Seventeenth Color Imaging Conference
Color Science and Engineering
Systems, Technologies, and Applications
www.imaging.org/conferences/CIC17
November 9-13, 2009
Albuquerque, New Mexico

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

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Welcome to CIC17

On behalf of the Society for Imaging Science and Technology and the Society for Information Display, we are delighted to invite you to join us at the 17th IS&T/SID Color Imaging Conference (CIC17). This year’s Technical Program Chairs Erno Langendijk and Francisco Imai have created a cutting-edge program on topics including lighting, printing, image capture, vision, appearance, and displays.

Each day of the technical program begins with a keynote talk. We are very excited to present these three distinguished speakers:

- Ted Adelson, John and Dorothy Wilson professor of vision science (MIT), will speak about “The Perception of Surfaces and Materials,” demystifying some dramatic visual effects.

- Ingrid Vogels, senior research scientist (Visual Experiences Group, Philips Research) will give an overview of the latest research in the fields of displays, lighting, and ambient illumination, in her talk “How to Make Life More Colourful: From Image Quality to Atmosphere Experience.”

- Robert W. G. Hunt will present a provocatively titled talk—The Challenge of our Known Unknowns—posing problems for the audience to attack in their color research.

In addition to the oral presentations, the technical program includes the popular Interactive Session and the preceding spotlight previews, moderated by Interactive Program Chairs Vien Cheung and Philipp Urban. The interactive sessions provide direct access to authors and their results in a rich environment for peer discussion.

We’ve added two panel discussions to this year’s program and hope to bring back the Late Breaking News session. On Wednesday afternoon Joshua Pines (Technicolor) moderates a panel discussion on Color and Movies, and on Friday morning, Louis Silverstein (VCD Sciences, Inc.) leads one on Color Enhancement.

In following with past years, the CIC week begins with a comprehensive set of short courses that span two days. Short Course Chairs Stephen Westland and Erika Kanematsu have assembled a range of informative classes taught by experts in their fields, including many new offerings. These courses are a great way to learn the relevant and focused background to get the most out of the technical papers, which follow during the conference.

We hope first-time attendees and familiar faces find the five days of color imaging in Albuquerque technically stimulating and a rewarding opportunity to network with industrial and academic colleagues from around the world.

The Welcome and Conference Receptions, as well as a special Thursday evening talk and musical event, offer attendees wonderful opportunities to network, and engage in detailed discussions of the day’s technical presentations.

We wish to express our sincere thanks and appreciation to the entire conference committee, reviewers, session chairs, and the helpful and professional staff at IS&T. We hope to see you in Albuquerque.

—Moshe Ben Chorin and Karen Braun, General Conference Co-Chairs
Conference At-a-Glance

Monday, November 9
Registration open 7:00 am to 5:00 pm
• Hunt two-day short course begins*
• four-hour short course on the fundamentals of color measurement*

Tuesday, November 10
Registration open 7:00 am to 6:00 pm
• Short Course Program (11 two-hour and 2 four-hour classes offered; see page 9)*
• Hunt two-day short course continues*
• Welcome Reception

Wednesday, November 11
Registration open 7:00 am to 5:45 pm
• Keynote: The Perception of Surfaces and Materials
• Technical Sessions
  • Extreme Color
  • Color Image Quality
  • Color and Movies
• Interactive Spotlight Session I
• Color and Movies Panel and Discussion
• Conference Reception
* separate ticket required

Thursday, November 12
Registration open 8:00 am to 5:00 pm
• Keynote: How to Make Life More Colourful: From Image Quality to Atmosphere Experience
• IS&T Honors and Awards Presentations
• Technical Sessions
  • Color and Light
  • Spectral Color
• Interactive Spotlight Session II
• Printing and Color
• Interactive Paper Session
• Conference Reception

Friday, November 13
Registration open 8:00 am to 3:30 pm
• Keynote: The Challenge of our Known Unknowns
• Cactus Award Presentation
• Technical Session
  • Color Enhancement
• Color Enhancement Panel Discussion
• Technical Sessions
  • Color Manipulation
• Late Breaking News (papers TBA)

Venue: Hotel Albuquerque at Old Town

www.hhandr.com/albuquerque.php
800 Rio Grande Boulevard, NW, Albuquerque, NM 87104 • 1-800/237-2133

CIC17 will be held at the charming Hotel Albuquerque at Old Town located in the city’s historic district. Room rates for singles/doubles are $110/night. Internet access is $5/week. The reservation form and information for registering online is located on page 19.

