

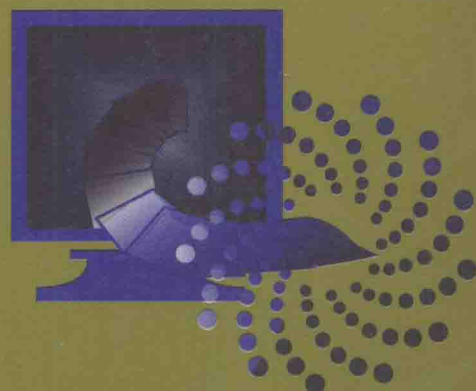
Final Program and Proceedings of IS&T/SID

Fourth Color Imaging Conference

Color Science, Systems, and Applications

November 19-22, 1996
The Radisson Resort
Scottsdale, Arizona

General Co-Chairs:
Ron Gentile, Adobe Systems Inc. (IS&T)
and Gerald Murch, Xerox Corporation (SID)



**The Society for Imaging
Science and Technology**



**The Society for
Information Display**

Cooperating Societies:

ISCC—Inter-Society *Color* Council

SEPJ—Society of Electrophotography of Japan

SMPTE—The Society of Motion Picture and Television Engineers

SPSTJ—Society of Photographic Science and Technology of Japan

Final Program and Proceedings of IS&T/SID

Fourth Color Imaging Conference: Color Science, Systems and Applications

November 19 - 22, 1996
The Radisson Resort
Scottsdale, Arizona

Sponsored by



**IS&T—The Society for Imaging
Science and Technology**
7003 Kilworth Lane
Springfield, VA 22151
703-642-9090; FAX: 703-642-9094
E-mail: info@imaging.org

**SID—The Society for
Information Display**
1526 Brookhollow Drive, Ste. 82
Santa Ana, CA 92705-5421
714-545-1526; FAX: 714-545-1547
E-mail: socforinfodisplay@mcimail.com

The papers in this volume represent the program of
The Fourth IS&T/SID
Color Imaging Conference:
Color Science, Systems and Applications
held November 19—22, 1996 in Scottsdale, Arizona

Copyright 1996

IS&T—The Society for Imaging Science and Technology
7003 Kilworth Lane
Springfield, Virginia 22151 USA
Telephone: 703-642-9090
Fax: 703-642-9094
E-mail: info@imaging.org
www.imaging.org

All rights reserved. This book, or parts thereof, may not be reproduced
in any form without the written permission of the Society.

ISBN: 0-89208-196-1

This book was produced from copy submitted by the authors.
No editorial changes have been made to the content.
Color pages have been provided as inserts by the authors.

Printed in the U.S.A.

Special Events

The Conference Reception

Wednesday, November 20, 1996
6:00 to 8:00 p.m.

The Product Displays

Chair: Joann Taylor, Color Technology Solutions
Thursday, November 21, 1996
3:05 - 5:35 p.m.

Held concurrent with the Poster Session.

Join us for this special opportunity to learn about color imaging products used in practice.
Products will be displayed by the following companies:

RIT
LightSource

X-Rite

MacBeth
ESECO

Tour of R.R. Donnelley & Sons

Thursday, November 21, 1996
5:30 - 9:00 p.m.

An optional tour of the R.R. Donnelley Casa Grande printing facility will be offered. The Casa Grande Facility is a state of the art gravure printing installation which manufactures catalogs, newspaper inserts and weekly tabloids. The tour will trace the journey of digital data from

customer transmission to proofing, imposition, digital engraving, printing and shipping of final printed products. Along the journey, issues specifically related to color reproduction and quality will be discussed. A light meal will be provided at the plant.

The Conference Committee

General Co-Chairs

IS&T, Ronald S. Gentile
Adobe Systems Inc.
Mailstop W14, 345 Park Avenue
San Jose, CA 95110-2704
408-536-3955; Fax: 408-537-4042
gentile@adobe.com

SID, Gerald Murch
Xerox Corporation
Desktop Doc. Syst., Bldg. 3
3400 Hillview Avenue
Palo Alto, CA 94304
415-813-7285; Fax: 415-813-6819
gmurch@adoc.xerox.com

Technical Program Co-Chairs

IS&T, Michael Stokes
Hewlett Packard
1501 Page Mill Road
Palo Alto, CA 96304
415-857-3908; Fax: 415-857-4320
stokes@hpl.hp.com

SID, Lindsay W. MacDonald
Centre for Res. in Applied Multimedia
Dept. of Information Technology
Cheltenham & Gloucester College of Higher Education
Broadlands, The Park, Cheltenham,
Glos. GL50 2QF, England
44-1242-544002; Fax: 44-1242-544032
LMacDonald@chilt.ac.uk

Technical Program Committee

Rob Buckley, Xerox Corporation
Jan De Clippeler, Agfa-Gevaert N.V.
Mark Fairchild, RIT
Michael Has, FOGRA Institute
Naoya Katoh, Sony Corporation
James King, Adobe Systems Inc.
Tim Kohler, Canon Information Systems Inc.
Yoichi Miyake, Chiba University

