferences/cic/ and clicking on the hotel reservation link.

A special block of rooms at a discounted rate of $139/night is being held at the Doubletree Hilton Los Angeles Downtown for the nights of November 12-16, 2012. The discounted rate will be honored three days prior and one day after these dates based on availability. To guarantee a room, make your reservation online as noted above; or call the hotel directly and identify yourself as part of the “IS&T Color and Imaging Conference 2012.”

A credit card guarantee is required to secure each reservation and 72 hours advance notice prior to scheduled arrival date is required to cancel a room and avoid a charge equal to one night and tax.

Check in time: 3:00 pm    Checkout time: noon

Room rates: $139 single/double + 15.565 occupancy tax
Internet access is complimentary
Valet parking is available for $18/day with unlimited in/out privileges.
Self-parking $12/day unlimited in/out privileges.

Transportation Information

The CIC hotel is 20 miles from Los Angeles International Airport (LAX), which has direct flights from many US and international cities including: Atlanta, Boston, Chicago, Dallas, Denver, Frankfurt, Newark, New York, Paris, Phoenix, Sydney, and Tokyo. For more information visit www.lawa.org/welcomelax.aspx.

There is non-stop bus service from LAX to Union Station for $7 one-way. Union Station is five city blocks from the hotel. From Union Station you can call the hotel at +1- 213-629-1200 and the hotel shuttle will pick you up, but there might be a 20-30 minute wait. For 50 cents you can catch the “D” DASH bus, which will leave you one block from the hotel on weekdays only. Or you can catch a taxi for approximately $5.00. Please visit www.lawa.aero/welcome_LAX.aspx?id=292#tabulation for more information.

Shuttles from LAX charge approximately $16 one-way. You can book online at www.supershuttle.com/. Taxis to downtown charge $57 – $73 depending on traffic.

For more information on flights and transportation, visit www.lawa.org/welcomelax.aspx.
CIC20 Conference Registration

Go to www.imaging.org/ist/conferences/CIC to register online.

Name

Title/Position

Company

Mailing Address

Telephone  Fax  Email

Conference registration includes admission to all technical sessions, full-color conference proceedings with CD, coffee breaks, and receptions. Separate registration fees are required for short courses and ICC DevCon 2012.

1. Please check all that apply. I am a

☐ speaker  ☐ session chair  ☐ committee member  ☐ IS&T member  ☐ SID member
☐ only taking short courses

2. Conference Registration

Register early and save! After Oct. 15, add $100 to conference registration; $50 to One-day registration; $30 to student registration.

To better serve you, IS&T is offering conference registration options that include membership (new or renewal). Register for just the conference as in the past or register for the conference plus IS&T membership,* with your choice of an online subscription to the Journal of Imaging Science and Technology (JIST) or Journal of Electronic Imaging (JEI).

<table>
<thead>
<tr>
<th>IS&amp;T/SID Member</th>
<th>Non-member</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conference registration</td>
<td>$675</td>
<td>$775</td>
</tr>
<tr>
<td>Conference registration [with comp membership + JIST]</td>
<td>$775</td>
<td>$775</td>
</tr>
<tr>
<td>Conference registration [with comp membership + JEI]</td>
<td>$775</td>
<td>$775</td>
</tr>
<tr>
<td>Student (ID required)</td>
<td>$145</td>
<td>$175</td>
</tr>
<tr>
<td>One-day Registration  ☐ Wed.  ☐ Thurs.  ☐ Fri.</td>
<td>$435</td>
<td>$435</td>
</tr>
</tbody>
</table>

* Membership benefits include access to the IS&T Digital Library, an online subscription to JIST or JEI, The Reporter newsletter, conference fee discounts, and access to the member directory. Membership takes effect by 12/1/12 and expires 12/31/13. This offer may be used for renewals.

Special Offer: One Day Registration + up to Four 2-hour Class (+ membership)

Take four 2-hour classes on Tuesday + register for one day of the conference for $675 or include membership for $775.