The hotel is located five miles from the Albuquerque International Sunport (airport) just off Interstate 25. Walking out the back door of the conference center takes you directly into Old Town Albuquerque, a quaint historic town square filled with restaurants, shops, and the Museum of Art and History (www.albuquerqueoldtown.com). For more information about Albuquerque and the surrounding area please visit www.itsatrip.org/.

There are direct flights to Albuquerque from more than 30 US cities including Newark, NJ, Baltimore, Washington, DC (IAD), Seattle, San Francisco, Los Angeles, Chicago, Atlanta, Orlando, and Dallas. For more information on other direct flights, visit http://www.itsatrip.org/meetings/services/getting-here.aspx.

The average weather in November is a comfortable and sunny high of 57°F/13°C.
Technical Program

Wednesday November 11, 2009

8:45 - 9:30 AM
KEYNOTE SESSION
Session Chairs: Karen Braun, Xerox Corporation, and Moshe Ben-Chorin, Genoa Color Technologies

Welcome Remarks
The Perception of Surfaces and Materials, Edward (Ted) H. Adelson, MIT (USA)

9:30 - 10:30 AM
EXTREME COLOR
Session Chair: Brian Funt, Simon Fraser University

Reflectance, Illumination, and Edges, John McCann, McCann Imaging (USA); Carinna Parrimian, University of the West of England (UK); and Alessandro Rizzi, Università degli Studi di Milano (Italy)
Jones and Condit Redux in High Dynamic Range and Color, Rodney L. Heckaman and Mark D. Fairchild, Rochester Institute of Technology (USA)
A Method for Designing and Assessing Sensors for Chromaticity Constancy in High Dynamic Range Scenes, Sivalogeswaran Ratnasingam and Steve Collins, University of Oxford (UK); and Javier Hernández-Andrés, University of Granada (Spain)

11:10 AM - 12:30 PM
COLOR IMAGE QUALITY
Session Chair: Nathan Moroney, Hewlett-Packard Co.

Image Quality Measure for Evaluating Gamut Mapping, Zofia Baranczuk and Peter Zolliker, Swiss Federal Laboratory for Materials Testing and Research (Switzerland); and Joachim Giesen, Friedrich-Schiller University Jena (Germany)
An Adaptive Bilateral Filter for Predicting Color Image Difference, Zhaohui Wang and Jon Yngve Hardeberg, Gjøvik University College (Norway)
Evaluating Display Quality with Electroencephalography, Wei-Chung Cheng, National Chiao Tung University (Taiwan)
SV-CIELAB: Video Quality Assessment Using Spatio-Velocity Contrast Sensitivity Function, Keita Hirai, Jambal Tumurtogoo, Cayano Kikuchi, Toshiya Nakaguchi, Norimichi Tsumura, and Yoichi Miyake, Chiba University (Japan)

2:00 - 3:10 PM
COLOR AND MOVIES
Session Chair: Lars Borg, Adobe Systems

Optimizing Anaglyph Colors (Focal), Thor Olson, Electronics for Imaging (USA)
Description and Evaluation of the Variability of the Human Color Vision in an Anti-Piracy Context, Didier Doyen, Jean-Jacques Sacré, and Laurent Blondé, Thomson R&D (France)
From Contrast Sensitivity Function Construction to Visual Weightings Computation for Digital Cinema, Vincent Rosselli, Mohamed-Chaker Larabi, and Christine Fernandez-Maloigne, University of Poitiers (France)

3:10 - 3:20 PM
INTERACTIVE PAPERS
SPOTLIGHT SESSION I
Session Chairs: Vien Cheung, University of Leeds and Philipp Urban, Technische Universität Darmstadt