Phil Robertson, Canon Information Syst. Res. Australia
Michael Rodriguez, R.R. Donnelley & Sons Co.
Gary Starkweather, Apple Computer Inc.
David Travis, System Concepts Ltd.
Joann Taylor, Color Technology Solutions
Shoji Tominaga, Osaka Electro-Communication University
Joel Trussell, North Carolina State University
Hiroaki Kotera, Chiba University

Sponsors Advisory Board Co-Chairs

John McCann, IS&T
Andras I. Lakatos, SID

Advisory Board Members

John Meyer, IS&T
Phil Heyman, SID

Audio/Visual Chair

Jan Morovic
Design Research Center
University of Derby
Brittania Mill, Mackworth Road
Derby DE 22 3BL UK
44-1332-622-218
44-1332-622-218
J.Morovic@derby.ac.uk

Poster/Product Displays Chair

Joann Taylor
Color Technology Solution
17890 N. W. Deercreek Court
Portland, OR 97229-3060
503-645-5129; Fax: 503-645-5129
joannt@teleport.com

Tutorials Chair

Rob Buckley
Xerox Corporation
800 Phillips Road, Bldg. 0128-27E
Webster, NY 14580
716-422-1282; Fax: 716-422-6117
Robert_Buckley.wrc@xerox.com

Welcome to the Conference

Welcome to the fourth annual IS&T/SID Color Imaging Conference. This conference has become the premier technical conference for scientists, technologists and engineers working in the areas of color science and systems and their application to color imaging. 1996 marks the fourth year of this topical, annual conference with a significant growth in overall participation as well as an increase in the professional disciplines represented. The conference is international in nature. In 1995 one third of the participants came from outside the United States and Canada.

As the Color Imaging Conference has grown and matured, the focal areas have expanded dramatically. Professional disciplines represented range from psychophysics, optical physics, image processing, color science, graphic arts, systems engineering as well as hardware and software development. In fact, it is the broad mix of professional interests that is the hallmark of this conference. The focus is color—color as a critical element of the research and application efforts of this segment of the professional imaging community.

While color science continues to be a fundamental component, an increasing number of presentations have focused on the application of color in a variety of emerging areas including printing, display, graphics, and imaging science. Beyond representing all areas of color imaging, this year's conference also expands into the areas of graphic arts in particular and computer science in general.

The conference program is designed to promote interaction between the participants. The format includes both keynote and invited addresses by leading specialists in various color related fields as well as submitted papers presented in oral and poster format. Despite rapid growth in the conference we have continued the single-session format this year which will allow participants to attend all presentations.

All of us involved in the fourth annual IS&T/SID Color Imaging Conference take great pride and satisfaction in this year's technical program. We hope that you enjoy the conference and that this digest of papers serves as a useful reference for many years to come.

Ronald S. Gentile
Gerald Murch

General Co-Chairs

The Tutorials

Tuesday, November 19, 1996

Tutorial Chair: Rob Buckley, Xerox Corporation

Early Morning Classes—8:00 to 10:00 a.m.

T1: Fundamentals of Colorimetry

Instructor: Joann M. Taylor, Color Technology Solutions

This tutorial will introduce you to the principles of the CIE system of colorimetry. It will provide a basic review of color science concepts including color terminology, fundamental colorimetry, and its use in deriving a variety of color quantities including XYZ tristimulus values, the CIE x, y and u'v' chromaticity diagrams, color spaces such as CIELAB and CIELUV as well as color difference metrics including ΔE , CMC, and CIE94. The tutorial will then describe the appropriate use of these colorimetric quantities in areas such as color matching and color rendering. It will also discuss their correlation with perceived color appearance and their inherent limitations. This tutorial is intended for imaging professionals that are new to color or those interested in refreshing or enhancing their current knowledge with a review of the basic concepts of colorimetry. Attendees of the tutorial will be able to:

- understand the principles and uses of CIE colorimetry
- identify and define the basic colorimetric quantities
- list and describe the four principal forms of colorimetric data
- explain and differentiate tristimulus values, chromaticity coordinates, color spaces and color difference metrics
- summarize the ways in which colorimetric quantities correlate with color matching, rendering and appearance
- compare and differentiate key color difference metrics.

Dr. Joann M. Taylor is president of Color Technology Solutions, in Portland, Oregon, a consulting firm specializing in color science and technology and its application to industrial problems. She received her MS and Ph.D. in Color Science/Analytical Chemistry at Rensselaer Polytechnic Institute. She is an active member of IS&T, ISCC, SID, ASTM, ACS and has served in a variety of technical and organizational roles at the Color Imaging Conference since its inception in 1993.

T2: Fundamentals of Digital Color Imaging Systems

Instructor: Paul Roetling
Xerox Digital Imaging Tech. Ctr.

