



Sixteenth Color Imaging Conference

Color Science and Engineering
Systems, Technologies, and Applications

www.imaging.org/conferences/CIC16

November 10–15, 2008
Portland, Oregon

Sponsored by
Society for Imaging Science and Technology and
Society for Information Display



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Program Committee

General Chairs

James Larimer
ImageMetrics LLC
650/678-0658
jim@imagemetrics.com

Nathan Moroney

Hewlett-Packard Laboratories
650/236-2825
nathan.moroney@hp.com

Technical Program Chairs

Karen Braun
Xerox Corporation
585/422-6380
karen.braun@xerox.com

Moshe Ben-Chorin

Genoa Color Technologies Ltd.
+972-9-950-9970 x106
moshe@genoacolor.com

Tutorials Chairs

Fumio Nakaya
Fuji Xerox Co., Ltd.
+81465-80-2395
fumio.nakaya@fujixerox.co.jp

Stephen Westland

University of Leeds
+44-113-343-3752
s.westland@leeds.ac.uk

Interactive Paper Chairs

Francisco Imai
Samsung R&D Center
408/544-5668
francisco.imai@gmail.com

Peter Morovic

Hewlett Packard Española SL
+43 93 4019293
peter.morovic@hp.com

Sponsorship Chair

Mitchell Rosen
Rochester Institute of
Technology
585/475-7691
rosen@cis.rit.edu

AV Chair

Vien Cheung
University of Leeds
+44-113-343-8082
t.l.v.cheung@leeds.ac.uk

IS&T Organization

Robert Buckley (Xerox Corp)
Conference VP
robert.buckley@xerox.com
Suzanne E. Grinnan
Executive Director
sgrinnan@imaging.org

Technical Program Committee

Masao Aizu, Canon
Aldo Badano, Food & Drug
Administration
Erno H. A. Langendijk, Philips
Research Laboratories, Eindhoven
Gabriel Marcu, Apple, Inc.
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Welcome to CIC16

On behalf of the Society for Imaging Science and Technology and the Society for Information Display, we are delighted to welcome you to the 16th IS&T/SID Color Imaging Conference. We hope first-time attendees and familiar faces find these six days of color imaging in Portland technically stimulating and a rewarding opportunity to network with industrial and academic colleagues from around the world. **We have a full week planned—including many new and special events—and we invite you to take advantage of all the opportunities this meeting provides.** An overview can be found on page 2.

The week begins with a comprehensive set of short courses that spans two days (Monday and Tuesday) and features the ever-popular Hunt Course. Short course chairs Fumio Nakaya and Stephen Westland have assembled a range of informative classes taught by experts in their fields, including many new offerings and four classes now offered on Monday. Monday also sees the return of **ICC DevCon'08**, which offers an opportunity to learn about the use and implementation of v4 ICC profiles.

The technical program begins Wednesday morning and CIC papers continue through noon on Friday. This year's technical program chairs—Karen Braun and Moshe Ben-Chorin—have created a cutting-edge program on topics including printing, HDR, gamuts, capture, vision, appearance, and displays. Each morning begins with a keynote and this year we are fortunate to have Andrew Stockman presenting on the new CIE cone fundamental based standard, Mary Czerwinski providing an overview of large display research, and Robert W. G. Hunt presenting an intriguingly titled talk: "The Push-Me Pull-You of Color."

2008 marks an expansion of the ever-popular Interactive Session. Interactive program chairs Francisco Imai and Peter Morovic created not one, but **two, interactive sessions** with corresponding spotlight previews. Interactive sessions provide direct access to authors, their results, and a rich environment for peer discussion. We hope that you enjoy the additional technical content and greater participation that the new schedule allows.

Please plan to join us on Friday afternoon and evening for **The Hunt Symposium**. Organized by Michael Kriss, the symposium will honor the varied and extensive contributions Robert W. G. Hunt has made to the field of color imaging. The symposium and Hunt reception are included in the registration fee; attendance at the banquet requires a separate ticket. The week concludes Saturday with "**The Black and White Meeting**," an ISCC Special Topics co-hosted by IS&T and SID.

We look forward to seeing you at the ICC DevCon, Welcome, Conference, and Hunt receptions, as well as the special Thursday evening microbrew outing we've planned to enjoy the fine local Portland beer scene. Please take advantage of these gatherings to meet new people, give us feedback about the conference, and engage in detailed discussions of the day's technical presentations.

Finally sincere thanks and appreciation to the entire conference committee, reviewers, session chairs, AV Chair Vien Cheung, and the dexterous and professional staff at IS&T. We hope you have a wonderful and productive time at the 16th Color Imaging Conference.

—Jim Larimer & Nathan Moroney, General Co-Chairs

Conference At-a-Glance

Monday, November 10

Registration open 7:00 am to 5:00 pm

- Hunt two-day short course*
- 4 two-hour short courses*
- ICCDevCon'08*
- ICCDevCon'08 Reception (open to all)

Tuesday, November 11

Registration open 7:00 am to 6:00 pm

- Short Course Program (12 two-hour and 2 four-hour classes offered)*
- Hunt two-day short course continues*
- Welcome Reception

Wednesday, November 12

Registration open 7:00 am to 5:45 pm

- Keynote: Physiologically-based Color Matching Functions
- Technical Sessions
 - Seeing Color
 - Extreme Color
 - Printing Color
- Interactive Spotlight and Paper Session I
- Conference Reception

* separate ticket required

Thursday, November 13

Registration open 8:00 am to 5:45 pm

- Keynote: Large Display Research Overview
- IS&T Honors and Awards Presentations
- Technical Sessions
 - Displaying Color
 - Capturing Color
 - Calculating Color
- Interactive Spotlight and Paper Session II
- Evening Microbrew Tour

Friday, November 14

Registration open 8:00 am to 3:30 pm

- Keynote: The Push-Me Pull-You of Color
- Cactus Award Presentation
- Technical Sessions
 - Perceiving Color
 - Achromatic Color
- The Hunt Symposium
 - Hunt Reception
 - Hunt Banquet*

Saturday, November 15

Registration open 8:00 to 10:00 am

- ISCC: The Black and White Meeting*

Venue: The Benson Hotel, Portland, Oregon

www.bensonhotel.com

309 SW Broadway, Portland, OR 97205 • 1-800/663-1144

CIC16 will take place at the lovely Benson Hotel in downtown Portland. Room rates for singles/doubles are **\$137/night, including Internet access in guest rooms**. The hotel is 12 miles (21 minutes by car) from Portland International Airport (PDX) and is accessible by taxi (\$35), shuttle (\$14), or Max Train (\$2.30, trains stop four blocks from the hotel).

Portland offers many exciting opportunities for cultural and dining experiences, including day trips to world famous wineries, the stunning Oregon Coast, and the beautiful Columbia Gorge Valley. To discover more about Portland, visit www.travelportland.com/visitors/.

There are numerous non-stop flights to Portland from many cities, including Atlanta (Delta); Boise (SW/Horizon); Boston (Alaska); Chicago (American/United); Frankfurt (Lufthansa); LA (Alaska/Delta/Horizon/United); Minneapolis (NW); Newark (Continental); San Francisco (Alaska/Horizon/United); and Tokyo (NW); visit www.flypdx.com/NonStop/Search.aspx for a complete list.

Technical Program

Wednesday November 12, 2008

8:30 – 9:30 AM KEYNOTE SESSION

Session Chairs: James Larimer, ImageMetrics LLC, and Nathan Moroney, Hewlett-Packard Laboratories

Welcome

Physiologically-based Color Matching Functions, Andrew Stockman, University College London (UK)

9:30 – 10:30 AM SEEING COLOR

Session Chair: R. Victor Klassen, Xerox Corporation

A Probabilistic Model of the Categorical Association Between Colors, Jason Chuang,¹ Maureen Stone,² and Pat Hanrahan¹; ¹Stanford University (USA) and ²StoneSoup Consulting (Canada)

Report on the Development of Improved Human Observer Functions, Christopher J. Edge, Eastman Kodak Co. (USA)

Retinal HDR Images: The Effects of Intraocular Glare and Object Size, John J. McCann, McCann Imaging (USA), and A. Rizzi, University of Milano (Italy)

CIETC1-71 Perspective: An Overview on Accurately Computing the Tristimulus Values (Wednesday Interactive), Changjun Li, University of Leeds (UK)

Report on the Optimization of Human Observer Functions and CIELAB (Thursday Interactive), Christopher J. Edge, Eastman Kodak Company (USA)

Minimizing Color Variation (Thursday Interactive), Gary Demos, Image Essence LLC (USA)

11:10 AM – 12:30 PM EXTREME COLOR

Session Chair: Philipp Urban, Rochester Institute of Technology

Conjoint Analysis of Parametrized Gamut Mapping Algorithm, Zofia Baranczuk-Turska,

PLEASE NOTE

This year there will be two Interactive Paper Sessions. These Sessions will contain presentations from all the topical areas, in no particular grouping order. To facilitate the location of papers related to the same subject, we have listed all papers by topic under the corresponding Session. Interactive papers are indicated and noted as to whether they will be given on Wednesday or Thursday. The exact order of the Spotlight Presentations will be handed out onsite.