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

Experimental Design in Incomplete Paired-Comparison Experiments, Vien Cheung, Stephen Westland, and Yuan Li, University of Leeds (UK)
Recent Progress with Extensions to CIECAM02, Changjun Li, M. Ronnier Luo, and Michael R. Pointer, University of Leeds (UK)
As in the past, this year’s CIC17 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 on Thursday. LBN papers offer researchers the opportunity to provide the latest technical results on recent research, i.e., results that were not available in April, 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 CIC17, please submit a full-length paper (2,000-3,500 words) that:

- is ready for publication,
- is in MS-Word or PDF format,
- follows the guidelines found at www.imaging.org/conferences/guidelines.cfm, and
- uses the US letter-size template.

Papers should be sent to cic17@imaging.org by September 8, 2009. Paper will be reviewed promptly and you will be expected to submit the final version (with any requested revisions) by September 20, 2009 so that the paper may be included in the conference proceedings.
Thursday November 12, 2009

8:30 - 9:20 AM
KEYNOTE SESSION
Session Chairs: Karen Braun, Xerox Corporation, and Moshe Ben-Chorin, Genoa Color Technologies

How to Make Life More Colourful: From Image Quality to Atmosphere Experience, Ingrid M.L.C. Vogels, Philips Research (the Netherlands)

IS&T Awards Presentations

9:30 - 10:30 AM
COLOR AND LIGHT
Session Chair: James Ferwerda, Rochester Institute of Technology

Creation and Rendering of Stochastic Dynamic Light Effects, Dragan Sekulovski and Ramon Clout, Philips Research Europe; and Bram Kater, G2 Speech BV (the Netherlands)
Spectral Imaging with a Programmable Light Source, Shoji Tominaga, Takahiko Horiiuchi, and Hirokazu Kakinuma, Chiba University; and Akira Kimachi, Osaka Electro-Communications University (Japan)
Watermark Encoding and Detection Using Narrowband Illumination, Raja Bala, Karen M. Braun, and Robert P. Loce, Xerox Research Center (USA)

11:10 AM - 12:10 PM
SPECTRAL COLOR
Session Chair: Norimichi Tsumura, Chiba University

Distributions of Parameters and Parameter Mismatch Gamuts, Philipp Urban, Technische Universität Darmstadt (Germany)
Spectral Imaging Model by XYZ+K Four-Band Filter, Hiroaki Kotera, Kotera Imaging Laboratory (Japan)
Yule-Nielsen Approach for Predicting the Spectral Transmittance of Halftone Prints, Mathieu Hébert and Roger D. Hersch, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

12:10 - 12:30 PM
INTERACTIVE PAPERS SPOTLIGHT SESSION II
Session Chairs: Vien Cheung, University of Leeds, and Philipp Urban, Technische Universität Darmstadt

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

Perceived Image Quality of Printed Images and Their Relation to Paper Properties, Ole Norberg and Mattias Andérsson, Mid Sweden University (Sweden)
Attributes of a New Image Quality Model for Color Prints, Marius Pedersen, Nicolas Bonnier, Jon Y. Hardeberg, and Fritz Albrechtsen; "Gjøvik University College (Norway), "Océ Print Logic Technologies SA (France), and "University of Oslo (Norway)
In Situ Measured Spectral Radiation of Natural Objects, Dietmar Wueller, Image Engineering (Germany)
Ghosting Reflection Compensation for Multispectral High Dynamic Range Imaging, Johannes Brauers and Til Aach, RWTH Aachen University (Germany)
Estimating Reflectances for a Spectral CMS, Kristyn Falkenstern and Phil Green, London College of Communication (UK); and Marc Mahy, Agfa Graphics (Belgium)
Preferred Color Correction for Mixed Taking-Illuminant Placement and Cropping, Erin Fredericks and Mitchell R. Rosen, Rochester Institute of Technology (USA)
Modeling Skin Colours for Preferred Colour Reproduction, Huanzhao Zeng, Hewlett-Packard Company (USA), and Ronnier Luo, University of Leeds (UK)
Material Classification Using Color and NIR Images, Neda Salamati, Sabine Süsstrunk,
and Clement Fredembach, Ecole Polytechnique Fédérative de Lausanne (Switzerland)

