

# **Program of Color Science / Munsell Color Science Laboratory**

Annual Report 2016

Rochester Institute of Technology

College of Science







### DIRECTOR'S REFLECTIONS: Munsell's Legacy

The MCSL was founded in 1983 when the Munsell Foundation dissolved itself, transferring its assets to the Rochester Institute of Technology to endow, in perpetuity, a laboratory for education and research in color science. Thirty-four years later we continue working hard to fulfill the intent of the Munsell Foundation and honor Munsell's legacy. As we enter 2017, Munell's legacy has been brought directly to our attention as we become involved in planning a Celebration of Munsell to be held in June 2018 at MassArt in Boston. The conference is cosponsored by the Inter-Society Color Council (ISCC) and the International Color Association (AIC) and our group has taken a leadership role in the papers committee.

As we look back, it is clear that the Foundation was Munsell's legacy. And the RIT Munsell Color Science Laboratory is the Foundation's legacy. I have always considered our lab to be something of the period at the end of the sentence that was the Munsell Color Company and the Munsell Foundation. However, looking back, I see that the "period" has grown up into a sentence of its own. If we look at life-spans, the Munsell Color Company survived from its founding in 1917 until its sale in 1969, 52 years. The Foundation was established in 1942 to oversee operations of the Company for the family and then survived beyond until 1983, a total of 39 years. For its last 14 years, the Foundation helped support graduate student research work in color science. And then the RIT-MCSL was founded in 1983 and is going strong today, 34 years later. Albert Munsell died in 1918, right after founding the Company, and it is clear that he had three lasting legacies, 52 years of the Munsell Color Company, 39 years of the Munsell Foundation, and 34 years (and counting) of the RIT Munsell Color Science Laboratory.

I think it is now fair to consider RIT-MCSL a significant part of Albert Munsell's legacy and I hope that spirit and motivation can help see the lab through coming growth and success for many decades to come. To celebrate this realization, I am also happy to announce that the name of our building, formerly Color Science Hall, has been changed by proclamation of the RIT Trustees to Munsell Color Science Laboratory in recognition of significant and important contribution of the Munsell Foundation to our university. We have all been working diligently to create an optimal environment for color science education and research. We think we live on the verge of greatness (as RIT likes to say), but will always perceive, and act upon, possibilities to improve. The state of our program and laboratory is very strong and we see a bright future. Some highlights of the past year include:

- ~ We continue to admitted outstanding new graduate students and the applicant pool continues to expand.
- ~ We offered a summer, on-line, course in Fundamentals of Color Science for the first time.
- ~ Drs. Farnand and Murdoch presented an ISCC Webinar about online teaching of color science.
- ~ Dr. Shengyan Cai completed her time as a Visiting Scholar from Tianjin University of Science and Technology in China.
- ~ Dr. Samuel Morillas Gomez joined as a Visiting Scholar from the Polytechnic University of Valencia in Spain.
- ~ Drs. Fairchild, Murdoch, and Farnand hosted a wonderful MCSL alumni reunion in San Diego during the Color & Imaging Conference.
- ~ Our group took a field trip to the University at Buffalo to visit The Brain Museum.
- ~ Dr. Berns' book on Color Science and the Visual Arts was published by The Getty.
- ~ Ph.D. alumnus, Max Derhak, was presented the 2017 ISCC Macbeth Award for contributions to color science and technology.
- ~ And we expect to continue building our faculty over the next 2-3 years.

As always, we thank all those who have provided financial and in-kind support over the year including Gamma Scientific, Peter Engeldrum, Dave Wyble, Xerox, Philips, Scot Fernandez, Hallmark, Google, and a very significant gift of student research support from former student Huan Zeng. In this report you can find lists of our students and alumni, brief research highlights from ongoing projects, a list of publications over the last year, and a directory of our people. We have kept it brief and visual out of respect for you. There is much more information about PoCS/MCSL on our website and we invite you to explore <mcsl.rit.edu>. Thank you to everyone who has supported the lab and our students in various ways over the years. Please enjoy this report and let me know if you have any comments, suggestions, or questions. Stay tuned for our continuing mission...