Peter Zolliker, and Iris Sprow, Swiss Federal Laboratory for Material Testing and Research (EMPA Switzerland); and Joachim Giesen, Friedrich-Schiller-Universität (Germany)

On the Relationship of Color Image Compression and Gamut: JPEG and JPEG2000, Tae-Yong Park and Yeong-Ho Ha, Kyungpook National University (South Korea)
Modified Multi-scaled Retinex Using Chromaticity of Highlight Region for Correcting Color Distortion, In-Su Jang, Kee-Hyon Park, and Yeong-Ho Ha, Kyungpook National University (South Korea)
Color Constancy for Multi-Illuminants High-Dynamic-Range Scenes, Jiangtao Kuang and Weihua Xiong, Omnivision Technology Inc. (USA)
Color Gamut Mapping Algorithm for Preserving Spatial Ratios (Thursday Interactive), Takahiko Horiuchi and Shoji Tominaga, Chiba University (Japan)

2:00 – 2:40 PM INTERACTIVE SPOTLIGHT SESSION I and 2:40 – 4:40 PM INTERACTIVE SESSION I

Session Chairs: Francisco Imai, Samsung R&D Center, and Peter Morovic, Hewlett Packard Española

Two-minute previews of papers noted as "Wednesday Interactive" will be presented during the spotlight session followed by discussions with authors during Interactive Session I.

**4:40 – 5:40 PM
PRINTING COLOR**

Session Chair: Kevin E. Spaulding,
Eastman Kodak Company

Geodesic Based Ink Separation for Spectral Printing, Behnam Bastani, Hewlett-Packard Co. (USA), and Brian Funt, Simon Fraser University (Canada)

Spectral Prediction Model for Variable

Dot-Size Printers, Fabrice Rousselle, Thomas Bugnon, and Roger D. Hersch, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

Printer Characterization for UV Encryption Applications, Yonghui Zhao and Raja Bala, Xerox Research Center (USA)

Further Accelerating the Inversion of the Cellular Yule-Nielsen Modified Neugebauer Model (Wednesday Interactive), Changjun Li and M. Ronnier Luo, University of Leeds (UK)

Spectral Data-Driven Model for Overprint Estimation (Wednesday Interactive), Pau Soler and Jan Morovic, Hewlett-Packard Española (Spain), and Howard Doumaux, Hewlett-Packard Co. (USA)

Compensating the Printer's Modulation Transfer Function in Spatial and Color Adaptive Rendering Workflows (Thursday Interactive), Nicolas Bonnier,^{1,2} Albrecht Lindner,^{1,2} Christophe Leynadier,¹ and Francis Schmitt²; ¹Océ Print Logic Technologies and ²Institut TELECOM (France)

Clustered-Dot Color Halftone Watermarks (Thursday Interactive), Basak Ozian, and Gaurav Sharma, University of Rochester (USA)

**7:00 – 9:30 PM
Conference Reception**

Thursday November 13, 2008

**8:30 – 9:30 AM
KEYNOTE SESSION**

Session Chairs: James Larimer, ImageMetrics LLC,
and Nathan Moroney, Hewlett-Packard Laboratories

Large Display Research Overview, Mary Czerwinski, Microsoft Research (USA)
Presentation of IS&T Honors and Awards

**9:30 – 10:30 AM
DISPLAYING COLOR**

Session Chair: Joshua Pines, Technicolor

Mapping Standard Image Content to Wide-Gamut Displays, Stacey E. Casella, Rodney L. Heckaman, and Mark D. Fairchild, Rochester Institute of Technology (USA); and Masato Sakurai, Sony Corporation (Japan)
Brighter, More Colorful Colors and Deeper, Darker Colors Based on a Theme of Brilliance, Rodney L. Heckaman and Mark D. Fairchild, Rochester Institute of Technology (USA)

Perceived Color Breakup In Spatio-Temporal Color Displays with Two and Three Color Fields, E. H. A. Langendijk, G. Cennini, and O. Belik, Philips Research Laboratories (The Netherlands)

Gamut Mapping in LCD Backlight Compensation (Wednesday Interactive), Louis Kerofsky, Jon Speigle, and Scott Daly, Sharp Labs of America (USA)

Image Quality Evaluation for Motion Picture Compressed by H.264/AVC (Wednesday Interactive), Naoya Matsumoto, Tokiya Abe, and Hideaki Haneishi, Chiba University (Japan)

Color Breakup: Taxonomy, Measurement, and Remedy (Wednesday Interactive), Wei-Chung Cheng, National Chiao Tung University (Taiwan)

Testing Colour Appearance Models Using Complex Images (Wednesday Interactive), YungKyung Park, Changjun Li, and M. Ronnier Luo, University of Leeds (UK); and Youngshin Kwak, Du-Sik Park, and Changyeong Kim, Samsung Advanced Institute of Technology (South Korea)

Software with Visual Phenomena, Tests, and Standard Colorimetric Computations for Didactics and Laboratory (Wednesday Interactive), Gabriele Simone, Gjøvik University College (Norway), and Claudio Oleari, Parma University (Italy)

Impact of Chromatic Surround on Display Perception (Wednesday Interactive), Mitchell R. Rosen, Changmeng Liu, Mark Updegraff, and Mark Fairchild, Rochester Institute of Technology (USA); and Justin Laird

and Ingrid Heynderickx, Philips Research Laboratories (The Netherlands)

Color Distribution Index (CDI) for Evaluating the Display Image Quality (Thursday Interactive), Toshiyuki Fujine, Takashi Kanda, Yasuhiro Yoshida, Michiyuki Sugino, and Masatsugu Teragawa, SHARP Corporation (Japan); Yoichi Yamamoto, CIS Laboratories Inc. (Japan); and Noboru Ohta, Rochester Institute of Technology (USA)

Predicting Perceived Colourfulness, Contrast, Naturalness, and Quality for Colour Images Reproduced on a Large Display (Thursday Interactive), Seo Young Choi, M. Ronnier Luo, Michael R. Pointer, and Peter A. Rhodes, University of Leeds (UK)

Selecting Among Combinations of RGB LED Wavelength by Pair Comparison (Thursday Interactive), Chia-Ping Chang, Li-Ming Huang, and Po-Tsun Lin, Chi Mei Optoelectronics Corp. (Taiwan)

A Comparative Study of Color and Contrast Enhancement for Still Images and Consumer Video Applications (Thursday Interactive), Abhijit Sarkar and Mark D. Fairchild, Rochester Institute of Technology, and Jorge E. Caviedes and Mahesh Subedar, Intel Corporation (USA)

**11:10 AM – 12:30 PM
CAPTURING COLOR**

Session Chair: Joseph Goldstone,
Lilliputian Pictures LLC

Colouring the Near-Infrared, Clement Fredembach and Sabine Süssstrunk, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

Exploiting Color Filter Array Sensor NIR

Spectral Sensitivity to Improve Color Accuracy: Spectral Reflectance Analysis, Shizhe Shen and Roy S. Berns, Rochester Institute of Technology (USA)

Evaluating Wide Gamut Color Capture of Multispectral Cameras, Yuri Murakami, Keiko Iwase, Masahiro Yamaguchi, and Nagaaki Ohyama, Tokyo Institute of Technology (Japan)

PCA-based Reflectance Analysis/Synthesis of Cosmetic Foundation, Shoji Tominaga and Yusuke Moriuchi, Chiba University (Japan)

Evaluation of Light Sources Based on Visual Colour Rendering (Wednesday Interactive), Cheng Li, M. Ronnier Luo, and Changjun Li, University of Leeds (UK)

An Illumination Independent Descriptor Using Chromatic Moment Invariants (Wednesday Interactive), Bing Li and De Xu, Beijing Jiaotong University (China), and Weihua Xiong, OmniVision Technologies (USA)
Cluster Based Color Constancy (Wednesday Interactive), Weihua Xiong, Jiangtao Kuang, and Xiaoyong Wang, OmniVision Technologies (USA)

Maximum Entropy Spectral Models for Color Constancy in the Presence of Interreflections (Wednesday Interactive), Sandra Skaff and James J. Clark, McGill University (Canada)