Effects of Image Dynamic Range on Apparent Surface Gloss, Jonathan B. Phillips, James A. Ferwerda, and Stefan Luka, Rochester Institute of Technology (USA)

Real Reproducing of 3D Appearance with Multi-Projectors and Cameras, Sayuri Kamimigaki¹, Shoji Yamamoto², Keita Hirai¹, Norimichi Tsumura¹, Toshiya Nakaguchi¹, and Yoichi Miyake³; ¹Chiba University, ²Tokyo Metropolitan College of Industrial Technology, and ³Research Center for Frontier Medical Engineering (Japan)

2:00 - 2:40 PM
PRINTING AND COLOR
Session Chair: Patrick Emmel, Clariant International Ltd
Evaluating the Use of the Perceptual Reference Medium Gamut in ICC Printing Works,
Nicolas Bonnier¹, ², Nicolas Cardin¹, ², Christophe Leynadier², and Alain Sarlat²; ¹Océ Print Logic Technologies SA and ²Ecole Nationale Supérieure Louis-Lumières (France)

Nominal Scaling of Print Substrates, Nathan Moroney and Giordano Beretta, Hewlett-Packard Laboratories (USA)

2:40 - 4:40 PM
INTERACTIVE PAPERS SESSION
Papers previewed on Wednesday and Thursday are presented during this session, which includes the chance to directly discuss research with presenters and light refreshments.

7:30 – 10:00 pm
THURSDAY EVENING PROGRAM
The Color of Music
Join us for a fascinating talk on the color of sound followed by an evening of music

To get these prices, contact info@imaging.org.
Friday November 13, 2009

8:30 - 9:15 AM
KEYNOTE SESSION
Session Chairs: Karen Braun, Xerox Corporation, and Moshe Ben-Chorin, Genoa Color Technologies

The Challenge of Our Known Unknowns, Robert W. G. Hunt, consultant (UK)
Cactus Award Presentation

9:20 AM - 10:30 AM
COLOR ENHANCEMENT
Session Chair: John McCann, consultant

Realistic Skin Smoothing (Focal), Clement Fredembach, Nathalie Barbuscia, and Sabine Süsstrunk, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
Improved Color Reproduction by Hue Preservation in Integrated Multi-Scale Retinex, Wangjun Kyung1, Tae-Hyoung Lee1, Choul-Hee Lee2, and Yeong-Ho Ha1; 1Kyungpook National University and 2Andong National University (South Korea)
Color Management for Flexible Cholesteric-LCD under LED Illumination, Wei-Chung Cheng, Huang-Ming P. Chen, Cheng-Fu Cheng, and Yuh-Ferng Liu, National Chiao Tung University; and Jih-Fon Huang, Industrial Technology Research Institute (Taiwan)

11:10 AM - 12:30 PM
COLOR ENHANCEMENT PANEL
A discussion between panelists and the audience featuring presentations on color enhancement technologies.
Moderator:
Louis Silverstein, VCD Sciences, Inc.
Panelists:
TBA

2:00 - 3:30 PM
COLOR MANIPULATION
Session Chair: Jon Yngve Hardeberg, Gjøvik University College

The tangiBook: A Tangible Display System for Direct Interaction with Virtual Surfaces (Focal), Benjamin A. Darling and James A. Ferwerda, Rochester Institute of Technology (USA)
Sharpening from Shadows: Sensor Transforms for Removing Shadows Using a Single Image, Mark S. Drew and Hamid Reza Vaezi Joze, Simon Fraser University (Canada)
Shaped Local Regression and its Application to Color Transforms, Vishal Monga and Raja Bala, Xerox Research Center (USA)
A Unified Approach to Colour2Grey and Image Enhancement through Gradient Field Integration, Graham D. Finlayson, Roberto Montagna, and David Connah, University of East Anglia (UK)

4:00 – 5:00 PM
LATE BREAKING NEWS
Session Chairs: Francisco Imai, Canon Development Americas, Inc., and Erno Langendijk, Philips Research Laboratories Eindhoven
Submission for papers presented in this session are due September 8, 2009; please see page 4 for details.
CIC17 Short Course Program

The Hunt Course: Basic Color Science and Imaging

Monday and Tuesday, November 9 & 10, 2009 • 8:30 am to 4:30 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 metamericism 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. In 2009, Hunt was awarded The Order of the British Empire “for services to the field of colour science and to young people through Crusaders.”