Sincerely,

Mark Fairchild Associate Dean of Research and Graduate Education, College of Science Professor and Director, Program of Color Science / Munsell Color Science Laboratory









## STUDENTS & ALUMNI

#### **Visiting Researchers**

Shengyan Cai, Tianjin University of Science and Technology Francis Wild, Griffith University Samuel Morillas Gomez, Polytechnic University of Valencia

#### **MCSL Current Students**

Anku. PhD. CS Ben Bodner, MS, CS Katherine Carpenter, PhD, CS Brittany Cox, PhD, CS Nargess Hassani, PhD, CS Fu Jiang, PhD, CS Morteza Maali Amiri, PhD, CS Adi Robinson, PhD, CS Matt Ronnenberg, PhD, CS Gaurav Sheth, PhD, CS Chris Thorstenson, PhD, CS Lili Zhang, PhD, CS

#### Alumni

2016 Yixuan Wang, MS, CS loel Witwer, MS, CS

2015 Yuta Asano, PhD, CS Maxim Derhak, PhD, CS Jennifer Kruschwitz, PhD, CS David Long, PhD, CS Ashley Penna, MS, IS

2014 Farhad Abed, PhD, CS Stephen Dolph, MS, IS Adria Fores Herranz, PhD, CS

2013 Justin Ashbaugh, MS, CS Lin Chen, MS, CS Benjamin Darling, PhD, CS Susan Farnand, PhD, CS Jun (Chris) Jiang, PhD, CS

2012 Ping-Hsu (Jones) Chen, MS, CS Simon Muehlemann, MS, PM

2011 Brian Gamm, MS, CS John Grim, MS, CS Marissa Haddock, MS, CS Dan Zhang, MS, CS

2010 Bingxin Hou, MS, IS Suparna Kalghatgi, MS, IE

2009 Erin Fredericks, MS, IS Rodney Heckaman, PhD, IS Mahnaz Mohammadi, PhD, IS Shizhe Shen, MS, CS

2008 Stacey Casella, MS, CS Ying Chen, MS, CS Mahdi Nezamabadi, PhD, IS Abhijit Sarkar, MS, CS Yang Xue, MS, IS Hongqin (Cathy) Zhang, PhD, IS Yonghui (Iris) Zhao, PhD, IS

2007 Kenneth Fleisher, MS, CS Jiangtao (Willy) Kuang, PhD, IS

2006 Yongda Chen, PhD, IS Timothy Hattenberger, MS, IS Zhaojian (Li) Li, MS, CS Joseph Stellbrink, MS, CS

2005 Maxim Derhak, MS, IS Randall Guay, MS, IS Jim Hewitt, MS, IS Justin Laird, MS, CS Joseph Slomka, MS, CS Erin Murphy Smoyer, MS, CS Yoshio Okumara, MS, CS Michael Surgeary, MS, IS

2004 Rohit Patil, MS, CS Sung Ho Park, MS, CS Xiaoyan (Yan) Song, MS, CS

2003 D. Collin Day, MS, CS Ellen Day, MS, CS Scot Fernandez, MS, IS Edward Hattenberger, MS, CS

Steve Jacob, MS, IS Xiaoyun (Willie) Jiang, PhD, IS Garrett Johnson, PhD, IS David Robinson, MS, IS Mitchell Rosen, PhD, IS Deniz Schildkraut, MS, CS Qun (Sam) Sun, PhD, IS

#### 2002

Arturo Aguirre, MS, CS Jason Babcock, MS, CS Anthony Calabria, MS, CS Jen Cerniglia Stanek, MS, IS Scot Fernandez, MS, CS Jason Gibson, MS, CS Shuxue Quan, PhD, IS Yat-ming Wong, MS, IS