This tutorial provides an overview of digital color imaging systems. It describes the elements of stand-alone and networked systems, the design criteria (in terms of common customer requirements) and how these criteria affect the parameters of each of the system elements. The options and

tradeoffs in each element are discussed, including how the various design criteria affect the tradeoffs chosen and how these tradeoffs then affect the overall performance characteristics of the system.

The tutorial is intended for engineers or scientists with background in imaging and some, limited, knowledge of color, who want to understand how the design tradeoffs in various parts of a digital color imaging system affect the overall system performance. The tutorial will also serve as an introduction to the more detailed discussions of individual aspects in tutorials conducted later in the day. Attendees of the tutorial will be able to:

- describe and give examples of the elements of a general digital color imaging system
- summarize the design criteria used to evaluate imaging systems
- explain the tradeoffs involved in the major system elements
- estimate the effect of any given tradeoff on the character of system performance
- compare the probable performance characteristics of systems with different sets of tradeoffs selected.

Paul Roetling is a Research Fellow and Manager of Color Integration in the Xerox Digital Imaging Technology Center in Webster, NY. He received a Ph.D. in Physics from the Univ. of Buffalo and has over 35 years experience in imaging systems. He is a Fellow of IS&T and OSA and was the Founding Editor of the Journal of Electronic Imaging, co-published by IS&T and SPIE.

Late Morning Classes—10:15 a.m. - 12:15 p.m.

T3: Color Appearance Models

Instructor: Mark Fairchild, RIT Munsell Lab

This tutorial covers the fundamental phenomena, techniques, and models of color appearance. Color-appearance models extend basic colorimetry, as typified by CIE tristimulus values, to the prediction of color matches and color appearance across widely varying viewing conditions. Recent advances in open systems for electronic image reproduction have accentuated the need for accurate and efficient color-appearance models to allow transformation of image data across media and viewing conditions.

This tutorial is intended for scientists and engineers who are involved in either designing or working with systems that produce or reproduce colored objects or images in various media and/or to be observed under varying viewing conditions. A knowledge of the fundamentals of colorimetry is assumed. Tutorial participants will be able to:

- define important color appearance phenomena and terminology
- summarize the formulation of color appearance models
- compare the Hunt, Nayatani, RLAB, LLAB, and ATD models
- judge the utility of color appearance models in their application.

Mark D. Fairchild is an Associate Professor of Color Science and Imaging Science and Director of the Munsell Color Science Lab. at RIT. He received his BS and MS degrees in Imaging Science from RIT and Ph.D. in Vision Science from the Univ. of Rochester. He is chair of CIE Technical Committee 1-34 on color appearance models and was presented with the 1995 Bartleson Award by the Colour Group (Great Britain) for his research work in color appearance and other areas of color science.

T4: Color in Hardcopy

Instructor: Gary Starkweather, Apple Computer

This tutorial will explain the principles of color imaging in hardcopy devices and acquaint the user with the different methods of electronic color printing. Furthermore, the various categories of color printing technology will be discussed and explained along with the advantages and disadvantages of each specific process. Guidance will be given in the appropriate use of each technology with regards to image fidelity, print speed, cost and size etc. of the printers themselves. The tutorial will also cover issues regarding controllers and interfaces to the various printers. Inherent in the use of any good color printer is the method of color management used or available to the user. Hence, the necessary requirements for device characterization and profiling will be discussed. Lastly, image examples from several technologies and printer types will be shown to demonstrate each printer's capabilities. The intended audience is individuals who procure, develop and utilize electronic color printing equipment. Attendees will be able to:

- understand color printing principles
- understand the various categories of electronic color printing technology
- determine the various issues in hardcopy image fidelity
- describe the issues surrounding color management
- understand controller implications with regards to the available technologies
- look at key system issues in electronic color printing.

Gary Starkweather is an Apple Fellow at Apple Computer, Inc. He has spent over 33 years in hardcopy technology and is credited with the invention of the laser printer. Prior to Apple, he was a Senior Fellow at Xerox PARC. He received his undergraduate education at Michigan State Univ. in Physics and did his graduate work in Optics at the Univ. of Rochester. He received a Scientific and Technical Academy Award in March of 1995 for his work with Pixar on color image scanning.

T5: Color in Electronic Displays

Instructor: Louis D. Silverstein, VCD Sciences Inc.

This tutorial will focus on the basic operating principles and visual characteristics of both emissive and non-emissive electronic color displays. The tutorial will provide a basic overview of colorimetry and photometry and relate them to the production and control of color on displays. Quantitative methods will be offered for characterizing, modeling and optimizing the color performance of each type of electronic color display.

This tutorial is structured for technically oriented professionals requiring a foundation in and working knowledge of color display technology. Attendees of the tutorial will be able to:

- understand the basic operating principles of emissive and non-emissive color displays
- identify and evaluate the differences between emissive and non-emissive display technologies
- relate colorimetric, photometric and functional visual characteristics of different technologies to different display applications and operating environments
- understand and estimate the essential optical characteristics of emissive and non-emissive displays
- calculate the basic colorimetric and photometric quantities for different types of displays.