Cost before October 11th:

- $650 IS&T/SID members
- $825 non-members
- $250 student members
- $285 student non-members

add $50 to all fees after Oct. 11, 2009
This short course begins by defining the basic terms surrounding the instruments and quantities used in spectral measurement. It then 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 recommended CIE geometries for reflectance and transmittance are covered. Extending beyond traditional color measurements, bispectral fluorescence measurements and gonio-apparent color measurement is also explained. Last, to evaluate instruments the concepts of precision and accuracy of measurement devices is introduced along with mathematical techniques for the analysis.

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
- Consider the implications of materials properties as they relate to color measurement, in particular when non-standard measurement techniques are required (e.g. to quantify fluorescence or gonio-apparent colors)

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

David R. Wyble is a color scientist within the Munsell Color Science Laboratory at the Rochester Institute of Technology. He holds a BS in computer science and MS and PhD degrees in color science from RIT and Chiba University, respectively. Wyble currently teaches graduate color measurement within MCSL. He has published in the areas of device characterization and color instrumentation. Wyble is active in ISCC and CORM.
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. 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.

**T2A: A Unified Paradigm for Color Management**
8:00 – 10:00 am (2 hours)
Instructor: Thomas E. Madden, Eastman Kodak Company

The principal objective of color management is to represent, control, and communicate color within and among color-imaging systems. Numerous color-management methods claiming to provide “device-independent” color have not proven in practice to be completely successful. This course sets forth the basic principles required to understand the successful management of color in imaging systems.

Two fundamentally different methods of representing color images are explored: scene-based and rendered-image-based color encoding. A discussion follows of three basic color-management paradigms describing the different behaviors of various types of color-imaging systems. A unified color-management paradigm is then described which, together with its unique appearance-based color encoding, offers a comprehensive solution to the difficult problem of managing color in today’s complex color-imaging systems.

**Benefits:** Attendees will be able to:
- Understand why images from various types of media and devices differ fundamentally in their basic color properties, and the impact these differences have on digital color management.
- List and compare the capabilities and limitations in the technologies used in various types of color-managed systems.
- Recognize how the relationship between colorimetry and color appearance can be handled in color-managed systems.
- Describe the properties of a unified color-management paradigm.
- Differentiate the unified paradigm’s appearance-based representation from other color-encoding methods.
- Explain how the unified paradigm can be translated to practical systems.

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

Tom Madden is a senior principal scientist at Eastman Kodak Company. The holder of numerous patents, he is co-author of Digital Color Management: Encoding Solutions and contributing author to several other color-imaging texts. Madden is an award-winning instructor at Kodak and a former adjunct instructor at RIT. He is a contributor to numerous publications, and a frequent lecturer at technical symposia, universities, and industries in the US, Canada, and Europe. Please note: A copy of Digital Color Management: Encoding Solutions is included with the price of the course.

T3A: Color Appearance Modeling and CIECAM02
8:00 – 10:00 am (2 hours)
Instructor: Nathan Moroney, Hewlett-Packard Laboratories

This 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.
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. It 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 trade-offs 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 trade-offs among image processing algorithms
  - Identify image processing problems from evaluation of output images

**T4A: Digital Camera Image Capture and Processing — From Pixels to Picture**

8:00 am – 12:15 pm
Instructor: Matt Whalen, Applied Color Science, Inc.

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.

**T1B: Color Difference Perception for Images**

10:15 am – 12:15 pm
Instructor: M. Ronnier Luo, University of Leeds

8:00 AM – 12:15 PM

**T4A: Digital Camera Image Capture and Processing — From Pixels to Picture**

8:00 am – 12:15 pm (4 hours)
Instructor: Matt Whalen, Applied Color Science, Inc.
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.

