RIT | Rochester Institute of Technology

Program of Color Science
Munsell Color Science Laboratory

Annual Report 2023

MCSL 40th Anniversary Celebration in June, 2023

RIT | College of Science

Munsell Color Science Laboratory

40 Years of Color Science Education & Research

mcsl.rit.edu

From the Director: ***Reflecting on 40 Years!***

Greetings! Whenever I visit a city, I love going to the top of a tall monument – the Eiffel Tower, CN Tower, London Eye – to get an overview and a feel for the place. 2023 marks 40 years since the beginning of the Munsell Color Science Laboratory in 1983. As I reflect on those 40 years, it's similar to being atop a monumental summit, but looking back instead of down.

Over 40 years, MCSL has had immense impact as the world's leading academic color science organization, producing research and training researchers that have affected many industries. Pretty much everything related to color is now cheaper, easier, and better: photography, printing, color management, archiving, lighting, graphics, and display. Looking forward, we work toward technology for more immersive and natural imaging and visual communication, and we look deeper into the visual system to better understand color and cognition.

In my second year leading POCS/MCSL and the Integrated Sciences Academy, I am getting more comfortable in the role and more excited about steering our course. As a partner in both the Neuroscience BS and Cognitive Science PhD programs, ISA is hiring new faculty and broadening our interdisciplinary scope, which offers new opportunities for MCSL.

Our 2023 Color Science entering class is the largest I have seen, indicating both strong interest in our program and bold plans for our research portfolio. As always, our research is funded through a combination of federal grants, corporate contracts, gifts, and endowment funds. If you are in a position to support us, please see the penultimate page for opportunities!

In this annual report, we are proud to highlight the accomplishments of the students and faculty of MCSL. We've been busy! Please reach out if you have interest in or questions about anything you read here.

All the best! *Mike*

Photo: *that's me reflecting in a concave mirror at the Corning Museum of Glass*

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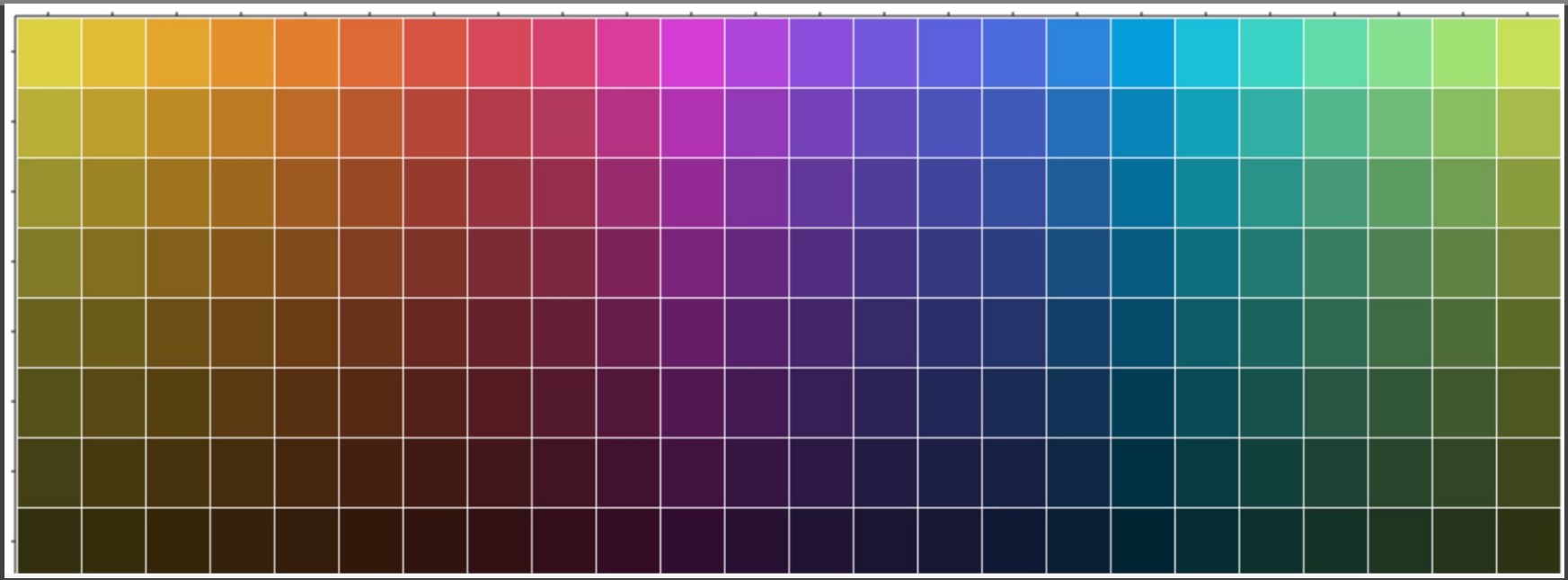
RIT Doctoral Hooding Delegate: **Olivia Kuzio**