Louis D. Silverstein is the Chief Scientist and founder of VCD Sciences, Inc., an organization involved in R&D in applied vision, color science and display technology. He received a Ph.D. in visual psychophysics from the Univ. of Florida and completed a postdoctoral fellowship at the Univ. of Wisconsin. Prior to founding VCD Sciences, Inc., he was a Senior Research Fellow at Honeywell's Systems and Research Center and a Research Scientist at the Boeing Co. He is a member of numerous technical societies, serves on the U.S. National Committee of the C.I.E., and has served an appointment to the National Academy of Sciences Committee on Vision.

Early Afternoon Classes—1:15 - 3:15 p.m.

T6: Color Management Systems

Instructor: Ronald S. Gentile, Adobe Systems Inc.

Plug-and-play systems provide customers with more solutions and opportunities. However, such heterogeneous environments increase the likelihood of color miscommunication. Color management systems are being developed and sold to increase accurate color communication in such systems. These color management systems are showing up in popular desktop applications and peripherals. Current color management systems employ International Color Consortium (ICC) profiles to describe color.

This tutorial is intended for scientists, engineers, designers, pre-press professionals and others interested in the area of color management systems and ICC profiles. Attendees should have a basic understanding of color and desktop computers. This tutorial will enable you to:

- describe the causes of color miscommunication
- understand the fundamentals of color management: device-independent color, profiles and color transformations
- compare device-dependent solutions to device-independent solutions
- understand and build ICC profiles
- evaluate and compare current color management systems: ColorSync, ICM and PostScript Level 2
- analyze systems issues and tradeoffs.

Ronald S. Gentile is a Senior Computer Scientist in the Advanced Technology Group at Adobe Systems Inc. He is the designer and implementor of many of Adobe's color technologies for both application and printer products. He received a Ph.D. in Electrical Engineering from Purdue University in the area of digital color imaging. He has served in a variety of technical and organizational roles at the Color Imaging Conference since its inception in 1993.

T7: Effective Use of Color

Instructors: Tim Kohler & Larry Lavendel,
Canon Information Systems

This tutorial will teach the design, technical, and psychophysical aspects of creating color presentations for 35mm slides, overheads, CRTs and the WWW. The tutorial will be given in two parts. The first part covers the design aspects of color selection, color composition, and information theory. The second part will focus on how to take advantage of the human visual system and color imaging technology to choose colors which will have the most impact and clarity. The students will leave with a practical toolkit of techniques, strategies, and resources for creating and adding color to information displays, from presentation graphics to WWW page design.

This tutorial is intended for anyone who creates color graphics to display information. After attending this course, the student will be able to:

- understand how color affects the delivery of information
- differentiate and evaluate the effective use of color in information display
- list the color characteristics of various color display technologies
- choose colors based on knowledge of the intended use
- design color compositions which are visually pleasing and clear
- create color designs based on color design theory.

Tim Kohler is a color engineer at Canon Information Sys. in Cupertino, CA. He has been working in the graphic arts industry for ten years, including quick print, in-plant printers and publication printing, and for three years has been a member of a team developing color management solutions for desktop color peripherals. Tim is the Canon representative to the International Color Consortium (ICC) and an active member of IS&T. Tim has studied Color Science, Printing, and Photography.

Larry Lavendel is the User Interface Guy at Canon Information Systems where he is involved in the research, design, and development of new color technologies and advanced graphical interfaces for Canon world-wide products. When not at Canon, he is a lecturer, teaching information graphics at Univ. of California, Santa Cruz in the Science Communication Dept. Under the name Ikitomi Design, Larry works as a freelancer in science illustration, exhibit design and construction, graphic arts, and computer based interactive education. He has a Graduate Certificate in Science Illustration.

Late Afternoon Classes—3:30 - 5:30 p.m.

T8: Complex Color Images

Instructor: John McCann, Consultant

This tutorial will discuss the properties of color appearance in complex images. It will review the two traditions of color: first, the tradition of physicists who seek to calculate a color match of individual pixels, and second, the tradition of the psychophysicists who seek to understand the spatial interactions of different parts of color images. It will review the details of both color contrast and color constancy. As background it will cover the experiments of Goethe, von Guericke, Count Rumford, Helmholtz, von Kries, Hering, Katz, Chevreul, Albers, and Land. For current work, it will cover color measurement experiments with Mondrians, measurements of real images, fine art reproductions, problems introduced by mismatch of display and print media gamuts, and digital image processing that calculates color sensations. Attendees of the tutorial will be able to:

- describe the objectives of different color calculations
- distinguish between calculations for color matches, color sensations, color perceptions and color appearances
- list the contrast and constancy experiments using complex images
- design measurements of complex images
- design experiments to measure color appearances
- differentiate between color appearance models

John J. McCann is a consultant, formerly Senior Manager of the Vision Research Lab, Polaroid Corp., he worked for many years with Edwin Land and Ansel Adams. His work on human psychophysics includes research on rods as color receptors, low-spatial-frequency vision, mathematical models of color vision and quantitative tests of Retinex theory. From 1979 to the present he has managed research on very-large format Polaroid photography, which includes the 20 (25 cameras, the Museum camera and Polaroid Replicas. Since 1978 he has been studying vision with computer processed digital images. This activity combines interests in mathematical models of vision with electronic imaging techniques. This basic research has concentrated on techniques for calculating color sensations and developing film recorders that control film exposures so that the photographic image is a record of color sensations rather than the record of light coming from the scene. He is an IS&T Fellow, and has served as Vice President, President

and currently as Past-President of IS&T. He was awarded the SID Certificate of Commendation for his work on the Color Imaging Conference. His work has led to 50 publications and ten U.S. patents.