Reflectance Prediction in Multi-Angle Measurement by Wiener Estimation Method (Wednesday Interactive), Pesal Koirala, Markku Hauta-Kasari, Jouni Hiltunen, and Jussi Parkkinen, University of Joensuu (Finland)
Illuminant Retrieval for Fixed Location Cameras (Thursday Interactive), Joanna Marguier and Sabine Süssstrunk, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

The Trade-off Between Color Reproduction Accuracy and Image Sensor Noise (Thursday Interactive), Hideyasu Kuniba, Nikon Corporation (Japan), and Roy S. Berns, Rochester Institute of Technology (USA)

Evaluation of Vehicular Camera Performance Through ISO-Based Image Quality Quantification (Thursday Interactive), Kyung-Woo Ko, Kee-Hyon Park, and Yeong-Ho Ha, Kyungpook National University (South Korea)

2:00 – 3:00 PM CALCULATING COLOR

Session Chair: Mark S. Drew, Simon Fraser University

Accuracy-Preserving Smoothing Of Color Transformation LUTs, Ján Morovic, Angel Albarran, Jordi Arnabat, Yvan Richard, and Martí Maria, Hewlett-Packard Española (Spain)

Sort-Damp-Select: An Efficient Strategy for Look-Up Table (LUT) Lattice Design, Vishal Monga and Raja Bala, Xerox Research Center (USA)

Computational Geometry Solution to Nonunique Forward Model Inversion for Multi-ink Printing, Gustav J. Braun, Kevin E. Spaulding, John D'Errico, and Douglas W. Couwenhoven, Eastman Kodak Company (USA)

Ergonomic Color Image Technology with High Visual and Material Efficiency Based on Unique Hues (Wednesday Interactive), Klaus Richter, Berlin University of Technology (Germany)

Using the ICC v4 Reference Medium Gamut (Wednesday Interactive), Randall Guay and Mark Shaw, Hewlett-Packard Co. (USA)

Lexical Image Processing (Wednesday Interactive), Nathan Moroney, Pere Obrador, and Giordano Beretta, Hewlett-Packard Laboratories (USA)

Optimal Interpolation and L^p Norm Minimisation in Colour Indexing (Wednesday Interactive), Graham D. Finlayson and Roberto Montagna, University of East Anglia (UK)

A Spatially Adaptive Wiener Filter for Reflectance Estimation (Thursday Interactive), Philipp Urban, Mitchell R. Rosen, and Roy S. Berns, Rochester Institute of Technology (USA)

Coding Efficiency of CIE Color Spaces (Thursday Interactive), David H. Foster,¹ Ivan Marin-Franch,¹ Sergio M. C. Nascimento,² and Kinjiro Amano¹; ¹University of Manchester (UK) and ²University of Minho (Portugal)

Applying LabRGB to Real Multi-Spectral Images (Thursday Interactive), Fumio Nakaya and Noboru Ohta, Fuji Xerox Company, Ltd. (Japan)

3:00 – 3:40 PM INTERACTIVE SPOTLIGHT SESSION II and

3:40 – 5:40 PM INTERACTIVE SESSION II

Session Chairs: Francisco Imai, Samsung R&D Center, and Peter Morovic, Hewlett Packard Española

Two-minute previews of papers noted as "Thursday Interactive" will be presented during the spotlight session followed by discussions with authors during Interactive Session II

EVENING MICROBREW TOUR

Join other attendees for this informal tour of local microbreweries. Tour gratis; associated costs are the responsibility of participants.

Friday November 14, 2008

8:30 – 9:30 AM KEYNOTE SESSION

Session Chairs: James Larimer, ImageMetrics LLC, and Nathan Moroney, Hewlett-Packard Laboratories

The Push-Me Pull-You of Color, Robert W.G. Hunt, consultant (UK)

Presentation of Cactus Award for "Best Interactive Paper"

9:30 - 10:30 AM PERCEIVING COLOR

Session Chair: Changjun Li, University of Leeds

Modelling Vividness Perception for Colour Laser Printer Evaluation, Youn Jin Kim, Yousun Bang, and Heui-Keun Choh, Samsung Electronics (South Korea)

Preferred Color Imaging Algorithms and Psychophysical Evaluation, Shuxue Quan and Elaine Jin, Aptina Imaging (USA)

Subjective Rules on the Perception and Modeling of Image Contrast, Seo Young Choi, M. Ronnier Luo, Michael R. Pointer, and Gui Hua Cui, University of Leeds (UK)

Segmenting Memory Colours (Wednesday Interactive), Clement Fredembach, Francisco

Sixteenth Color Imaging Conference

Estrada, and Sabine Süssstrunk, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

An Investigation into Perceptual Hue-Ordering (Thursday Interactive), David Connah,¹ Marina Bloj,² and Graham D. Finlayson¹; ¹University of East Anglia and ²University of Bradford (UK)

A Solution to CIECAM02 Numerical and Range Issues (Thursday Interactive), Graeme W. Gill, Computer Graphics Technology PL (Australia)

Saliency Map for Human Gaze Prediction in Images (Thursday Interactive), Puneet Sharma, Faouzi Alaya Cheikh, and Jon Yngve Hardeberg, Gjøvik University College (Norway)

11:10 AM – 12:30 PM ACHROMATIC COLOR

Session Chair: Clement Fredembach, Ecole Polytechnique Fédérale de Lausanne (EPFL)

Quaternion Color Curvature, Lilong Shi, Brian Funt, and Ghassan Hamarneh, Simon Fraser University (Canada)

Fast Colour2Grey, Ali Alsam, National Gallery London (UK), and Mark Drew, Simon Fraser University (Canada)

Visual Equivalence: An Object-Based Approach to Image Quality, James A. Ferwerda, Munsell Color Science Lab (RIT); and Ganesh Ramanarayanan, Bruce Walter, and Kavita Bala, Cornell University (USA)

Alpha, Contrast, and the Perception of Visual Metadata, Maureen Stone, StoneSoup Consulting, and Lyn Bartram, Simon Fraser University (Canada)

2:00 – 5:00 PM HUNT SYMPOSIUM

Session Chair: Michael Kriss, MAK Consulting

Objectives in Color Reproduction: A 21st Century Progress Report, Roy Berns, Rochester Institute of Technology (USA)

Nearly 40 years ago, Robert Hunt defined the following six color reproduction objectives: spectral, colorimetric, exact, equivalent, corresponding, and preferred. Since then, advances in

color imaging have been astounding including hyper-spectral and HDR capture; multi-primary, high luminance, and dynamic range display; and multi-ink output. This lecture will review Dr. Hunt's color reproduction objectives and report on our progress in achieving these objectives, and perhaps, whether these objectives should be modified in light of our astounding advances in color reproduction.*

Color Vision and More Comprehensive Color Appearance Models, Hirohisa Yaguchi, Chiba University (Japan)

At the AIC 2nd Congress in 1973, the late Dr. Wyszecki said "methods of assessing the appearance of color stimuli are considered the ultimate goal of colorimetry." Robert Hunt played a large role in achieving this goal. Today, CIECAM02—widely used as a tool of advanced colorimetry—was intended to be an empirical model; however, some aspects of the model are closely related to the human color vision mechanism. This lecture will discuss the relationship between color vision and color appearance models, and report on more comprehensive models including mesopic, dichromatic, and categorical color appearance.*

Holy Grail of Colour Appearance Research, M. Ronnier Luo, University of Leeds (UK)

A general review of Robert Hunt's contribution to color science since his initial work in 1950 will be given, focusing on the topic with which he was most involved: color appearance. Starting with his initial research on adaptation—he investigated changes in color appearance due to different illuminants and luminances of adaptation fields—we will then discuss his work defining terms for visual correlates such as hue and brightness and proposed methods for formulating them. After looking at Hunt's work establishing the framework of color appearance models, this talk will explain his contributions to the generation of large psychophysical data sets for the testing of various models, particularly CIECAM97s and CIECAM02.*

6:00 – 7:00 PM HUNT RECEPTION 7:00 – 10:00 PM HUNT BANQUET

* Full abstracts for these presentations can be found at www.imaging.org/conferences/cic16.

Special Pre- and Post-Conference Events

ICC DevCon '08

for Users and Product Developers Working with ICC-based Color Management

Monday, November 10, 9:00 am to 7:30 pm • The Benson Hotel

Digital information today includes color. How should color be encoded? How should it be processed for application? ICC DevCon 2008 is your opportunity to learn from the experts—experienced developers and users in the imaging, printing, and publishing color community. Join in the development of color management technologies for today and the future.

Below is the program schedule; for speaker information and other details visit www.color.org. You may register directly for DevCon when you register for CIC16—see page 24 for rates and details.