2023 PhD Graduate Olivia Kuzio (with color target)

Olivia Kuzio represented Color Science and all RIT PhD graduates on the Commencement stage, delivering remarks as the Doctoral Hooding Delegate. *Congratulations, Olivia!*

Olivia began her doctoral studies in color science in 2017. She conducted her research in the Studio for Scientific Imaging and Archiving of Cultural Heritage, where she learned the science and art of advanced technical imaging for museum applications. Her dissertation focused on developing and refining accessible techniques and tools for carrying out these kinds of imaging with more familiar, affordable photography equipment. Concurrently with her doctoral studies, she also pursued parallel interests in the chemical nature of artists' materials, and earned an MS in chemistry in 2022. She enriched her graduate studies with internships at the Smithsonian Museum Conservation Institute and the Getty Conservation Institute, where she performed scientific imaging and material analysis on collections objects ranging from ancient Near-Eastern cuneiform tablets to Renaissance oil paintings to 20th-century Bauhaus pastel color studies. Olivia defended her dissertation in February, 2023, and is currently a fellow in the Science Department of the Getty Conservation Institute in Los Angeles, CA.

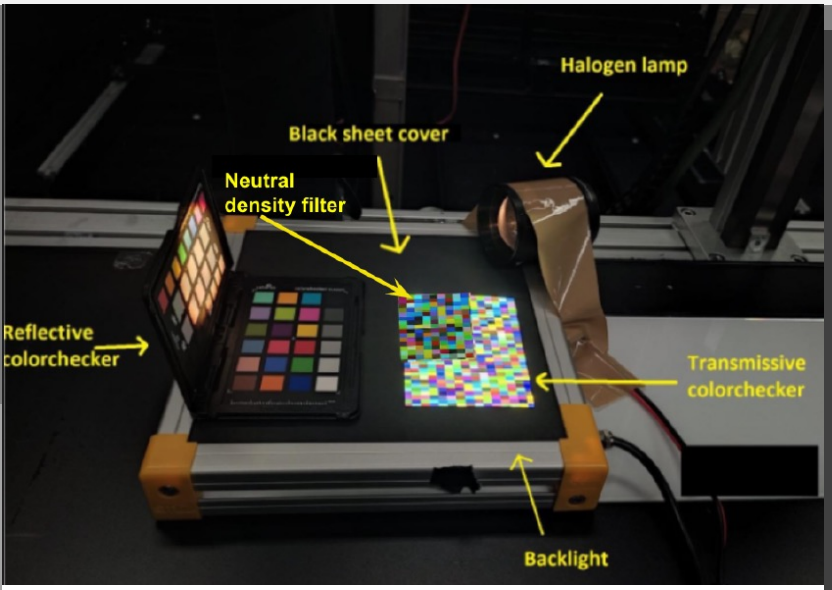
Research Highlight: **Structure of Color Appearance Models**