T9: Digital Halftoning for Color

Instructor: Charles M. Hains
Xerox Digital Imaging Tech. Ctr.

This tutorial will introduce you to the principles of digital halftoning, with emphasis on practical aspects of dot design. It will compare basic methods for digital halftoning and will describe methods of implementation. This tutorial is intended for those with a technical background who use, specify or evaluate digital halftoning in their current position. Attendees of the tutorial will be able to:

- understand how digital halftoning works
- list and compare basic methods for digital halftoning, including line screens, clustered dots, diffuse dots, and stochastic screens
- explain the difference between error diffusion & blue noise masks
- classify and compare implementations based on PostScript spot-functions, PostScript level 2 threshold arrays, supercells, Holladay shifted threshold arrays, and error diffusion
- list dot design elements that can affect dot gain, visual noise and image quality
- distinguish two-, three-, and four-color moiré.

Charles Hains is a Principal Scientist in the Xerox Digital Imaging Technology Center in Pasadena, California. He received an MS in Systems Engineering from West Coast University in 1973. He has considerable experience in digital halftone implementation and design and he is the inventor of the Xerox "Quad Dot" technology.

T10: Photographic Scanning, Digital Cameras, and Reproduction Goals

Instructor: Jack Holm, Imaging Consultant

The quality of digital photographs is highly dependent on the approach used to obtain them. This tutorial outlines methods for digital image capture, lists the advantages and disadvantages of each in terms of desired reproduction goals, and specifies general quality criteria for system evaluation. In discussing reproduction goals, this tutorial will describe device-independent color and direct transformation techniques for achieving them, including insights based on experiences with conventional photography and television. This course is designed for professionals involved in the processing of color and tone in digital photographs. After completion of this course, attendees should be able to:

- differentiate between reproduction goals and select the appropriate goal for a particular application
- judge the relative merits of film and electronic image capture
- compare approaches to the scanning of transparencies, negatives, and prints
- develop and evaluate strategies for achieving desired tone and color reproduction
- identify the factors affecting image quality and performance in a system
- establish general quality requirements for pictorial imaging systems.

Jack Holm is a consultant specializing in the application of imaging science to the solution of problems in pictorial imaging. He is the author of 24 publications, and holds leadership positions on the ANSI and ISO standards committees for electronic and conventional photography.

Table of Contents

Special Events.....	iv
The Conference Committee.....	v
Welcome to the Conference.....	vi
The Tutorials.....	vii
The Papers Program.....	xi
The Papers.....	1
The Poster Papers.....	91
Authors Index.....	247
Week-at-a-Glance.....	IBC

Cooperating Societies

ISCC—Inter-Society *Color* Council

SEPJ—Society of Electrophotography of Japan

SMPTE—The Society of Motion Picture and Television Engineers

SPSTJ—Society of Photographic Science & Technology of Japan

Thank You Corporate Sponsors

Adobe Systems Inc.
BARCO Display Systems
Canon Information Systems Inc.
Corbis Corporation
Eastman Kodak Company: Digital & Applied Imaging
Eastman Kodak Company: Color Management Group
Fuji Photo Film Co. Ltd.

Hewlett Packard Labs
Konica Corporation
R. R. Donnelley & Sons
Scitex
Silicon Graphics Inc.
Sony Corporation
SunSoft
Xerox Corporation

The Papers Program

Wednesday, November 20, 1996

8:15 - 8:30 am

Introduction

Ronald S. Gentile, Adobe Systems Inc. and Gerald Murch, Xerox Corp.

Wednesday, November 20, 1996

8:30 - 11:30 am

Color Management

Session Chair: James King, Adobe Systems, Inc.