#### 2001

Alexei Krasnoselsky, MS, CS Sun Ju Park, MS, CS Michael Sanchez, MS, IS Lawrence Taplin, MS, CS Barbara Ulreich, MS, IS

#### 2000

Sergio Gonzalez, MS, CS Sharon Henley, MS, CS Patrick Igoe, MS, IS Susan Lubecki, MS, CS Richard Suorsa, MS, CS

#### 1999

Gus Braun, PhD, IS Barbara Grady, MS, CS Katherine Loj, MS, CS Jonathan Phillips, MS, CS Mark Reiman, MS, CS Mark Shaw, MS, CS Di-Yuan Tzeng, PhD, IS Joan Zanghi, MS, CS

1998 Scott Bennett, MS, CS Fritz Ebner, PhD, IS Garrett Johsnon, MS, CS Naoya Katoh, MS, CS David Wyble, MS, CS

#### 1997

Peter Burns, PhD, IS Christopher Hauf, MS, CS Brian Hawkins, MS, CS Jack Rahill, MS, IS Alex Vaysman, MS, IS

### 1996

Karen Braun, PhD, IS Cathy Daniels, MS, CS Yue Qiao, MS, IS Hae Kyung Shin, MS, IS

1995 Richard Alfvin, MS, CS Seth Ansell, MS, CS Susan Farnand, MS, IS

1994 Taek Kim, MS, IS Audrey Lester, MS, CS Jason Peterson, MS, IS Debra Seitz Vent, MS, IS James Shyu, MS, CS

#### 1993

Nathan Moroney, MS, CS Elizabeth Pirrotta, MS, CS Mitchell Rosen, MS, IS



1992 Mark Gorzynski, MS, IS Rich Riffel, MS, IS Brian Rose, MS, CS

#### 1991 Yan Liu, MS, CS Ricardo Motta, MS, IS Amy North, MS, CS Greg Snyder, MS, IS Michael Stokes, MS, CS

#### 1989 Mitch Miller, MS, IS Kelvin Peterson, MS, IS Lisa Reniff, MS, CS

#### 1987 Denis Daoust, MS, IS Wayne Farrell, MS, IS

1986 Mark Fairchild, MS, IS

#### Key:

CS: Color Science IE: Industrial Engineering IS: Imaging Science MS: Master of Science PhD: Doctor of Philosophy PM: Print Media

### RESEARCH HIGHLIGHT: Imagine RIT: Weigh In on your Favorite Color



MCSL made a colorful and interactive splash at Imagine RIT with an exhibit in the main floor of Gosnell Hall. Visitors were confronted with three bathroom scales, hacked through an Arduino to control the relative contributions of red, green, and blue light to a giant LED-driven light source. The result was both fun and educational: kids were happy to step and jump on the scales, enjoying the colorful response, while others were treated to some basic color science education. Because additive color mixing can be represented as a center-of-mass computation on a chromaticity diagram, we decided to make that "mass" analogy literal, hence the bathroom scales. A simple description of weight on the scales behaving like relative "pull" toward the respective primaries, illustrated with interactive light, brightened a lot of visitors' faces through what was a busy but fun day for our students and faculty.

Michael J. Murdoch



## RESEARCH HIGHLIGHT: Perceived Capture Quality - Cultural Heritage Objects

The Harvard libraries house millions of images of interest to researchers worldwide. To increase access to this content, Harvard has embarked on an effort to digitize books, maps, papers, and other artifacts. To most efficiently produce usable content, Harvard personnel are evaluating currently available mass digitization hardware. As part of this assessment, an evaluation was conducted at the Munsell Color Science Laboratory of the capture quality attainable for four reproduction systems. In a perceptual experiment, images captured by the four systems of twenty-one objects, including book pages, photographs, maps, manuscripts, and prints served as stimuli. Observers were asked to scale the overall quality of the test images relative to an anchor image. The experiment was performed at RIT and Harvard on the same make and model, calibrated displays. The results indicated that two digitization

systems were clearly superior to the other two.