Morning presentations will deal with various aspects of the following: Consider an application developer working in the consumer application domain. The application developer would like to enable the use of camera raw images in an application that:

- enables a user to compose images into documents which include vector graphics,
- provides a print-look preview on a wide-gamut LCD display
- and then generates a print via a home printer, achieving color fidelity with the on-screen preview.

What are the operating system supports [CMM supports] and enablements for this application and how should the application developer best use them? What are the application platform portability factors that can affect the solution?

Morning Abstract: Problem Statement, ICC Chair, William Li, Kodak Graphic Communications

Discussion of Intelligent CMM—X-Rite CMM, Moshe Kedar, X-Rite

Color Management in Mac OS—From Raw Image Data to Display and Print, Luke Wallis, Apple Computer, Inc.

Color Management Bricks on Linux, Kai-Uwe Behrmann, Oyranos, open source CMS

ICC-hosted LUNCH with colleagues and speakers

Afternoon tutorial topics on various implementation topics to include: **Color Measurement for Profile Creation,** Phil Green, London College of Communication

Flexible Color Management for Graphic Arts, Craig Revie, FFEI

ICC Profile Internal Mechanics, Marti Maria Sagner, Hewlett-Packard Co.

Floating Point Color Processing with ICC Profiles, Max Derhak, Onyx Graphics

How to Use the New sRGB Preference Profile in a Workflow, Inge Tastl, Hewlett-Packard Company

Soft Proofing Color, William Li, Kodak Graphic Communications

Networking Reception and Sponsor Demonstrations

ICC DevCon '08 Networking Reception and Sponsor Demonstration open to all CIC16 Attendees

Join colleagues for a special Networking Event from 5:30–7:30 pm on Monday, November 10th. The event will feature ICC Color Management Technology demonstrations by ICC DevCon '08 sponsors.

ISCC/IS&T/SID Special Topics Meeting

The Black and White Meeting

Saturday, November 15, 8:30 am to 3:20 pm

A one-day meeting devoted to the special challenges and solutions for black and white, two of the most important properties of a colored image. Registration includes lunch.

8:30 – 10:15 am WHITE

Fluorescent Excitation from White LEDs, Dave Wyble (RIT)

Indoor Daylight: Illuminant C with UV Extrapolation, Byron Jordan (National Resource Council of Canada)

Estimating the Spectral Reflectance of Fluorescent Offset Papers for Varying Illuminants, Eva-Maria Löffler (Abteilung PrePress-Reproduktion)

Gärtner-Griesser Coefficients for UV Calibration for CIE Illuminant D50 Simulators, Veronika Lovell & Danny Rich (Sun Chemical)

10:45 am – 12:00 pm BLACK

Perceived and Device Black and White as Reference Colours in Image Technology, Klaus Richter (Berlin University of Technology)

Perceptual Assessment of Blackness, Renzo Shamey and Reid Clouts (North Carolina State University)

Designing the Neutral Scale—Noise and Perception, Jack Holm (Hewlett Packard)

12:00 – 1:15 pm

Hosted Lunch with colleagues and speakers

1:15 – 3:20 pm MEASUREMENT, CALIBRATION, AND STANDARDS

The Characteristics of Optical Brightening Agent Fluorescence Emission and How they Relate to Methods for UV-cut Measurement, Brian Gamm (RIT)

AATCC UV Calibration Textile Standard, Roland Connelly (X-Rite Inc.)

Evaluation of UV Calibration and Whiteness Formulae, Ye (David) Chen (University of Leeds)

The Evolution of ISO 2469 for International Agreement on Optical Properties for Pulp and Paper, Joanne Zwinkels (National Resource Council of Canada)

ISO TC6/WG3 and the Role of Authorized Labs: Transferring Calibrations to Users and Consumers, Pat Robertson (Technidyne Corp.)

Registration

Register when you register for CIC or via the ISCC website at www.iscc.org.

Rates until October 13

ISCC/IS&T/SID Members: \$200

Non-members: \$250 / Students: \$100

Rates increase \$50 after October 13, except for students.

For the latest information on the ISCC one-day conference, go to www.iscc.org

Short Course Program: Two-day Event

The Hunt Course: Basic Color Science and Imaging

Monday and Tuesday, November 10 & 11, 2008 • 8:30 am to 5:00 pm

An in-depth short course with Dr. Robert W. G. Hunt

This comprehensive two-day course covers the principles of color perception, measurement, and reproduction, as applied to photography, television, printing, desktop publishing, and electronic imaging. Each day consists of six one-hour lectures with discussion.

Prerequisites

A minimum of one year of college chemistry, physics, and math is recommended and some experience with color systems is helpful, but not mandatory.

Benefits

Attendees will be able to:

- Describe normal color vision in terms of system components and their functions, trichromacy, adaptation, and luminance
- Discuss light sources including incandescent and fluorescent lamps, daylight, color temperature, and standard illuminants
- Understand the principles of spectrophotometry, including the geometry of illumination, and viewing and dealing with fluorescent samples
- Explain the experimental basis of colorimetry, and the reason why some colors cannot be matched by RGB additive mixtures
- Explain primaries, chromaticity, the effects of changing primaries, and color matching functions
- Describe the CIE system of colorimetry, including the XYZ, u', v', CIELUV, and CIELAB systems, and understand the concepts of whiteness, advanced color difference formulae, observer and illuminant metamerism indices,

color inconstancy index, chromatic adaptation transform, and color appearance models

- Describe color reproduction in terms of both additive and subtractive trichromatic principles and become familiar with television display devices and color film and its processing
- Learn about densitometry and describe the factors affecting tone reproduction
- Understand the principles involved in broadcast television and digital cameras
- Discuss the application of color science to lithographic printing
- Appreciate what factors affect quality in digital imaging and desktop publishing
- Understand the essential requisites of successful color imaging

Robert Hunt worked for 36 years at the Kodak Research Laboratories in Harrow, England, taking early retirement as Assistant Director of Research in 1982. Since then he has been an independent color consultant. Hunt has had two published books: The Reproduction of Colour, now in its sixth edition, and Measuring Colour, now in its third. He has attended all the previous Color Imaging Conferences and is a regular contributor of keynote papers.

Cost before October 13th:

\$650 IS&T/SID members
\$825 non-members
\$250 students

add \$50 to all fees after Oct. 13, 2008

CIC16 Short Course Program

MONDAY NOVEMBER 10, 2008

M1: 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 the fundamental colorimetry is assumed.

M. Ronnier Luo is a Professor of Colour and Imaging Science at the Department of Colour Science, University of Leeds, and the Director of CIE Division 1 (Vision and Colour). He has more than 300 publications in color and imaging science and

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is a Fellow of IS&T and the Society of Dyers and Colourists. He is also the recipient of the 2004 Centenary Medal from the Society of Dyers and Colourists, the Royal Photographic Society's 2003 Davies Medal, and a 1994 Bartleson Research Award.

M2: Retinal Modeling in Color Imaging

10:15 – 12:15 pm (2 hours)

Instructor: Sabine Süsstrunk, Ecole Polytechnique Federale de Lausanne (EPFL)

The course first introduces the functionality of the retina and early visual cortex processing, with emphasis on the models that find correspondence in color science and color image processing, such as the cone mosaic, trichromacy, adaptive non-linearities, receptive fields, spectral sharpening, contrast-sensitivity, etc. It then discusses how these models can be applied in the development of efficient color imaging algorithms and systems, with a focus on in-camera processing. Specific examples includes demosaicing, white-balancing, and high-dynamic range image rendering.

Benefits: Attendees will be able to:

- Identify the retinal models and infer their computational equivalence
- Describe several color imaging algorithms based on retinal models
- Understand the benefit of considering retinal models in the development of efficient color image processing and systems

Intended Audience: scientists, engineers, and managers involved in the design and

manufacturing of color imaging algorithms and devices. Participants should be familiar with the function and basic properties of digital cameras. A rudimentary knowledge of color science and image processing would be helpful.

Professor Sabine Süsstrunk leads the Images and Visual Representation Group (IVRG) at the Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland, where she has taught since 1999. Her main research areas are in computational photography, color imaging, image quality metrics, image indexing, and archiving. Süsstrunk is an Associate Editor for IEEE Transactions on Image Processing and has served as chair or committee member for many international conferences on color imaging, digital photography, and image systems engineering. She is currently Director of CIE Division 8 (Imaging Technology). She is a senior member of IS&T and a member of IEEE, ACM, and OSA.

M3: Color Optimization for Displays

1:30–3:30 pm (2 hours)

Instructor: Gabriel Marcu, Apple, Inc.