8:30 am	<i>Keynote Address: A Universal Paradigm for Color Management, Edward J. Giorgianni, Eastman Kodak Company, Rochester, New York</i>	1
9:20 am	A Minimax Method for Sequential Linear Interpolation of Nonlinear Color Transformations , <i>A. Ufuk Agar and Jan P. Allebach, School of Electrical and Computer Engineering, Purdue University, West Lafayette, Indiana</i>	1
9:45 - 10:15 am	Coffee Break	
10:15 am	Color Correction Method Based on the Spectral Reflectance Estimation using a Neural Network , <i>Yoshifumi Arai, Shigeki Nakauchi and Shiro Usui, Department of Information and Computer Sciences, Toyohashi University of Technology, Toyohashi, Japan</i>	5
10:40 am	Color Matching with ICC Profiles—Take One , <i>Robert Chung and Shih-Lung Kuo, Rochester Institute of Technology, Rochester, New York</i>	10
11:05 am	Building a Precision Colour Imaging System , <i>David P. Oulton, Christopher J. Boston and Robin Walsby, UMIST Manchester, United Kingdom</i>	14
11:30 - 1:00 pm	Lunch Break	

Wednesday, November 20, 1996

1:00 - 3:05 pm

Scanning Devices

Session Chair: Jan De Clippeleer, Agfa-Gevaert

1:00 pm	Analysis Multispectral Image Capture , <i>Peter D. Burns and Roy S. Berns, Munsell Color Science Laboratory, Center for Imaging Science, Rochester Institute of Technology, Rochester, New York</i>	19
---------	--	----

1:25 pm	Digital Camera Color Calibration and Characterisation , <i>U. Lenz, CCD Videometrie, Unterschleissheim, Germany; Habil and R. Lenz, TU Muenchen, Muenchen, Germany</i>	23
1:50 pm	New Quality Measures for a Set of Color Sensors—Weighted Quality Factor, Spectral Characteristic Restorability Index and Color Reproducibility Index— , <i>Johji Tajima, NEC Corporation, Kawawaki, Japan</i>	25
2:15 pm	Measures of Goodness for Color Scanners , <i>Gaurav Sharma and H. Joel Trussell, ECE Dept., North Carolina State University, Raleigh, North Carolina</i>	28
2:40 pm	Scanning Color Negatives , <i>Chris Tuijn, Agfa-Gevaert N.V., GS/EPS/R&D, Mortsel, Belgium</i>	33
3:05 - 3:30 pm	Coffee Break	

Wednesday, November 20, 1996

3:30 - 5:35 pm

Applications

Session Chair: Sabine Susstrunk, Corbis Corporation

3:30 pm	Invited: The History of Photographic Image Fading, with a Suggested Strategy for the New Hard Copy Media , <i>James M. Reilly, Image Permanence Institute, Rochester Institute of Technology, Rochester, New York</i>	38
3:55 pm	Electronic Imaging, a Tool for the Reconstruction of Faded Color Photographs and Motion Pictures , <i>Franziska S. Frey, Image Permanence Institute, Rochester Institute of Technology, Rochester, New York; Rudolf Gschwind and Lukas Rosenthaler, Institute of Physical Chemistry, University of Basel, Basel, Switzerland</i>	39
4:20 pm	Image Capture and Restoration of Medieval Stained Glass , <i>Lindsay W. MacDonald, Cheltenham & Gloucester College, United Kingdom, John Oldfield, Cornell University, Ithaca, New York</i>	44
4:45 pm	Spectrophotometric Image Analysis of Fine Art Paintings , <i>Henri Maître, Francis Schmitt, Jean-Pierre Cretiez, Yifeng Wu and Jon Yngve Hardeberg, École Nationale Supérieure des Télécommunications, Département Images, Paris, Cedex, France</i>	50
5:10 pm	Color Management Issues in the United States Imagery System (USIS) , <i>Scott Foshee, National Security Programs Team</i>	*

Conference Reception

6:00 to 8:00 pm

Thursday, November 21, 1996

8:30 - 9:45 am

Gamut Mapping and Color Appearance

Session Chair: Shoji Tominaga, Osaka Electro-Communication University

8:30 am	<i>Keynote Address: Why is Black-and-White so Important in Color?, R. Hunt, City University, London, England</i>	54
9:20 am	Learning Color Constancy , Brian Funt, Vlad Cardei and Kobus Barnard, School of Computing Science, Simon Fraser University, Vancouver, Canada	58
9:45 - 10:15 am	Coffee Break	
10:15 am	<i>Invited: Visualisation and Metavisualisations: Helping a User with Colour Gamut Mapping*, Philip K. Robertson, Canon Information Systems Research, Australia</i>	60
10:40 am	Color Gamut Mapping by Optimizing Perceptual Image Quality , Shigeki Nakauchi, Masahiro Imamura and Shiro Usui, Department of Information & Computer Sciences, Toyohashi University of Technology, Toyohashi, Japan	63
11:05 am	Gamut Mapping Based on the Fundamental Components of Reflective Image Specifications , Wilkin W. K. Chau and William B. Cowan, Department of Computer Science, University of Waterloo, Ontario, Canada	67
11:30 - 1:00 pm	Lunch Break	

Thursday, November 21, 1996

1:00 - 3:05 pm

Printing Devices

Session Chair: Ed Pariser, R.R. Donnelley & Sons Co.