Susan Farnand



### RESEARCH HIGHLIGHT: Dynamic Visual Adaptation Lab



In September, a new light lab was commissioned in MCSL, providing an immersive physical environment with accurately-controlled LED lighting. The lighting fixtures, which bathe the lab walls with 5 high-resolution color channels (red, green, blue, 4000K white, and "mint green"), were donated by Philips Lighting. The custom installation was funded in part by a Boot Camp grant from the Office of the Vice President for Research with the mission of jump-starting a new line of research in MCSL. The lab was designed primarily for research studying temporal chromatic and luminance adaptation to dynamic lighting, and it will host additional research on color rendering, object appearance, and anything else that can benefit from a large, controllable, immersive lighting system!

Michael J. Murdoch



## RESEARCH HIGHLIGHT: Lighting and Wine Color Measurement

The color of wine is considered an important component of the sensory evaluation of its quality. However, wine color is rarely observed under optimal, or even controlled viewing conditions. The color, spectral properties, and luminance levels of the lighting will all have a significant impact on wine color appearance and, therefore, sensory appreciation (also known as taste and enjoyment). This project is an undertaking designed to perform a series of careful colorimetric measurements of different types of wine from around the world in order to assess the importance of viewing conditions on wine appearance and appreciation. Measurements have been completed and analyses are forthcoming.

Mark Fairchild





### RESEARCH HIGHLIGHT: MCSL at CIC



RIT has traditionally had a visible presence at the annual Color and Imaging Conference sponsored by IS&T. For the 24th conference in San Diego in November, MCSL made contributions including two oral and two interactive papers in the technical program and a workshop organized by Dave Wyble including presentations by Max Derhak and Mark Fairchild. Behind the scenes, Michael Murdoch served as Technical Co-Chair and Susan Farnand served as JIST-First Guest Editor to help prepare the event. In 2017, Susan will continue as Guest Editor, and Michael will take on the role of General Chair. MCSL and RIT Alumni Relations co-sponsored an alumni event one evening that brought together more than 20 alumni for libations and networking.

Michael J. Murdoch

### RESEARCH HIGHLIGHT: Multispectral Camera for Cultural Heritage

Roy's multispectral camera is finished. It consists of a Rodenstock HR Digaron S 100mm f/4 lens with helical focus mount, Finger Lakes Instrumentation (FLI) Atlas focus, FLI filter wheel, and Trusense KAF-50100 microlens 50MP CCD sensor. The visible regionfilters were pairs of Schott glass. The specific visible region filters were determined by Yixuan Wang during her MS research. 380 nm and 880 nm were added to enable UV and near IR imaging.

Roy S. Berns



### RESEARCH HIGHLIGHT: Measuring Cyanobacteria using Smartphone Cameras



With the proliferation of smartphones, it is of interest to determine if they may be calibrated for crowd-sourcing applications. This project aims to evaluate the possibility of using spectral information in smartphone camera images to identify the presence of cyanobacteria in a water sample. Two species of cyanobacteria, anabaena and gloeocapsa, and two species of green algae that closely resemble the cyanobacteria, spirogyra and scenedesmus, will be grown. The samples will be cultured in Erlenmeyer flasks under cool-white fluorescent light on a 16/8-hour cycle.

The color, absorption, and transmission spectra of each species will be measured at multiple concentrations. Color profiles of four different smartphone cameras will be built, starting by using the lab's CCSG Evaluation software. Once the characteristics of the spectra are determined, images will be taken of the samples using each smartphone. If data outside the visible range are required, near-infrared camera attachments will be implemented.

Katie Carpenter, Susan Farnand

## RESEARCH HIGHLIGHT: Estimation of Skin Reflectance Using a Digital Camera

Skin spectral reflectance, and color, are useful indicators of psychological and physiological processes. However, the accurate measurement of spectral reflectance typically requires specialized hardware. The current project aims to estimate skin spectral reflectance, color, and physiological parameters using a digital camera.