Ronnier Luo is a professor of colour and imaging science in 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 is a Fellow of IS&T and the Society of Dyers and Colourists. He is also the recipient of the 2009 and 2004 Gold Medal and Centenary Medal from the Society of Dyers, the 2003 Davies Medal from the Royal Photographic Society of Great Britain, and a 1994 Bartleson Research Award.

T2B: Color Optimization for Displays
10:15 – 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, color gamut, viewing angle, uniformity, 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 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, pre-press professionals, and those confronting display related color issues.

Gabriel Marcu is senior scientist in 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 short 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 EI Color Imaging Conference: Display, Hardcopy, Processing, and Applications. Marcu is a SPIE Fellow.

T3B: Image Appearance
10:15 – 12:15 pm (2 hours)
Instructor: Mark Fairchild,
Rochester Institute of Technology (RIT)

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 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.

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 preference assessment, the modern analysis method for rank order experiments is introduced. A hands-on experience is the focus of the course and a rank-order image preference experiment is conducted and analyzed using ordinary spreadsheet software. Error bars are computed and range tests run so that the stimuli may be placed in groups not statistically significantly different from each other. The technique is especially useful for hard-copy preference, or preference of hard-copy reproductions of soft-copy originals.

**Benefits:** Attendees will be able to:
- Construct an image preference scale 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:** this course assumes no prior experience with psychometric-based image preference/quality assessment, so those new to psychometrics can expect to understand the material; what is assumed is a passing familiarity (perhaps from a previous life) with basic statistics. However, because the focus is hands-on activity, even those familiar with psychometrics who wish to bring their knowledge up to date are encouraged to attend. If you are using paired comparison and want to learn
a faster, more efficient way, or if you have tried rank-order in the past, but are unfamiliar with modern analysis techniques or have been wary of unreasonable assumptions (which are avoided in this modern analysis protocol), you should attend this course. Scientific, engineering, and marketing personnel will all 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 graduate-level courses at RIT, as well as for corporate and government clients.

In this course, attendees go through the process of characterizing a digital camera’s color analysis, including measuring the spectral sensitivities of the camera, determining transforms from raw camera RGB to scene-referred, and calculating the camera’s color analysis gamut. Images are processed using the characterizations determined, and the results are compared to in-camera processed images and images processed by camera raw processing applications using default characterizations. Scene-referred images are encoded in appropriate file formats and examples of some methods for processing scene-referred images to output-referred is shown. Most of the above is accomplished using publicly available hardware and software, so attendees should be able to perform characterizations on their own after completing the course.

Benefits: Attendees will be able to:
- Measure the spectral sensitivities of a digital camera
- Select appropriate spectral training sets, white balancing methods, and error minimization metrics for determining camera characterization transforms
- Determine camera characterization transforms and the resulting scene analysis color gamuts
- Create modules for applying the camera characterization transforms such as ICC profiles and DNG metadata
- Convert camera raw files to scene-referred color encodings including RIMM RGB, scRGB, and ACES (Academy of Motion Picture Arts & Sciences Color Encoding Specification).

Intended Audience: while there will be some theoretical discussion, the primary focus of the course is on real-time and interactive performance of the tasks. The course is designed more like a lab practical than a lecture. For this reason, it should be accessible to a range of participants with backgrounds in digital photography and color science (although the pace will be relatively fast due to time limitations).

Jack Holm is the president & CTO of Tarkus Imaging, a San Jose, California startup engaged in digital photography technology development and licensing, consulting, and test & measurement. He is convener of the ISO committee responsible for digital camera colour characterization, secretary for the IEC committee on multimedia colour measurement and management, and a contributor to the AMPAS Image Interchange Framework. Formerly he was a principal scientist at HP and a professor at RIT.

This course examines the relationship between color and gloss in reflective surfaces. Real materials exhibit varying de-
Degrees of gloss and their apparent color may vary considerably with viewing angle, yet color measurement and device characterization procedures usually try to avoid the specular components from non-Lambertian surfaces. This is a significant problem for applications such as capture of 3D object geometry, scene interpretation in machine vision, and realistic rendering of surfaces in computer graphics. This course covers relevant topics, based on recent experimental results, publications, and international standards.