This tutorial introduces color optimization techniques for various display types, covering LCD (transmissive, reflective and transfective), 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, gamma correction, color gamut, viewing angle, white point, gray tracking, response time, 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 various displays from mobile devices to LCD TV
- Understand the color performances and limitations for various LCD modes (TN, IPS, MVA, FFS and OCB) used in different devices (mobile, monitor, LCD TV and projector)

- 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, prepress professionals, and others 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 displays and for RAW color for digital camera in MacOS X. He has taught seminars and short courses on color topics for UC Berkeley, IMI London (UK), and various IS&T, SPIE, and SID conferences. He was co-chair of the 2006 SPIE/IS&T Electronic Imaging Symposium and the 11th IS&T/SID Color Imaging Conference. He is co-chair of the EI Color Imaging Conference: Display, Hardcopy, Processing, and Applications. Marcu is a Fellow of SPIE.

M4: Image Quality and Preference Assessment Using Ranks: A Hands-on Experience

3:45 – 5:45 pm (2 hours)

Instructor: J. A. Stephen Viggiano, Rochester Institute of Technology (RIT)

Learn how to use human observations to assess image quality and get hands-on experience doing it. After a brief introduction/review of psychometric image quality assessment, the modern analysis method of rank order experiments is introduced. A hands-on experience is the focus of the course and a rank order image quality experiment is conducted and analyzed using ordinary spreadsheet software. Error bars are

computed and multiple range tests run, so that the stimuli may be placed into groups not statistically significantly different from each other.

Benefits: Attendees will be able to:

- Construct a scale of image preference from a rank-order experiment
- Establish statistical significance between different alternatives in a rank-order experiment
- Understand results of rank-order experiments presented by others
- Recognize the advantages of rank-order experiments over other methods
- Avoid pitfalls in older analysis methods

Intended Audience: The tutorial assumes no prior experience with psychometric-based preference/quality assessment, so those new to psychometrics can expect to understand the material; all that's assumed is a passing familiarity (perhaps from a previous life) of basic statistics. However, because the focus is on the hands-on activities and the review is relatively brief, even those familiar with psychometrics who wish to bring their knowledge up to date are encouraged to attend. If you're using paired comparison and want to learn a faster and more efficient way, or if you've tried rank order in the past, but are unfamiliar with modern analysis techniques or had been wary of unreasonable assumptions (which are avoided in this modern analysis protocol), you should attend this tutorial. Scientific, engineering, and marketing personnel will benefit from this hands-on experience.

J. A. Stephen Viggiano is Principal and Founder of Acolyte Color Research, a consulting and research firm specializing in solutions to problems in color science and technology. He is also a PhD candidate at RIT's Center for Imaging Science, with a concentration in Color Science. Between 1991 and 2001, Viggiano was a member of the faculty of RIT's College of Imaging Arts and Sciences, and has recently taught Data Analysis at RIT's School of Mathematical Sciences. Until 2001, he was also

employed by RIT Research Corporation, where he had risen to the position of Principal Imaging Scientist. Viggiano has presented this workshop as part of some of his graduate-level courses at RIT, as well as for corporate and government clients.

TUESDAY NOVEMBER 11, 2008

8:00 – 10:00 AM

T1A: Spatio-chromatic Vision Models for Imaging

8:00 – 10:00 am (2 hours)

Instructor: Jan Allebach, Purdue University

This course describes the context, structure, and applications of spatio-chromatic vision models for imaging. After a brief review of the important characteristics of the visual system and the basic concepts of color science, a general framework for spatio-chromatic vision models based on trichromacy, color opponency, and the limited spatial frequency response of the vision system is developed. Next applications of these models to color image quantization and digital color halftoning are discussed. During the last part of the course, a more complex group of models that account for the multi-channel nature of the visual system, the dependence of percept on contrast, and the role of the psychometric function in describing detection and discrimination is introduced. Finally, potential applications of these models to image quality assessment are discussed.

Benefits: Attendees will be able to:

- Understand the fundamental spatio-chromatic aspects of the visual system and how they can be captured in models
- Know how spatio-chromatic models for the human visual system can be used in the development of color image quantization and halftoning algorithms, and also for image quality assessment

Intended Audience: scientists, engineers, analysts, and managers involved in the design,

engineering, manufacturing, marketing, or evaluation of imaging products, algorithms, or systems. Participants should be familiar with the function and basic properties of color imaging systems. A rudimentary knowledge of color science, linear systems, and image processing would be helpful, but is not essential.

Jan P. Allebach is Hewlett-Packard 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 is used in products, some of which have sold 100s of millions of units world-wide. His current research interests include image rendering, image quality, color imaging, and digital publishing. Allebach is a Fellow of IEEE, IS&T, and SPIE. He has been Distinguished/Visiting Lecturer for IS&T and the IEEE Signal Processing Society, and has received four teaching awards while at Purdue. He received the Bowman Award from IS&T in 1998, and was named 2004 Electronic Imaging Scientist of the Year by IS&T and SPIE. In 2007, he was named Honorary Member of IS&T—the Society's highest honor. In 2008, he received the Purdue College of Engineering Mentoring Excellence Award and the Purdue Sigma Xi Faculty Research Award.

T1B: Color Management Concepts for Digital Imaging Systems

8:00 – 10:00 am (2 hours)

Instructor: Kevin Spaulding, Eastman Kodak Company

Color management technology enables predictable and desirable color reproduction to be achieved in digital imaging systems. This tutorial discusses color management concepts in the context of an image state architecture that has been developed to describe the relationship between various types of digital images, image capture and display devices, image processing workflows, and digital color encodings. Color management is presented as five connected classes of operations including input, rendering, un-rendering, effects, and output. The characteristics and properties of color manage-

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color@imaging.org.

Priority will be given to students.

ment transforms used for each of these basic operations are described together with a discussion of how these transforms can be implemented in the framework of the ICC Color Management System.

Benefits: Attendees will be able to:

- Describe common digital imaging workflows within the context of an image state architecture model
- Understand the characteristics and uses of commonly encountered color encodings (e.g., sRGB, sYCC, ICC PCS, RIMM/ROMM RGB, etc.)
- Distinguish between the different types of color management transformations used in digital imaging systems
- Understand the relationship between color management systems and the image state architecture model

Intended Audience: scientists, engineers, analysts, and managers involved in the design, engineering, manufacturing, marketing, or evaluation of digital imaging systems.

Kevin Spaulding received a BS in Imaging Science from Rochester Institute of Technology (1983), and MS and PhD in Optical Engineering from the University of Rochester (1988 and 1992). He has been with Eastman Kodak Company since 1983 where he is currently a senior principal scientist in the Inkjet Systems Division. Spaulding serves on several international standards committees that are working on standards pertaining to the unambiguous communication of digital color image data in digital imaging systems. His research interests include color reproduction, digital halftoning, image processing algorithms for digital camera and printers, and image quality metrics.

T1C: Color Appearance Modeling and CIECAM02

8:00 – 10:00 am (2 hours)

Instructor: Nathan Moroney,
Hewlett-Packard Laboratories

This short course begins with a review of color appearance phenomena and the basics of color appearance modeling, including chromatic adaptation, color attribute correlates, and other topics, such as gamut mapping or device modeling. The class focuses on the CIECAM02 color appearance model and its applications. The majority of the course considers the forward model or the calculation of color appearance attributes given stimulus tristimulus values and information about the viewing conditions. The inverse model is briefly covered, as are the publicly available CIECAM02 tools and the advantages and trade-offs of using this model for specification applications. Finally, in-class demonstrations and worked examples are used to show the model and its application to displays.

Benefits: Attendees will be able to:

- Understand the basic components of a color appearance model
- Acquire working familiarity with the CIECAM02 color appearance model
- Gain exposure to available tools and resources for CIECAM02
- Participate in a hands-on demonstration of the model

Intended Audience: researchers and developers working in the area of color appearance and color reproduction. The course includes examples and a detailed technical discussion of the model so attendees will benefit from previous familiarity with colorimetry and the basics of color science.

Nathan Moroney is a principal scientist at Hewlett-Packard Laboratories. He holds a BS in color science from Philadelphia University and an MS in color science from the Munsell Color Science Laboratory of the Rochester Institute of Technology. He was chair of technical committee 8-01, which developed the CIECAM02 model. Moroney has

published papers, been granted patents, and given invited presentations on color appearance modeling, non-photo realistic rendering, and color naming algorithms, and is the author of the reference magazine Color Thesaurus. He is an IS&T Fellow and a member of ISCC.