1:00 pm	Characterising Desktop Colour Printers Without Full Control Over All Colorants , Jan Morovic and M. Ronnier Luo, Design Research Centre, University of Derby, United Kingdom	70
1:25 pm	Algorithm-Independent Color Calibration for Digital Halftoning , Shen-ge Wang, Xerox Corporation, Webster, New York	75
1:50 pm	Color Halftoning with Blue Noise Masks , Qing Yu and Kevin J. Parker, Department of Electrical Engineering, University of Rochester, Rochester, New York; Meng Yao, Tektronix, Inc., Wilsonville, Oregon	77
2:15 pm	The Color Gamut of Halftone Reproduction , Stefan Gustavson, Department of Electrical Engineering, Linkoping University, Linkoping, Sweden	80
2:40 pm	Predicting the Spectral Behaviour of Colour Printers for Transparent Inks on Transparent Support , Patrick Emmel, Isaac Amidror, Victor Ostromoukhov and Roger David Hersch, Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland	86
3:05 - 5:30 pm	Coffee Break in the Poster & Demonstration Session	

Thursday, November 21, 1996

3:05 - 5:30 pm

Poster Papers

Session Chair: Joann Taylor, Color Technology Solutions

P1	Selection of High Contrast Color Sets , <i>P. Campadelli* and R. Schettini, *Dipartimento di Scienze dell'Informazione, Università degli Studi di Milano, via Comelico, Milano, Italy, ITIM, CNR, Via Ampere, Milano, Italy</i>	91
P2	Art-Works Colour Calibration by Using the VASARI Scanner , <i>A. Abrardo, V. Cappellini, M. Cappellini and A. Mecocci, Dipartimento di Ingegneria Elettronica, Università di Firenze, Firenze, Italy</i>	94
P3	A Pictorial Review of Color Appearance Models , <i>Mark D. Fairchild and Lisa Reniff, Munsell Color Science Laboratory, Center for Imaging Science, Rochester Institute of Technology, Rochester, New York</i>	97
P4	The Effect of Image Content on Color Difference Perceptibility , <i>Susan P. Farnand, Eastman Kodak Company, Rochester, New York</i>	101
P5	Spectral Based Color Image Editing (SBCIE) , <i>Joyce Farrell, Hewlett-Packard Laboratories, Palo Alto, California</i>	104
P6	Color Management for Color Facsimile , <i>Jon Yngve Hardeberg, Francis Schmitt, Ingeborg Tastl, Hans Brettel and Jean-Pierre Cretetz, Ecole Nationale Supérieure des Télécommunications, Département Images, Paris, France</i>	108
P7	An Exploration of the Pantone® Hexachrome™ Six-Color System Reproduced by Stochastic Screens , <i>Stephen Herron, Isis Imaging Corporation, Vancouver, British Columbia, Canada</i>	114
P8	Spectral Reflectance of Skin Color and its Applications to Color Appearance Modeling , <i>Francisco Hideki Imai, Norimichi Tsumura, Hideaki Haneishi and Yoichi Miyake, Department of Information and Computer Sciences, Chiba University, Chiba, Japan</i>	121
P9	Retinex Image Processing: Improved Fidelity To Direct Visual Observation , <i>Daniel J. Jobson, Zia-ur Rahman* and Glenn A. Woodell, NASA Langley Research Center, Hampton, Virginia, *Science and Technology Corporation, Hampton, Virginia</i>	124
P10	Gamut Mapping for Computer Generated Images (II) , <i>N. Katoh and M. Ito, Research Center, Sony Corporation, Tokyo, Japan</i>	126
P11	Segmentation of Color Maps Using Eigenvector Line-Fitting Techniques , <i>Alireza Khotanzad, Image Processing and Analysis Laboratory, Electrical Engineering Department, Southern Methodist University, Dallas, Texas; Edd Zink, Productivity Systems Incorporated, Richardson, Texas</i>	129
P12	Image Quality Metrics for Printers/Plotters , <i>Yair Kipman, KDY Inc., Nashua, New Hampshire</i>	134
P13	Design and Implementation of an ICC Profile Validator , <i>Tim Kohler, Canon Information Systems, Cupertino, California</i>	139
P14	Recovery of Fundamental Spectrum from Color Signals , <i>Hiroaki Kotera*, Hideto Motomura† and Teruo Fumoto‡, *Chiba University, Chiba, Japan, †Matsushita Research Institute Tokyo, Inc., Tokyo, Japan</i>	141