Benefits: Attendees will be able to:
- Review colorimetry, the CIE system, and its limitations
- Explore the physics of gloss and the bidirectional reflectance distribution function (BRDF)
- Learn about the measurement of gloss for multi-angle and goniometric methods and standards
- Understand the appearance of gloss, including visual scales and interaction with color
- Learn about modeling of gloss in computer graphics and physical and visual models
- Discover imaging techniques, based on digital photography and laser scanning

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

Lindsay MacDonald is professor of digital media at the London College of Communication. He was formerly a professor at the Colour & Imaging Institute in Derby. He has edited eight books on various aspects of color image science and engineering; his research interests include the application of colorimetry and color imaging to cultural heritage media, including paintings, stained glass and ceramics. He has been a frequent speaker at CICs and was conference co-chair in 1996. MacDonald is a Fellow of IS&T and the Royal Photographic Society. He was a member of CIE Technical Committee TC1-65 “Measurement of Visual Appearance;” has recently stepped down as chair of The Colour Group (Great Britain); and is now chair of the organizing committee for the Twelfth Congress of the AIC, to be held in the UK in 2013.

1:30 – 5:45 PM

T4C: Spectral Imaging Workflow
1:30 – 5:45 pm (4 hours)
Instructors: Mitchell Rosen, Rochester Institute of Technology, and Philipp Urban, Technische Universität Darmstadt

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 overviews 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 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, 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 for JIST.

He is active in organizing international conferences on spectral imaging. Rosen co-edited the book Color Desktop Printer Technology. His website is www.cis.rit.edu/rosen and he can be reached at rosen@cis.rit.edu.

Philipp Urban has been head of an Emmy-Noether research group at the 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 the RIT Munsell Color Science Laboratory, where he developed the first spectral-based copying system especially designed for artwork reproduction. He holds a MS in mathematics from the University of Hamburg and a PhD from the Hamburg University of Technology (Germany).

Psychophysical methods from experimental psychology can be used to quantify the relationships between the properties of images and the attributes people perceive. The results of psychophysical experiments can be used to create predictive models of human perception that can guide the development of effective and efficient color imaging algorithms and enabling interfaces. The course provides an introduction to the use of psychophysical methods in color science and engineering and will teach attendees how to develop experiments that can be used to advance color imaging research and applications.

Throughout the presentation, relevant examples are used so that attendees understand how to design and run their own experiments; analyze the results; and develop perceptually-based algorithms and applications.

**Benefits:** Attendees will be able to:
- Identify the major techniques for measuring perceptual thresholds and scales
- Design psychophysical experiments using these techniques
- Analyze the data from these experiments to derive perceptual metrics
- Apply this knowledge to practical problems in color and imaging science and engineering

**Intended Audience:** those who want to be able to interpret the results of perception psychology experiments and develop their own user perception studies. The course assumes a basic level understanding of issues in color imaging science and engineering. Familiarity with freshman-level college math is helpful. No specific knowledge of...
perception psychology or statistical methods is required. All relevant concepts are introduced in the class.

James A. Ferwerda is an associate professor in the RIT Munsell Color Science Laboratory. He received a BA in psychology, MS in computer graphics, and a PhD in experimental psychology from Cornell University. The focus of his research is on building computational models of human vision from psychophysical experiments, and developing advanced graphics algorithms based on these models. Current research interests include: high dynamic range imaging; perceptually-based rendering; perception of material properties; and low-vision and assistive technologies. In 1992 he received the IEEE Computer Society Paper of the Year Award, and in 2003 he was selected for the National Academy of Engineering Frontiers of Engineering Program. He is an associate editor of ACM Transactions on Applied Perception, was guest editor for a special edition of IEEE Computer Graphics and Applications on Applied Perception, and serves as a member of CIE Technical Committee TC8-08 on High Dynamic Range Imaging.

T2D: Color in High Dynamic Range Imaging
3:45 – 5:45 pm (2 hours)
Instructor: Greg Ward, Anyhere Software

The techniques and technologies behind high dynamic range (HDR) imaging, covering methods for HDR capture, representation, editing, and display are described and the course 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. Tone- and gamut-mapping issues for low dynamic range (LDR) output and printing are also addressed.