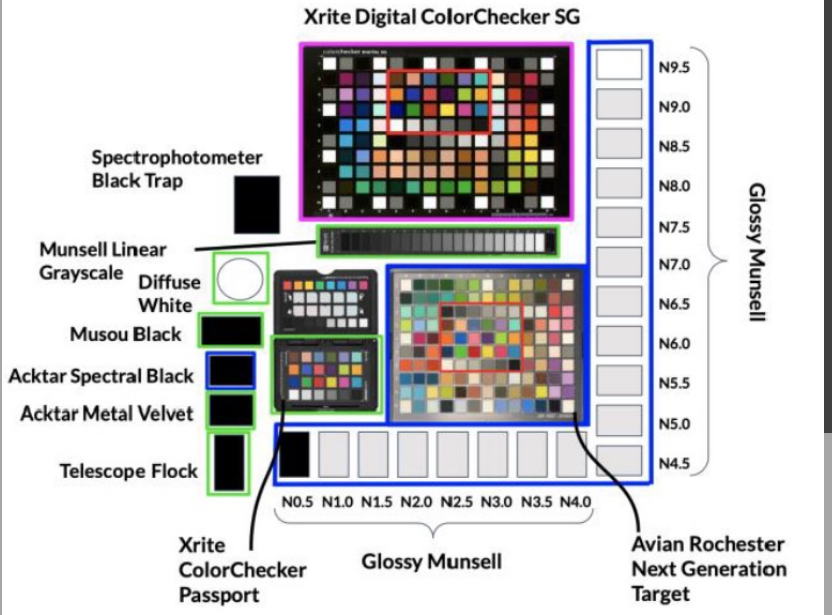


At CIC in 2012, Mark and Rod Heckaman presented a paper, *Deriving Appearance Scales*, that suggested an implementation of color appearance modeling in which the dimensions of color perception (brightness, lightness, colorfulness, saturation, chroma, and hue) were derived without reliance on an intermediate multidimensional color space. Mark and his students have been working to further define these potential uni-dimensional appearance scales. At the ISCC Color Impact 2023 conference, Mark led a workshop to guide participants in considering the benefits of deriving color appearance scales prior to, rather than after, construction of a multidimensional color space. This concept was also explored in a CR&A paper entitled *On the questionable utility of color space for understanding perception*. The accompanying figure, constructed using the Virtual Color Atlas, shows the potential benefit of an independently-derived scale of lightness based on the concept of brilliance and the DIN system for various hues at constant saturation levels.

Mark D. Fairchild

Research Highlight: **Camera characterization for HDR scene acquisition**





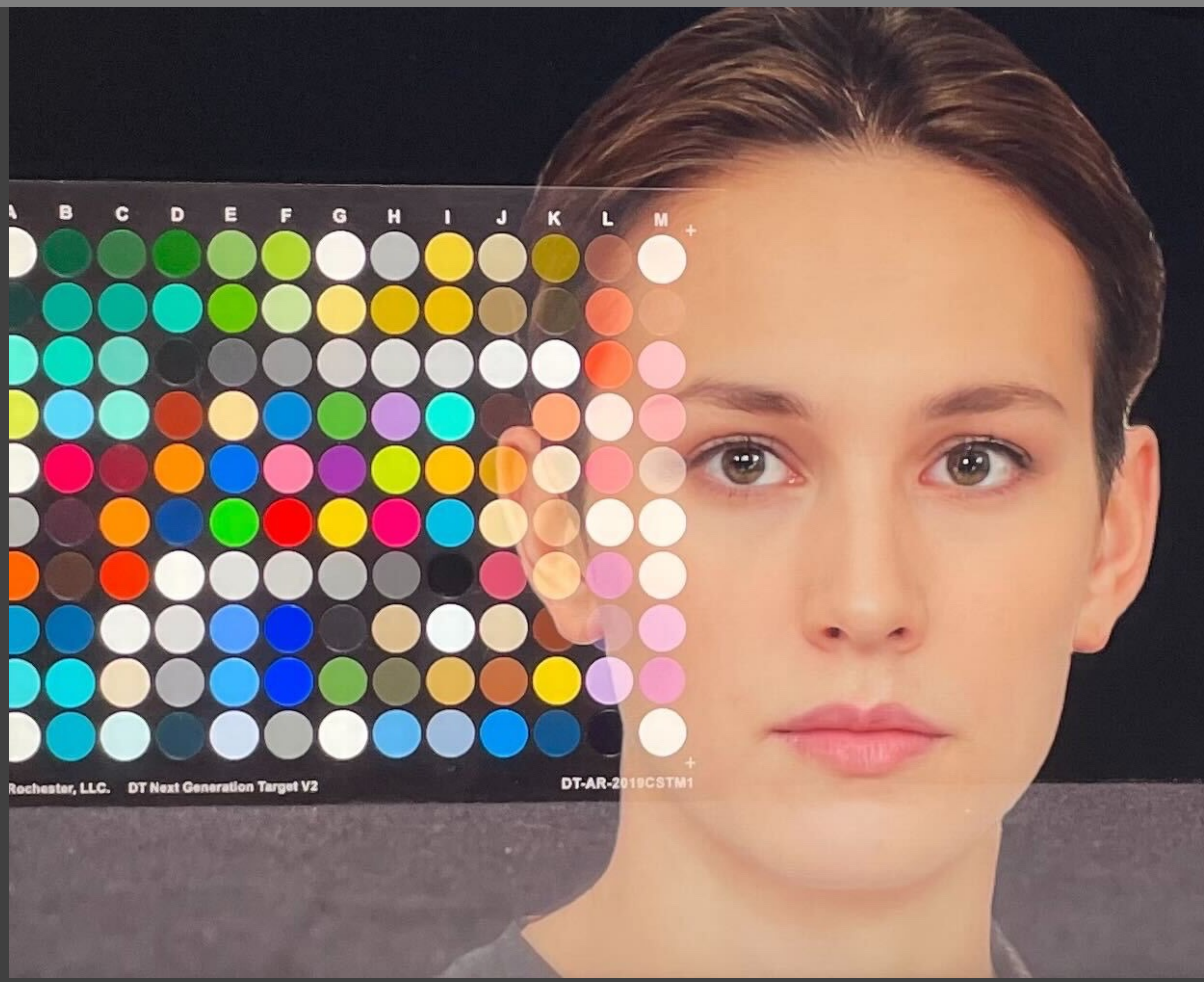
Current camera characterization standards are typically designed with limited dynamic range applications in mind. However, applying these standards to High Dynamic Range (HDR) scene acquisition presents several limitations, hindering accurate color reproduction. To address this challenge, a new approach is under investigation, focusing on the contributions of more representative color targets, including both transmissive and reflective patches, in HDR environments. Additionally, the optimization process and exposure settings of the characterization process are being examined. The study aims to improve camera characterization accuracy, especially in capturing higher ranges of luminance levels and complicated color variations. One selected application of this research pertains to the high-quality rendering of images depicting cultural heritage materials, necessitating precise color reproduction and HDR scene capture. Another application involves improving spectral and hyperspectral acquisition to accommodate extended dynamic range scenes.