To take advantage of this offer you must fax or e-mail this form to IS&T. Check one below:

| One-day Registration  ☐ W  ☐ Th  ☐ F  + classes | $675 | $____ |
| One-day Registration  ☐ W  ☐ Th  ☐ F  + classes + membership (JIST) | $775 | $____ |
| One-day Registration  ☐ W  ☐ Th  ☐ F  + classes + membership (JEI) | $775 | $____ |

Then select up to 4 2-hr classes on the page 25 and enter total from above on “total from previous page” line on page 25.
3. Short Course Registration  (be sure to multiply number of classes by per course fee and place on total line)

Register early and save! After Oct. 15, add $50 to the 2-day Course; add $30 to any 2-hour Class.

<table>
<thead>
<tr>
<th>Course Type</th>
<th>IS&amp;T/SID Member</th>
<th>Non-member</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>___ Color Science and Imaging (two-day course)</td>
<td>$675</td>
<td>$850</td>
<td>$_____</td>
</tr>
<tr>
<td>___ Color Science and Imaging Student (two-day course)</td>
<td>$265</td>
<td>$290</td>
<td>$_____</td>
</tr>
<tr>
<td>___ 2-hour course (per class; select below)</td>
<td>$155</td>
<td>$185</td>
<td>$_____</td>
</tr>
<tr>
<td>___ 2-hour course Student (per class; select below)</td>
<td>$50</td>
<td>$50</td>
<td>$_____</td>
</tr>
</tbody>
</table>

Check all that apply:

- SC1A
- SC1B
- SC1C
- SC1D
- SC2A
- SC2B
- SC2C
- SC2D
- SC3A
- SC3B
- SC3C
- SC3D
- SC4A
- SC4B
- SC4C
- SC4D

OR

Take three or more classes and receive 20% off the total price*

(enter three or more two-hour courses, fill in member or non-member fee next to each, add together, and multiply by .80 to get your price, representing 20% savings; add additional lines if needed; students may not take advantage of this offer)

\[ T_{\text{total}} = (T_{\text{total}} + T_{\text{total}} + T_{\text{total}}) \times .80 = \text{total} \]

4. ICC DevCon 2012

After October 15, add $50 to the appropriate fee below; does not apply to students. Note that registration includes lunch and an evening networking reception.

<table>
<thead>
<tr>
<th>Company</th>
<th>Individual</th>
<th>Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>___ first registrant from company</td>
<td>$300</td>
<td>$400</td>
</tr>
<tr>
<td>___ additional registrant[s] from company**</td>
<td>$200</td>
<td>$300</td>
</tr>
<tr>
<td>___ student</td>
<td>$25</td>
<td>$25</td>
</tr>
</tbody>
</table>

** please provide names: ______________________________________________

5. Extra copy of Proceedings

| Extra copy of CIC20 Proceedings | $100 | $_____|

6. Spouse/Guest Tickets

| Admission to CIC20 Social Events and Evening Lecture | $120 | $_____|

Name/Affiliation of Guest for badge: ______________________________________

☐ I’m taking advantage of the special one day + four 2-hour course offer $_____ 

total from previous page $_____ 

Wire transfer fee ($25 if applicable) $_____ 

GRAND TOTAL $_____ 

Payment Method: ☐ AmEx ☐ MasterCard ☐ VISA ☐ Discover ☐ Wire Transfer ☐ Check 

Card#: ________________________ Exp. Date: ________________________ 

Name as it appears on card: ________________________________________________ 

Authorization Signature: ________________________________________________

Return this form with signed credit card authorization to

IS&T, 7003 Kilworth Lane, Springfield, VA 22151, fax to 703/642-9094, or e-mail registration@imaging.org. Contact registration@imaging.org for wire transfer information.

Please note: To cover bank charges and processing fees, there is a cancellation fee of $75 until November 9, 2012. After that date, the cancellation fee is 50% of the total plus $75.

No refunds will be given after December 11, 2012. All requests for refund must be made in writing.