8:00 AM – 12:15 PM

T1D: System Interactions in Digital Color Imaging

8:00 – 12:15 pm (4 hours)

Instructors: Raja Bala, Xerox Corporation, and
Gaurav Sharma, University of Rochester

This short course underscores the system aspect of color imaging by providing insight into the common interactions among different functions within a digital imaging system. It begins with a brief overview of the basic color processing functions, including color halftoning, device calibration, characterization, gamut-mapping, quantization, and compression. The course then highlights common system interactions among these functions, and illustrates through specific case studies how knowledge of these interactions may be beneficially exploited for improving overall system performance and/or image quality.

Benefits: Attendees will be able to:

- List basic processing functions in a digital color imaging system, and schematically represent a system from input to output
- Describe unintended interactions between input and output characterization profiles and ways to mitigate these
- Comprehend and exploit the interactions between color and spatial dimensions in optimizing a color imaging system
- Explain how media characteristics influence the performance of color imaging devices
- Understand the interactions between halftones and color in output devices and some techniques for co-optimization of these
- Appreciate how system design and

optimization can surmount problems that are not resolvable in individual components

Intended Audience: engineers, scientists, students, and managers interested in acquiring a broad, system-wide view of digital color imaging systems. Practitioners and experts who are familiar with specific components also stand to gain a better perspective for the remainder of the system. Case studies on system optimization presented in this course will be of interest to technologists looking for ways to improve their digital color imaging systems and will hopefully serve as inspiration for additional research in this area. Attendees are expected to be familiar with basic image processing and colorimetry.

Raja Bala is a principal color scientist at Xerox Innovation Group, where he has performed research and development in color imaging for the last 15 years. He has been an adjunct faculty member in the School of Electrical Engineering at Rochester Institute of Technology.

Gaurav Sharma is an associate professor in the Electrical and Computer Engineering Department at the University of Rochester, where he has been since Fall 2003. Prior to that, he was with the Xerox Innovation Group. He has worked on research in color imaging for the past 15 years and is editor of the Digital Color Imaging Handbook, published by CRC press in 2003.

10:15 AM – 12:15 PM

T2A: Color Gamut Mapping

10:15 – 12:15 pm (2 hours)

Instructor: Ján Morovic, Hewlett-Packard Español

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 repro-

ducing different ranges (gamuts) of colors. When addressing color gamut differences it is necessary to assign reproducible colors to all the original ones, called gamut mapping. This short course, based on the instructor's recently published *Color Gamut Mapping* book, provides an introduction to color reproduction, makes the role of gamut mapping explicit in its context, discusses how it is implemented in actual color management systems, and focuses 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:

- Understanding 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
- Choose from among the multitude of existing gamut mapping approaches
- Trace a 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 or students taking courses involving color and imaging components. Knowledge of the fundamentals of colorimetry, color appearance, and color management is assumed.

Ján Morovic is a senior color scientist and Master Technologist at Hewlett-Packard's Large Format Printing division in Barcelona, Spain. He has a BA in Print Management from the London College of Printing and a PhD in Color Science from the University of Derby. Between 1998 and 2003, Morovic 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 at Hewlett-Packard on a variety of color reproduction technologies used in current products across their printer portfolio, including HP Professional PANTONE Emulation, HP CMYK Plus, and the color separations for HP's 12-ink Z-series Designjet printers. He has published 70 peer-reviewed journal and conference papers and is the recipient of The Royal Photographic Society of Great Britain's 2003 Selwyn Award.

T2B: Spectral Imaging Workflow

10:15 – 12:15 pm (2 hours)

Instructors: Mitchell Rosen and Philipp Urban, Rochester Institute of Technology (RIT)

Conventional trichromatic imaging (*i.e.*, RGB) can have a wide range of colorimetric accuracy and is always constrained by metamerism. For color-critical, scientific, and archival applications, trichromatic imaging is often insufficient. Spectral imaging alleviates these limitations. This short course is an overview of spectral capture, spectral color management, and spectral printing.

Benefits: Attendees will be able to:

- Understand the advantages and disadvantages of spectral imaging compared with trichromatic imaging
- List and compare different techniques of spectral imaging
- Become familiar with the foundations of estimating spectral reflectance from multi-channel images
- Learn about separation techniques for spectral reproduction
- Comprehend the applications of spectral imaging for multi-ink printing, spectral color management

Intended Audience: 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, camera and printer designers, and image processing specialists.

Mitchell R. Rosen is a research professor with the Munsell Color Science Laboratory and Director of the Infinite Pixel Liberation Laboratory (iPixLab) at RIT. His recent projects have spanned subjects such as spectral and colorimetric color reproduction, color management, immersive dynamic media, digital cinema and on-demand print quality. From 2002 - 2007, he was Color Imaging Editor of IS&T's Journal of Imaging Science and Technology. He is active in organizing international conferences on spectral imaging. Rosen co-edited the book Color Desktop Printer Technology.

Philipp Urban is a research scientist with the Munsell Color Science Laboratory at RIT. His research focuses on spectral-based image acquisition, processing, and reproduction, color correction, and uniform color spaces. He developed the first spectral-based printing system that is capable of separating high-resolution spectral images in a few minutes on today's low cost computers. As part of the Art Spectral Imaging group (www.art-si.org) he is working on a spectral-based copying system. Urban holds an MS in Mathematics from the University of Hamburg and a PhD from the Hamburg University of Technology, Germany.

T2C: Image Appearance

10:15 – 12:15 pm (2 hours)

Instructor: Mark Fairchild, Rochester Institute of Technology (RIT)

This tutorial 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

Tutorial Fees

Separate registration is required.

If you register:	by Oct. 13	after Oct. 13
2-hour Member	\$150	\$180
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4-hour Member	\$225	\$255
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- 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 a professor at the Munsell Color Science Laboratory in RIT's Chester F. Carlson Center for Imaging Science. He received his BS and MS degrees 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. that serves as a reference to the fundamentals of color appearance and the formulation of specific models.

1:30 – 3:30 PM

T3A: Color in High Dynamic Range Imaging

1:30 – 3:30 pm (2 hours)

Instructor: Greg Ward, Anywhere Software

The instructor describes the techniques and technologies behind high dynamic range (HDR) imaging, covering methods for HDR capture, representation, editing, and display. The tutorial features live demonstrations of HDR image capture using a standard digital camera, and image-based lighting techniques for rendering synthetic objects into a real environment. The instructor also addresses tone- and gamut-mapping issues for low dynamic range (LDR) output and printing.

Benefits: Attendees will be able to:

- Compare LDR to HDR 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, we hope to convey the simplicity and power of this exciting new trend in digital imaging.

Greg Ward is a leader in the HDR space, having developed the first widely-used HDR image file format in 1986 as part of the RADIANCE lighting simulation system. Since then, he has developed the LogLuv TIFF HDR image format, the JPEG-HDR format, and authored the application Photosphere, an HDR image builder and browsing program.

More recently, he has been involved with Dolby Canada's 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, Ward has developed rendering algorithms, reflectance models and measurement systems, tone reproduction operators, HDR image processing techniques, and photo printer calibration methods. His past employers include Lawrence Berkeley National Laboratory, EPFL, SGI, Shutterfly, and Exponent. Ward holds a BS in Physics from UC Berkeley and MS in Computer Science from San Francisco State University. He is currently a consultant in Albany, California (www.anywhere.com).

T3B: Vectorial Color

1:30 – 3:30 pm (2 hours)

Instructor: James Worthey, consultant

When the right color matching functions (CMFs) are used, vector methods demystify camera sensors, lighting, and other topics. In Jozef Cohen's invariant formulation, the vectors of spectral lights at unit power define the "locus of unit monochromats" (LUM). Orthonormal opponent CMFs map lights into Cohen's color space and establish intuitive axes: whiteness, red-green, and blue-yellow. If a camera's LUM matches the eye's, it meets Luther's criterion. The instructor presented details at CIC12 and CIC 14. The course emphasizes the practical use of color vectors and the orthonormal CMFs. If you plan to bring a computer to the course, please install a VRML viewer prior to attending. For background, see www.jimworthey.com.

Benefits: Attendees will be able to:

- Use the orthonormal CMFs and calculate color vectors
- Understand LUMs as an invariant summary of matching
- Work with 3D plots of such data as color chips under a lighting change
- Compare light sources on the basis of vectorial composition

- Generate a camera's orthonormal basis and compare its LUM to the eyes. The algorithm is simple; understanding may take a little time

Intended Audience: scientists and engineers who design or apply camera systems or lights. While certain applications will be stressed, the vectorial approach applies to all color work. For example, multi-primary systems and image compression are natural applications.

James Worthey received a BS in EE, an MS in Physics, and a PhD in Physiological Optics from Indiana University. He researched lighting and color at the National Institute of Standards and Technology and published several applications of opponent colors. A breakthrough came in 2003 when he combined opponent colors with Cohen's ideas and computer graphics.