Leah Humenuck, Aqsa Hassan, Susan Farnand, Mekides Assefa Abebe

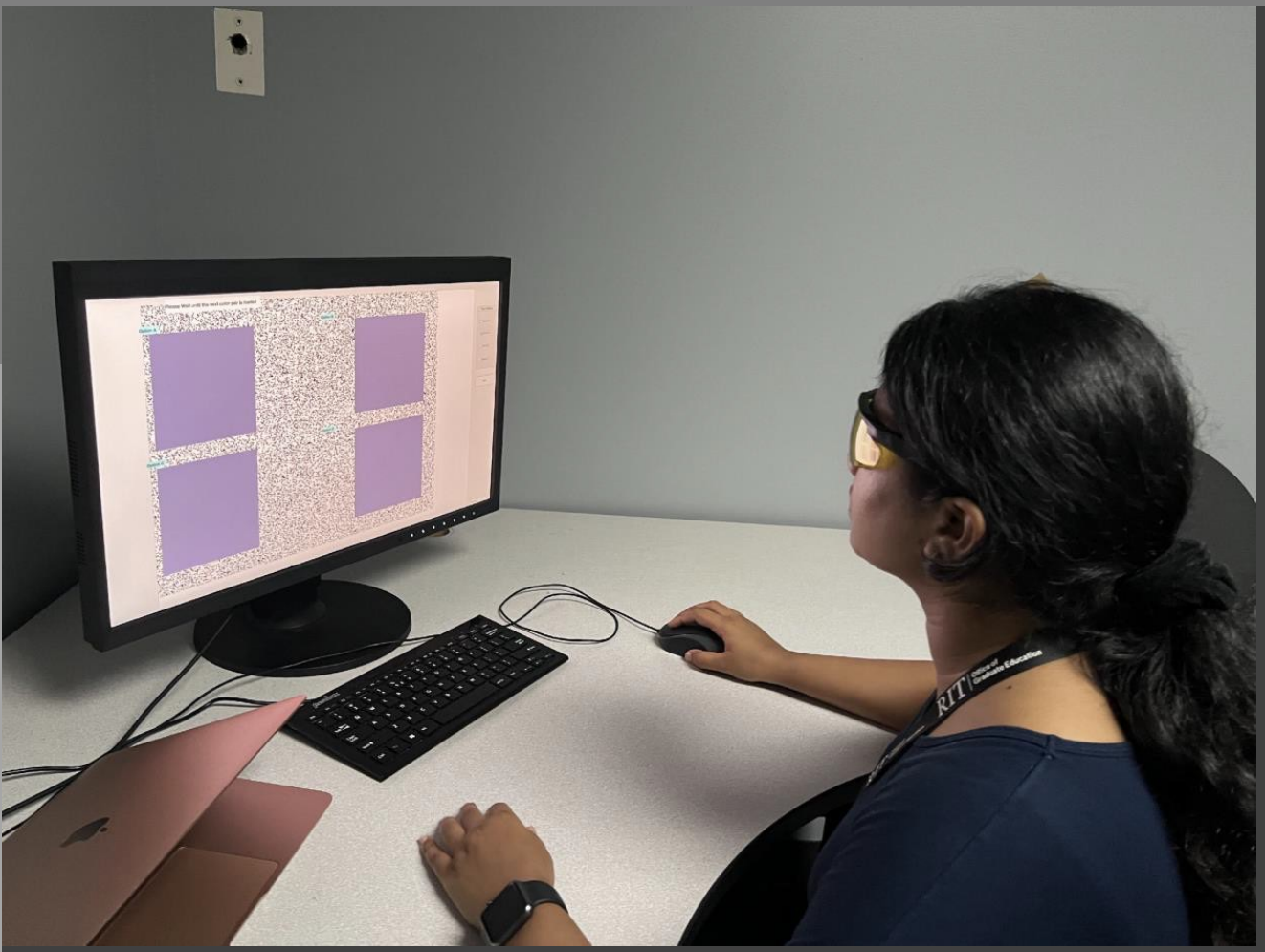
Research Highlight: **Natural Rendering in Transparent AR**