Chris Thorstenson, Mark Fairchild



### RESEARCH HIGHLIGHT: Color and Material Appearance in Mixed Reality



In ongoing research, we are modeling color appearance in augmented reality (AR). The model is based on the physical light mixture in AR – displayed colors overlaid on a real, illuminated background – and aims to predict appearance attributes. Using a benchtop AR simulator comprising a viewing booth, LCD display, and halfmirror, a series of measurements of virtual color patches on different real backgrounds under different illuminants were made to confirm the light mixture predictions by the model. To verify the perceptual predictions of the model, an experiment is underway, in which observers use the method of adjustment to match the appearance of virtual colors on different backgrounds. This work was presented in poster format in the Symposium of Applied Perception Conference in July and in an oral presentation at RIT's VR/AR Symposium in December. Microsoft provided a gift of funding that supports this research.

Nargess Hassani, Michael J. Murdoch

### RESEARCH HIGHLIGHT: Observer Calibrator

Our recent work on individual differences in color matching functions, in collaboration with Technicolor, took advantage of a metameric color matching instrument created by Technicolor and known as the observer calibrator. This year, Susan Farnand led a multidisciplinary team of engineering students who worked on a project to create a new observer calibrator for RIT with Mark Fairchild as the customer. The instrument is complete and in the coming months other students will be calibrating it and determining how well they can measure individual color matching functions.

Mark Fairchild, Susan Farnand





### RESEARCH HIGHLIGHT: Perceived Quality of Smartphone Images



Smartphones have become ingrained in the daily activities of millions of people worldwide. As increasing numbers of images are being taken by smartphones it has become important to assess the image quality provided by these devices. Although the main target of these studies has been digital quality, some images are being printed, making print quality from smartphone captures of interest as well. Two studies at the Munsell Color Science Lab at the Rochester Institute of Technology assessed displayed and printed quality of smartphone images.

Real-world test images were evaluated by observers using paired comparison and quality ruler protocols on an electronic display (below) and using a rank order protocol for prints (on right). Twelve scenes with varied content were captured using eight smartphones from a range of manufacturers. The images were printed on five commercially available printers. The image quality ratings generated in the soft-copy experiments were used to validate objective metrics developed in the IEEE Cell Phone Image Quality (CPIQ) effort to establish a consumer rating system. These ratings are also being compared to the ratings generated in the hard copy rank order experiment to determine if displayed image quality translates to printed quality.

Susan Farnand

## RESEARCH HIGHLIGHT: Workshops on Multi-Spectral & Multi-Light Photography

Participants in the first Andrew W. Mellon Foundation Workshop on Multi-Spectral and Multi-Light Photography, held at the Smithsonian's Museum Conservation Institute. Our PhD candidate Brittany Cox is in the center. Workshops were also presented at other museums around the world.

Roy S. Berns, Brittany D. Cox



### RESEARCH HIGHLIGHT: Rochester Landmarks Scavenger Hunt



All first year and second year students joined together for a social scavenger hunt to create image stimuli for computational vision science class. Students visited and photographed 17 landmarks in Rochester and the RIT campus including George Eastman Museum, Highland Park, High Falls of the Genesee River, Kodak Tower, Memorial Art Gallery, Mount Hope Cemetery, Rochester Museum & Science Center, Strong Museum, etc. Each student took one photo at each landmark. 60 photos from all 119 collected photos were used in an indirect scaling experiment. All pairs of student photos at each landmark were compared in the experiment to evaluate photographer's performance like a photography competition. Interval scale values and dispersions of photographers' performance were generated. High-scoring photos are included throughout this annual report.