T3C: Medical Imaging Applications of Spectral Imaging

1:30 – 3:30 pm (2 hours)

Instructor: Yoichi Miyake, Chiba University Research Center for Frontier Medical Engineering

This course contains an introduction of multi-spectral imaging and its applications to medical imaging. Most imaging devices such as CCD cameras, scanners, LCDs, and film are three channel devices generating RGB signals or CIE-XYZ tristimulus values, which are dependent on the characteristics of imaging devices and illuminant conditions. For a true record of an object, it is necessary to capture the reflectance spectra of every sample point independent of both the spectral characteristics of imaging systems and the spectral radiant distribution of the illumination. In this course, fundamentals and applications of spectral imaging, particularly medical imaging, are introduced and described. The course is designed for graduate students and engineers in printing, camera, and electronics.

Benefits: Attendees will be able to:

- Understand multi-spectral imaging
- Learn how to record spectral imaging
- Estimate the reflection spectra from multi band images
- Gain knowledge of multi band cameras
- Learn about BRDF and spectral image of 3-D object
- Become familiar with the development of spectral imaging endoscopes

Intended audience: color scientists and engineers for image quality, cameras, and printers, as well as engineers for medical image processing

Yoichi Miyake has been a professor at Chiba University since 1989. He received his PhD from Tokyo Institute of Technology (1978). In 1978 and 1979, he was a post doctoral fellow at the Swiss Federal Institute of Technology (ETHZ). In 1997, he was a guest professor of University of Rochester. He received the Charles E Ives Award (for best paper) from IS&T in 1991, 2001, and 2005. He was named IS&T Fellow in 1995 and Honorary Member in 2003. In 2000 he was given the Electronic Imaging Scientist of the Year award by IS&T and SPIE. Miyake has published many books and original papers on image processing, color science, and image evaluations and he is as a pioneer of spectral image processing. He served as a president of SPSTJ (The Society of Photographic Science and Technology of Japan) from 2000 to 2002 and as vice president of IS&T from 2000 to 2004. He also served as a president of The Japanese Association of Forensic Science and Technology from 1998 to 1999. He is currently professor and director of Research Center for Frontier Medical Engineering at Chiba University.

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To bring CIC more in line with other conferences IS&T offers, we've reduced most technical registration and short course fees from 2007 rates. Take advantage of these savings now! (see registration form for details)

1:30 – 5:45 PM

T3D: Digital Camera Image Capture and Processing—From Pixels to Picture

1:30 – 5:45 pm (4 hours)
Instructor: Matt Whalen,
Applied Color Science, Inc.

This course presents an overview of the image capture and processing elements in a digital camera that transform raw pixel output from an electronic image sensor into full color video or still images. The course examines the differences between CCD and CMOS image sensors that affect image quality and describes a generic image processing pipeline (exposure control, Bayer de-mosaic, color matrix, gamma, white balance, and sharpening, etc.). The function of each processing element is discussed including the variations for specific implementations and tradeoffs between image quality and available camera resources.

Benefits: Attendees will be able to:

- Understand the differences between CCD and CMOS sensors and the relative merits/limitations of each
- Know the basic elements of a digital camera image processing pipeline
- Understand the differences between video and still image processing
- Appreciate the tradeoffs among image processing algorithms
- Identify image processing problems from evaluation of output images

Intended Audience: digital camera designers, image processing engineers and managers engaged or interested in developing new digital imaging devices or improving existing image processing workflows.

Matt Whalen, founder and chief imaging scientist for Applied Color Science, Inc. (www.appliedcolor-science.com) has been actively involved in CMOS image sensor applications and digital image processing for more than 10 years. Whalen's work in image sensor evaluation and image processing development has ranged from consumer products

(AT&T Videophone, SiliconFilm's eFilm cartridge to medical (Smith and Nephew HD endoscopy camera) to professional (RED digital cinema camera). Whalen has held senior technical positions with Lucent/ Bell Labs, Conexant, and SiliconFilm Technologies. 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 in these areas. He has a BS and MS in Physics from Rutgers University and is a member of IS&T.

3:45 – 5:45 PM

T4A: Wide Gamut Color Capture and Reproduction

3:45 – 5:45 pm (2 hours)
Instructor: Charles Poynton, consultant

The color gamut of digital imaging systems, in both the professional and consumer domains, has historically been limited by CRT technology and by the BT.709 and sRGB standards. Emergent display technologies (such as LED-backlit LCDs and laser- and LED-illuminated DLPs) are poised to enable wide-gamut color, and D-SLR cameras are already capable of wide-gamut capture. The emergence of these display technologies brings new challenges in how to capture wide-gamut color, and how to transform between wide gamut and moderate gamut representations at origination equipment, and at display equipment. Deployment of wide-gamut color in consumer electronics is particularly challenging; there is a huge distribution infrastructure, and there are trillions of "legacy" images. How is the existing infrastructure to be adapted? How are legacy images to be treated? And how are new, wide-gamut images to be displayed on legacy devices?

The course outlines the color science and color image coding issues behind wide gamut capture and reproduction. It describes why cameras are inherently wide-gamut. The course also outlines the color transforms necessary to optimize classical colorimetry, and explains how color transforms interact with the picture rendering

transforms that are a part of all commercial imaging systems. A discussion of several wide-gamut standards including Adobe RGB 1998 (IEC "opRGB," for graphics arts), SMPTE/DCI P3 R'G'B' and X'Y'Z' (for digital cinema), and xvYCC (for broadcast television) is included.

Benefits: Attendees will be able to:

- Summarize various deployed and proposed wide-gamut encoding systems
- Estimate gamut coverage of various capture and display technologies
- Explain the signal processing required to capture, encode, and reproduce wide-gamut scenes
- Evaluate wide-gamut color encoding systems

Intended Audience: appropriate for technical professionals who are experienced in the engineering of color imaging systems. Many graphs, equations, and diagrams will be presented.

Charles Poynton is an independent contractor specializing in the physics, mathematics, and engineering of digital color imaging systems, including digital still cameras, digital video, HDTV, and digital cinema (D-cinema). He does technology forecasting, systems modeling, algorithm development (including digital filter design), video signal processing architecture, color characterization and calibration, and image quality assessment. He is involved in engineering wide color gamut systems, including xvYCC.

T4B: Color Management in Apple ColorSync

3:45 – 5:45 pm (2 hours)
Instructor: Luke Wallis, Apple Computer, Inc.

This course provides an overview of ColorSync, which is the foundation block of Color Management in Mac OS X. The course describes the architecture of color management in the system, along with the principles of using ColorSync. It then addresses details of acquiring color data from input color devices like cameras and scanners, and managing the color data for display, printing, and storing. The class also

demonstrates how to automate a color management workflow in Mac OS X.

Benefits: Attendees will be able to:

- Get an overview of the color management architecture in Mac OS X
- Become familiar with the principles of color management in ColorSync
- Understand the role of drivers for color devices in Mac OS X color management
- Understand different mechanisms of color management in the applications running on Mac OS X
- Apply the knowledge from the course to solve practical problems of color processing on Mac OS X

Intended Audience: engineers, scientists, project managers, prepress professionals, and others confronting color management issues.

Luke Wallis is a senior scientist in ColorSync group at Apple Computer. His responsibilities include color color management in Mac OS X and ColorSync framework.

T4C: Color Vision and Color Appearance

3:45 – 5:45 pm (2 hours)

Instructor: David H. Foster,
University of Manchester

This course introduces the physiology, physics, and psychology of human color vision and color appearance. The first part concentrates on the spectral sensitivities of the receptors of the eye, the luminosity function, light adaptation and von Kries scaling, and post-receptoral coding. The second part identifies some of the factors complicating color-vision models, including selective absorption in the ocular media, retinal inhomogeneity, rod intrusion, and color deficiency. The third part introduces sensory, perceptual, and cognitive cues influencing color appearance and color constancy, including mean chromaticity, spatial chromatic contrast, and highlights. The last part deals with the experimental measurement of color appearance, particu-

larly color naming, achromatic adjustment, and color matching, both with geometric stimuli and images of natural scenes.

Benefits: Attendees will be able to:

- Describe the spectral sensitivities of the receptors of the eye and the major chromatic and achromatic properties of post-receptoral coding
- Appreciate the effects on color perception of pre-receptoral absorption, and its variation from individual-to-individual, rod intrusion, and color deficiency
- Recognize key sensory, perceptual, and cognitive cues to color appearance, and assess their relative significance
- Compare the main experimental methods of evaluating color appearance and analyze the limits of visual judgments with synthetic and naturalistic stimuli
- Assess the adequacy of color-appearance models and display devices in relation to these visual limits

Intended Audience: scientists, engineers, and students interested in color vision and color appearance, color measurement and reproduction, and color theory. No specialist background in physics, biology, or psychology is required.