Rendering human faces in optical see-through (OST) augmented reality (AR) with naturalistic fidelity is a challenging endeavor, given the distortions caused by the background visible through the transparent display. This research aims to explore the correlation between perceived naturalness and facial color attributes, including the redness and yellowness of skin as well as the gamma of the image. Building on a previous study that uncovered a nearly proportional relationship between average lightness and gamma preference for AR fruit stimuli, this project seeks to ascertain whether the gamma preference for faces in OST-AR behaves similarly. The study employs the same transparent AR setup previously used in experiments investigating color appearances, brightness, transparency, and realness in AR. The findings of this research are expected to contribute significantly to the enhancement of naturalness in human facial image rendering within the OST-AR context, thereby improving the overall user experience in augmented reality applications.

Zilong Li, Michael J. Murdoch



Research Highlight: **Metrics for Evaluating Protective Lens Performance**



This study, at the intersection of military innovation and human perception, evaluated high-end eyewear, focusing on metrics like contrast threshold, correctness of response, and response time. It explored the impact of various tints for color contrast enhancement. Participants wore tinted eyewear, engaging in tasks identifying color patches with contrast patterns. Two experiments revealed participant variability in adjusting color values for visibility thresholds and a decreasing correctness trend with higher spatial frequencies. Response times, especially with dark-tinted eyewear, indicated difficulty. The study also evaluated the efficacy of a model predicting color appearance through eyewear tint. It is an important step in understanding how different color-enhanced eyewear influences human performance, suggesting considerations for future research, including more precise experiments and expanded lens comparisons.

Likhitha Nagahanumaiah and Susan Farnand

Research Highlight: **Saturation and Brightness in HDR Images**

We conducted a psychophysical experiment in which observers compared the saturation and brightness between high-dynamic-range images that had been modulated in chroma and achromatic lightness. Models of brightness which account for the Helmholtz-Kohlrausch effect include both chromatic and achromatic inputs into brightness metrics, and this experiment was an exploration of whether these metrics could be expanded to images. The observers consistently judged saturation in agreement with the predictions of our color appearance modeling. However, some unexpected results and differences between observers in their methods for judging brightness indicate that further modeling, including spatial effects of color perception, need to be included to apply our model of the Helmholtz-Kohlrausch effect to images.