Lili Zhang

### RESEARCH HIGHLIGHT: Inter-Observer Variability in Lighting Metrics

Modeling brought together Mike's interests in lighting quality metrics and Mark's ongoing research on inter-observer variability. Color rendering, conceptually how light sources affect object colors, can be described by metrics such as the IES TM-30-15 Rf (illuminant fidelity, effectively how similarly are object colors rendered compared to how they would look under a reference light) and Rg (illuminant gamut, or how much object colors are boosted in chroma by a light source, compared to a reference light). As can be seen in the above diagram, Rg/Rf values are typically reported as points (black dots), using standard colorimetric observers. Taking into account the normal variation in sensitivity in people with normal color vision, these points expand into fuzzy blobs (red clouds). Quantifying this natural variation helps the lighting industry understand what level of precision is meaningful in such metrics.

Michael J. Murdoch, Mark Fairchild

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## RESEARCH HIGHLIGHT: Recovering Spectral Reflectance Using Several Cameras

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In this work, it is attempted to reconstruct reflectance from the colorimetric values through putting several different cameras (either cellphone cameras or ordinary ones) into use; fig. I, (a) and (b) shows the set-up; the idea stems from researches where colorimetric information captured under different light sources or using different colored filters placed in front of RGB camera were utilized in spectral recovery. Simulations were done using different cameras' sensitivity showing the possibility of the idea working; afterwards, several cellphones (and cameras) were used and picture of similar targets were taken using them; their colorimetric information were put together and results of the recovery were examined after adding each cellphone data into the process. The results of both cellphones and cameras in terms of root mean squared error are shown in fig. I, (d) and (c), respectively. As it is observed, the larger the number of cameras, the better the recovery results.

Morteza Maali Amiri, Mark Fairchild

## 2016 PUBLICATIONS

### **Books and Journal Papers**

R.S. Berns, Color Science and the Visual Arts: A Guide for Conservators, Curators, and the Curious, Getty Conservation Institute, ISBN: 978-1606064818 (2016). M.D. Fairchild, Gabriel Lippmann, in the Encyclopedia of Color Science & Technology, Springer, ISBN: 978-3-642-27851-8 (Online) (2016). M.D. Fairchild, Gustav Theodor Fechner, in the Encyclopedia of Color Science & Technology, Springer, ISBN: 978-3-642-27851-8 (Online) (2016). M.D. Fairchild, Johan Adolf von Kries, in the Encyclopedia of Color Science & Technology, Springer, ISBN: 978-3-642-27851-8 (Online) (2016). M.D. Fairchild, Joseph William Lovibond, in the Encyclopedia of Color Science & Technology, Springer, ISBN: 978-3-642-27851-8 (Online) (2016). M.D. Fairchild, Stanley Smith Stevens, in the Encyclopedia of Color Science & Technology, Springer, ISBN: 978-3-642-27851-8 (Online) (2016). F.M. Abed and R.S. Berns, Linear modeling of modern artist paints using a modification of the opaque form of Kubelka-Munk turbid media theory, Color Research Application, on-line (2016). Y.Asano, M.D. Fairchild, and L. Blondé, Individual colorimetric observer model, PLOS ONE 11, e0145671 (2016). Y.Asano, M.D. Fairchild, L. Blondé and P. Morvan, Color matching experiment for highlighting inter-observer variability, Color Research and Application 41, 530-539 (2016). M.D. Fairchild and R.L. Heckaman, Measuring observer metamerism: The Nimeroff approach, Color Research and Application 41, 115-124 (2016). S. Farnand, P.Vaidyanathan, and J. Pelz, Recurrence Metrics for Assessing Eye Movements in Perceptual Experiments. Journal of Eye Movement Research, 9(4), (2016). D.L. Long and M.D. Fairchild, Observer metamerism models and multiprimary display systems, SMPTE Motion Imaging Journal 125, 18-29 (2016).