David Foster, professor of vision systems, University of Manchester, received his PhD in physics from Imperial College London under the supervision of W.D. Wright. Foster has published more than 150 journal papers on psychophysics and color vision. Foster is a Fellow of the Institute of Physics, the Institute of Mathematics and its Applications, and OSA; is senior editor of Vision Research, and is associate or advisory editor of two other journals.

Join colleagues for the
Hunt Symposium Banquet
on Friday from 7:00-10:00 pm.
Dinner features a three-course meal,
champagne toast, Oregon wines, and
remarks by colleagues and friends in
honor of Dr. Hunt.
(see registration form for details)

CIC16 Hotel Registration

Name _____
Title/Position _____
Company _____
Mailing Address _____
Telephone _____ Fax _____ Email _____

Reservations Deadline: October 18, 2008

The Benson Hotel

www.bensonhotel.com

309 Southwest Broadway • Portland, OR 97205

telephone 503/228-2000; toll-free 888/523-6766; fax 503/471-3920

you may fax this form to the number above or send it to reservations@bensonhotel.com

A special block of rooms at a discounted rate is being held at The Benson Hotel for the nights of November 8-15, 2008. We have also arranged for complementary Internet access in guest rooms at this rate. The discounted rate will be honored for three days before and after the 8th–15th based on availability. To guarantee a room, please fill out this form and fax or e-mail it to the Benson as noted. Reservations made after Oct. 18, 2008 will receive the group rate based on availability. *Please identify yourself as part of the "IS&T CIC16 Conference."*

Check in time: 4:00 pm Checkout time: noon

Room rates: \$137 single/double \$189 junior suite
+ 12.5% state and local taxes

Please note: The Benson Hotel is a 100% smoke-free establishment.

Arrival Time/Date _____ Departure Date _____

Please reserve my Single Double Suite:

I prefer the following bed type: King Queen Double double

Special Requirements (please indicate):

Deposit: AMEX MC VISA

Card# _____ Exp. Date _____

Name of cardholder _____

Notice of cancellation must be given to the hotel 24 hours prior to arrival date to receive a full refund. Be sure to obtain a cancellation number.

There is no charge for children under 18 years when sharing a room with a parent.

Transportation Notes: Information on flights in/out of Portland (PDX) can be found at www.flypdx.com. Go to www.travelportland.com/visitors/transportation.html for information on getting around Portland. Taxis to the Benson cost approximately \$35/one-way. Other transportation options are available.

- Blue Star Airporter (www.bluestarbus.com/ or 503/249-1837) provides shuttle service every hour on the half hour from 7:00 am – midnight from PDX to the Benson Hotel. The cost/person is \$14 one-way/\$24 round-trip. Catch the shuttle at their check-in counter outside the baggage claim area on island three under the sign "Scheduled Busses and Vans."
- Via MAX Rail (www.trimet.org/go/cgi-bin/plantrip.cgi): Board the Red Line to City Center & Beaverton. Debarx at Pioneer Square North; the hotel is four blocks from the stop. Travel time: 46 minutes. Fare: \$2.30.

CIC16 Conference Registration

Name _____
 Title/Position _____
 Company _____
 Mailing Address _____
 Telephone _____ Fax _____ Email _____

Conference registration includes admission to all technical sessions, the Hunt Symposium, full-color conference proceedings with CD, coffee breaks, and four receptions (DevCon, Welcome, Conference, and Hunt). Separate registration fees are required for short courses, ICC DevCon, the Hunt Symposium Banquet, and The Black and White Meeting. You may also register online at www.imaging.org/conferences/CIC16.

Conference Registration (CHECK ONE)	IS&T/SID Member	Non-member	TOTAL
<i>After October 13, add \$50 to the appropriate fee below.</i>			
___ Technical Registration	\$595	\$705	\$ _____
___ Speaker/Session Chair	\$495	\$605	\$ _____
___ Student (ID required)	\$125	\$150	\$ _____

Extra copy of Proceedings (special pre-conference/onsite rate)	IS&T/SID Member	Non-member	TOTAL
___ Extra copy	\$85	\$85	\$ _____

Hunt Short Course Registration	IS&T/SID Member	Non-member	TOTAL
<i>After October 13th, add \$50 to the appropriate fee below.</i>			
___ 2-day Hunt Course	\$650	\$825	\$ _____
___ 2-day Hunt Course Student	\$250	\$250	\$ _____

Short Course Registration (be sure to multiply number of classes by per course fee and place on total line)	IS&T/SID Member	Non-member	TOTAL
<i>After October 13th, add \$30 to the appropriate fee below. Students add \$5.</i>			
___ 4-hour tutorial <input type="checkbox"/> T1D <input type="checkbox"/> T3D	\$225	\$255	\$ _____
___ 4-hour tutorial Student <input type="checkbox"/> T1D <input type="checkbox"/> T3D	\$50	\$50	\$ _____
___ 2-hour tutorial (per class)	\$150	\$180	\$ _____
___ 2-hour tutorial Student (per class)	\$50	\$50	\$ _____

Check all that apply: M1 M2 M3 M4 T1A T1B T1C T2A T2B T2C T3A T3B T3C T4A T4B T4C

OR

Take three or more classes and receive 25% off the total price

(enter three tutorials, fill in member or non-member fee next to each, add together, and multiply by .75 to get your price, representing 25% savings; add additional lines if needed)

T _____ \$ _____ + T _____ \$ _____ + T _____ \$ _____ = \$ _____ x .75 = \$ _____

Page Subtotal \$ _____

continued on next page

Sixteenth Color Imaging Conference

DevCon'08	Member*	Non-member	TOTAL
<i>* Members of ICC/IS&T/SID/ISCC</i>			
<i>After October 13, add \$50 to the appropriate fee below; does not apply to students. Note that registration includes lunch and an evening networking reception.</i>			
___ first and second registrant from company	\$350	\$450	\$ _____
___ additional registrant from company	\$250	\$325	\$ _____
___ Student	\$50	\$50	\$ _____

The Black and White Meeting Member*

<i>* Members of ISCC/IS&T/SID</i>			
<i>After October 13, add \$50 to the appropriate fee below; does not apply to students. Note that registration includes lunch.</i>			
___ Technical Registration	\$200	\$250	\$ _____
___ Student	\$100	\$100	\$ _____

Hunt Symposium Banquet (includes 3-course meal, champagne, and Oregon wine)

___ Banquet ticket		\$75	\$ _____
please list any dietary restrictions: <input type="checkbox"/> vegetarian <input type="checkbox"/> kosher <input type="checkbox"/> other: _____			

Spouse/Guest Tickets

___ Admission to CIC16 Welcome, Conference, and Hunt Receptions	\$65	\$ _____
___ Guest ticket for Hunt Symposium Banquet	\$75	\$ _____
Name/Affiliation of Guest for badge: _____		
please list any dietary restrictions: <input type="checkbox"/> vegetarian <input type="checkbox"/> kosher <input type="checkbox"/> other: _____		

Membership	US address	Non-US Address	TOTAL
___ IS&T new membership (<i>join now; your membership is good until 12/09</i>)	\$95	\$105	\$ _____
___ IS&T membership renewal (expires 12/31/09):	\$95	\$105	\$ _____
___ Student membership (expires 09/30/09)	\$25	\$25	\$ _____

Members receive one complementary online journal. Please select one:

JIST (Journal of Imaging Science and Technology) JEI (Journal of Electronic Imaging)

join now and calculate fees based on member rates

Subtotal from previous page \$ _____

GRAND TOTAL \$ _____

Payment Method: Check (Check # _____) AMEX MC VISA Discover
 (to arrange for a bank transfer, contact info@imaging.org)

Card#: _____ Exp. Date: _____

Name as it appears on card: _____

Authorization Signature: _____

Return this form with signed credit card authorization or check payable in US dollars to
 IS&T, 7003 Kilworth Lane, Springfield, VA 22151 or fax to 703/642-9094
 register online at www.imaging.org/conferences/cic16

Please note: To cover bank charges and processing fees, there is a cancellation fee of \$75 dollars until November 7, 2008. After that date, the cancellation fee is 50% of the total plus \$75. All requests for refund must be made in writing. No refunds will be given without a written request after December 7, 2008.

Sixteenth Color Imaging Conference / CIC16



Society for Imaging Science and Technology
7003 Kilworth Lane
Springfield, VA 22151 USA
703/642-9090; 703/642-9094 (fax)

imaging.org

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Become part of the CIC online community!
Search Facebook or LinkedIn groups for "color imaging conference"