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. 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.anyhere.com).
CIC17 Hotel Registration

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Reservations Deadline: October 8, 2009

Hotel Albuquerque at Old Town
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telephone 505/843-6300; toll-free reservations 1-800-505-7829; fax 505/842-8426

Reservations may be made at www.hotelabq.com; enter GRPE79 in the box noted RATE CODE.
Or fax this form to 505/842-8426

A special block of rooms at a discounted rate ($110) is being held at the Hotel Albuquerque at Old
Town for the nights of November 9-13, 2009. The discounted rate will be honored for three days
before and after these dates based on availability. To guarantee a room, please fill out this form
and fax it to 505/842-8426; make your reservations online as noted above; or call the hotel
directly and identify yourself as part of the “IS&T Color Imaging Conference.” Reservations made
after October 8, 2009 will receive the group rate based on availability.

Check in time: 3:00 pm     Checkout time: noon
Room rates: $110 single/double  + 12.875% room tax
Internet access is an additional $5/week.

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 Please reserve my ___ Single  ___ Double      I prefer a ___ King    ___ 2 double beds

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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 Information
Information on flights in/out of Albuquerque (ABQ), as well as ground transportation, can be found at
www.cabq.gov/airport.

The Sunport Shuttle provides convenient service between the airport and the hotel for $15/one way;
$28/round trip, per person. The Sunport Shuttle check-in counter is located inside the airport on the Baggage
Claim level across from Southwest’s Baggage Carousel No. 3. The shuttle runs from 4:30 am until 10:00 pm.
For reservations and more information, please visit www.sunportshuttle.com or call 505/883-4966.

Taxi service is also available at the terminal. The typical charge is $24. For more information and services call
the Albuquerque Cab Company 505/883-4888 or Yellow Cab Company 505/247-8888.
CIC17 Conference Registration

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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. You may also register online at www.imaging.org/conferences/CIC17.

Conference Registration (CHECK ONE) IS&T/SID Member Non-member TOTAL

Register early and save $100. After October 11, add $100 to the appropriate fee below.
___ Technical Registration $620 $720 $ _____
___ Speaker/Session Chair $520 $620 $ _____
___ Student (ID required) $125 $150 $ _____

Extra copy of Proceedings (special pre-conference/onsite rate)
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Hunt Short Course Registration
After October 11th, add $50 to the appropriate fee below.
___ 2-day Hunt Course $650 $825 $ _____
___ 2-day Hunt Course Student $250 $285 $ _____

Short Course Registration (be sure to multiply number of classes by per course fee and place on total line)
After October 11th, add $35 to the appropriate fee below.
___ 4-hour course ❑ M1 ❑ T4A ❑ T4C $230 $260 $ _____
___ 4-hour course Student ❑ M1 ❑ T4A ❑ T4C $50 $50 $ _____
___ T2A (2-hours, includes book, see p. 11*) $235 $260 $ _____
___ T2A Student (2-hours, includes book, see p. 11*) $130 $130 $ _____
(see note bottom of next page)
___ 2-hour course (per class) $155 $185 $ _____
___ 2-hour course Student (per class) $50 $50 $ _____
Check all that apply: ❑ T1A ❑ T1B ❑ T1C ❑ T1D ❑ T2B ❑ T2C ❑ T2D
❑ T3A ❑ T3B ❑ T3C

OR
Take three or more classes and receive 25% off the total price*
(enter three two- or four-hour courses, 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; students may not take advantage of this offer)

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* Members receive one complementary online journal; you may purchase a hard copy or online subscription in addition to your complementary online journal. Please select one complementary online journal:

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**register online at www.imaging.org/conferences/cic17**

Please note: To cover bank charges and processing fees, there is a cancellation fee of $75 until November 6, 2009. 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 9, 2009.

*If you already own a copy of Digital Color Management: Encoding Solutions by Edward J Giorgianni and Thomas E Madden, you may choose one of the other books highlighted on page 6. Please indicate the one you’d like as part of your registration here: ___________________________________________

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