P15	Gamut Calculation of Color Reproduction Devices , <i>Marc Mahy, Agfa-Gevaert N.V., Mortsel, Belgium</i>	145
P16	Color Clusterization using Modified HSL Space , <i>Gabriel Marcu and Satoshi Abe*, Array Corporation, Tokyo, Japan, * Faculty of Computer Science, University of Tokyo, Hongo, Tokyo, Japan</i>	151
P17	A Comparison of Color Metrics , <i>John J. McCann, Consultant, Belmont, Massachusetts</i>	155
P18	Automated Color Specification of Archaeological Objects , <i>Christian Menard and Ingeborg Tastl, Department for Pattern Recognition and Image Processing, Technical University, Vienna, Austria</i>	160
P19	Unsupervised Classification of Complex Color Texture Images , <i>Raimondo Schettini and Andrea Pessina, Istituto Tecnologie Informatiche Multimediali, Consiglio Nazionale delle Ricerche Milano, Italy</i>	163
P20	Is Color Constancy Task Independent? , <i>Jon M. Speigle and David H. Brainard, Department of Psychology, University of California, Santa Barbara, California</i>	167
P21	A Color Mapping Method for CMYK Printers and Its Evaluation , <i>Shoji Tominaga, Osaka Electro-Communication University, Neyagawa, Osaka, Japan</i>	172
P22	Development and Construction of a Low-cost Colorimeter , <i>Ralf Vohsbeck-Petermann, Computer Graphics Center, ZGDV, Darmstadt, Germany</i>	176
P23	Design and Performance Analysis of Hierarchical Color Space Quantizers , <i>Xia Wan, Jiankun Li, Yung-Kai Lai and C.-C. Jay Kuo, Integrated Media Systems Center, University of Southern California, Los Angeles, California</i>	178
P24	Color Reproduction Based on Low Dimensional Spectral Reflectance Using the Principal Component Analysis , <i>Takayuki Sato, Yoshiki Nakano and Tetsuo Iga, Toyo Ink Mfg. Co., Ltd. Imaging Systems Laboratory, Tokyo, Japan; Shigeki Nakauchi and Shiro Usui, Department of Information and Computer Sciences, Toyohashi University of Technology, Toyohashi, Japan</i>	185
P25	An Approach to the Color Management among Color Devices , <i>Tsuneo Sato, Kimiyoshi Miyata and Masayuki Saito, Mitsubishi Electric Co., Kanagawa, Japan</i>	188

Tour of R.R. Donnelly Printing Facility

5:30 - 9:00 pm

Friday, November 22, 1996

8:30 - 9:45 am

Image Processing

Session Chair: Hiroaki Kotera, Chiba University

8:30 am	Keynote Address: The Symbiotic Relationship Between Computer Graphics and Colour Imaging , <i>Donald P. Greenberg, Program of Computer Graphics, Cornell University, Ithaca, New York</i>	192
9:20 am	Invited: A Strategy for Pictorial Digital Image Processing (PDIP) , <i>Jack Holm, Consultant, Rush, New York</i>	194
9:45 - 10:15 am	Coffee Break	

10:15 am	The Maximum Ignorance Assumption with Positivity , <i>Graham D. Finlayson and Mark S. Drew*</i> , <i>Department of Computer Science, The University of York, York, United Kingdom</i> , <i>* School of Computing Science, Simon Fraser University, Vancouver, Canada</i>	202
10:40 am	Elimination of Highlights using RGB Color Distribution and Image Position , <i>Michael Hild</i> , <i>Osaka Electro-Communication University, Faculty of Information Science and Technology, Department of Engineering Informatics, Neyagawa, Osaka, Japan</i>	205
11:05 am	Ethical Issues in Digital Image Manipulation , <i>Lindsay W. MacDonald</i> , <i>Professor of Multimedia Systems, Cheltenham and Gloucester College of Higher Education, Cheltenham, England</i>	209
11:30 - 1:00 pm	Lunch Break	

Friday, November 22, 1996

1:00 - 2:40 pm

Display Devices

Session Chair: Gerald Murch, Xerox Corporation

1:00 pm	Psychophysical Generation of Matching Images for Cross-Media Color Reproduction , <i>Karen M. Braun and Mark D. Fairchild</i> , <i>RIT Munsell Color Science Lab, Rochester, New York</i>	214
1:25 pm	New Soft Proofing Method , <i>Nobuaki Usui and Atsushi Imamura</i> , <i>DaiNippon Screen Mfg. Co., Ltd. Kyoto, Japan</i>	220
1:50 pm	Effects of Ambient Illumination on the Appearance of CRT Colors , <i>Heui-Keun Choh, Du-Sik Park, Chang-Yeong Kim, and Yang-Seock Seo</i> , <i>Samsung Advanced Inst. of Tech., Kyungki-do, Korea</i>	224
2:15 pm	<i>Invited: Computer-Controlled CRT Colorimetry: A View from CIE</i> , <i>Roy Berns, RIT, Rochester, New York</i>	227
2:40 - 3:00 pm	Coffee Break	

Friday, November 22, 1996

3:00 - 4:15 pm

Standards

Session Chair: Michael Has, FOGRA

3:00 pm	<i>Invited: CIE Colorimetry and Colour Displays</i> , <i>J. Schanda</i> , <i>University Veszprém, Hungary and CIE Central Bureau, Vienna</i>	230
3:25 pm	The FlashPix™ Image File Format , <i>Christopher R. Hauf and J. Scott Houchin</i> , <i>Eastman Kodak Company, Rochester, New York</i>	234
3:50 pm	Proposal for a Standard Default Color Space for the Internet—sRGB , <i>Matthew Anderson*</i> , <i>Ricardo Motta†</i> , <i>Srinivasan Chandrasekar*</i> , <i>Michael Stokes‡</i> , <i>*Microsoft, Palo Alto, California, †Hewlett-Packard, Palo Alto, California</i>	238