## 2016 PUBLICATIONS

### **Conference Proceedings & Articles**

B. Bodner and R.S. Berns, An iccMAX material profile example: converting spectral images of artwork to paint-concentration Images, IS&T, 24th Color Imaging Conference, San Diego, California, United States, in M.D. Fairchild, Spotlight Summary of "Method to determine degrees of consistency in experimental datasets of perceptual color differences" by Morillas et al., OSA Spotlight on Optics, Nov. (2016). S.P. Farnand, A methodology for perceptual image quality assessment of smartphone cameras, IS&T's Electronic Imaging Symp: Image Quality and Systems Performance conference, February (2016). N. Hassani and M. J. Murdoch, Color Appearance Modeling in Augmented Reality, ACM Symposium on Applied Perception, Anaheim, CA: ACM (2016). Zhou, B. Grotton, K. Kruse, A. Skinner, A. DoVale, S. Farnand and M.D. Fairchild, Observer calibrator for color vision research, IS&T Electronic Imaging 2017 Conference, San Francisco, in press (2017).

- Y.Asano, M.D. Fairchild, and L. Blondé, Individual colorimetric observer model, PLOS ONE 11, e0145671 (2016).
- R.S. Berns, Color science and the visual arts: A guide for conservators, curators, and the curious, Getty Conservation Institute, Los Angeles (2016).
  - R.S. Berns, Modification of CIEDE2000 for assessing color quality of image archives, IS&T Archiving Conference 181-185(5) (2016).
    - press (2016).
- S. Cai and M.D. Fairchild, Individual corresponding colors data and chromatic adaptation transform, IS&T 24th Color & Imaging Conference, San Diego, 248-253 (2016).
  - M.D. Fairchild, From photon to brain: The perception of a color, IS&T 24th Color & Imaging Conference, San Diego, 291-293 (2016).
  - M.D. Fairchild, Individual differences in color matching and adaptation: Importance in lighting, Light + Color: IES Research Symposium III, Gaithersburg, (2016).
  - M.D. Fairchild, Individual differences in color matching and adaptation: Theory and practice, IS&T 24th Color & Imaging Conference, San Diego, 115-120 (2016).
- M.J. Murdoch and M.D. Fairchild, Effects of inter-observer variation on color rendering metrics, IS&T 24th Color & Imaging Conference, San Diego, 187-191 (2016).

## 2016 PUBLICATIONS

### **Theses & Dissertations**

J. Witwer, Incorporating Gallery Lighting in a Color-Managed Imaging Workflow for Cultural Heritage, Rochester Institute of Technology M.S. Thesis, 2016.

Y. Wang, Design and Construction of a Multispectral Camera for Spectral and Colorimetric Reproduction, Rochester Institute of Technology M.S. Thesis, 2016.

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## FACULTY & STAFF

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### **PoCS/MCSL Faculty & Staff**

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Mark Fairchild, Ph.D. Associate Dean of Research & Graduate Education, College of Science Professor & Director, Program of Color Science/Munsell Color Science Laboratory (585) 475-2784 mdfpph@rit.edu

Susan Farnand, Ph.D. Visiting Assistant Professor (585) 475-4567 spfpci@rit.edu

> Val Hemink Senior Staff Specialist (585) 475-7189 vlhpci@rit.edu

Michael Murdoch, Ph.D. Assistant Professor (585) 475-4134 mmpocs@rit.edu

> Dave Wyble, Ph.D. Color Scientist (585) 475-7310 dawpci@rit.edu

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#### **Program of Color Science Allied Faculty**

Elena Fedorovskaya, Media Sciences Jim Ferwerda, Imaging Science Joe Geigel, Computer Science Andy Herbert, Psychology David Long, Motion Picture Science Garrett Johnson, Affiliate Noboru Ohta, Affiliate

### **PoCS/MCSL Board of Counselors**

Ellen Carter, Color Research & Application Scot Fernandez, Hallmark Francisco Imai, Canon USA Tom Lianza, Sequel Color Science M. Ronner Luo, U. Leeds et al. Ricardo Motta, Apple

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# RIT Program of Color Science / Munsell Color Science Laboratory

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