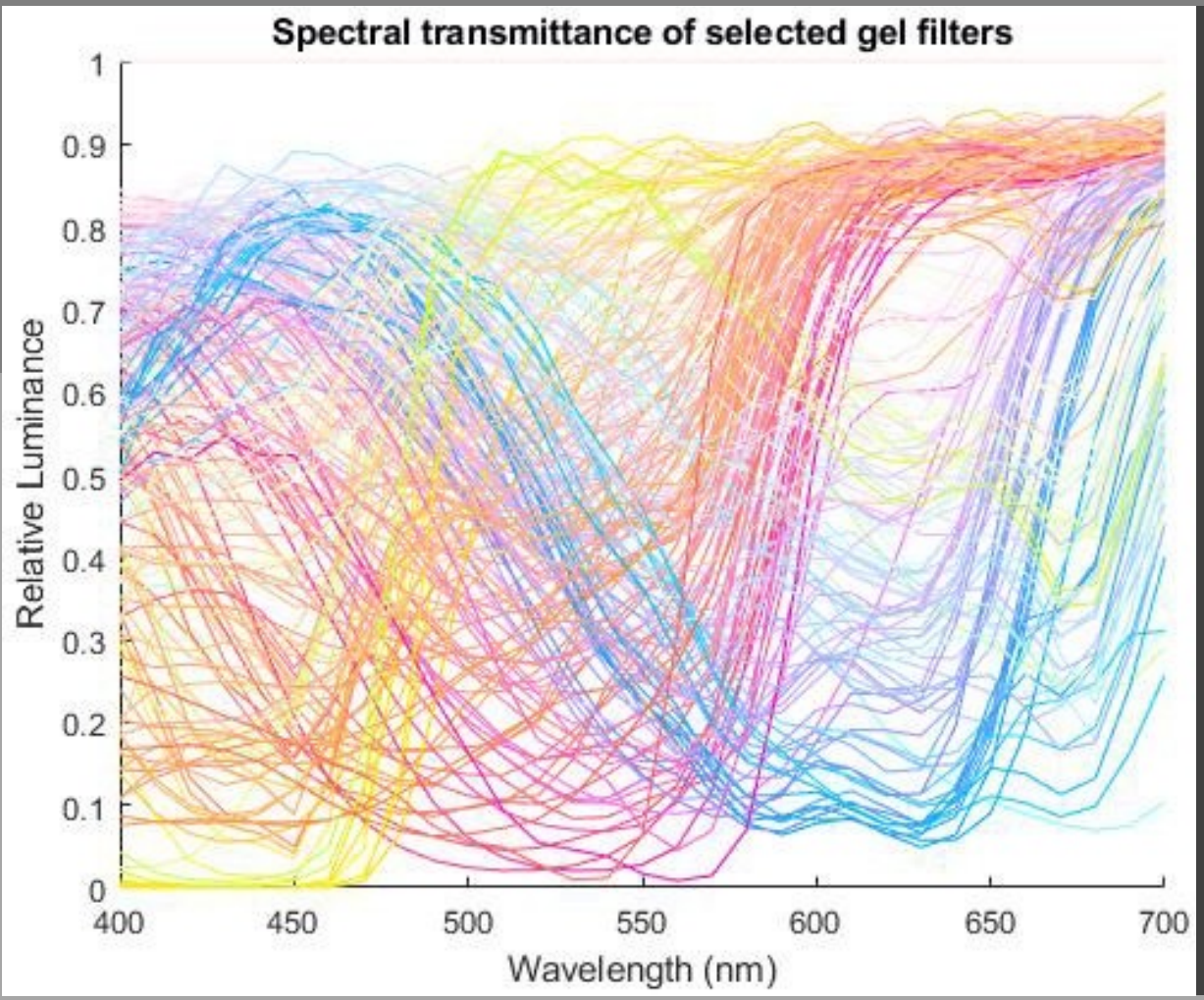
Luke Hellwig, Mark D. Fairchild

Research Highlight: **Practical Spectral Imaging for Cultural Heritage Applications**

Leah Humenuck traveled to Dubrovnik, Croatia with Izzy Moyer, a BS Museum Studies student partnered with RIT Croatia. She provided guidance and support for the setup and installation of a portable multispectral imaging system for the Dubrovnik State Archive. While there she gave BeyondRGB presentations to archivists, conservators, and to two RIT Croatia classes. The BeyondRGB work continues with the third cohort of senior Software Engineers. Leah is a semifinalist for the Fulbright U.S. Student Program for research with the Norwegian University of Science and Technology focused on using mobile phone imaging for documentation of cultural heritage items.

Leah Humenuck and Susan Farnand

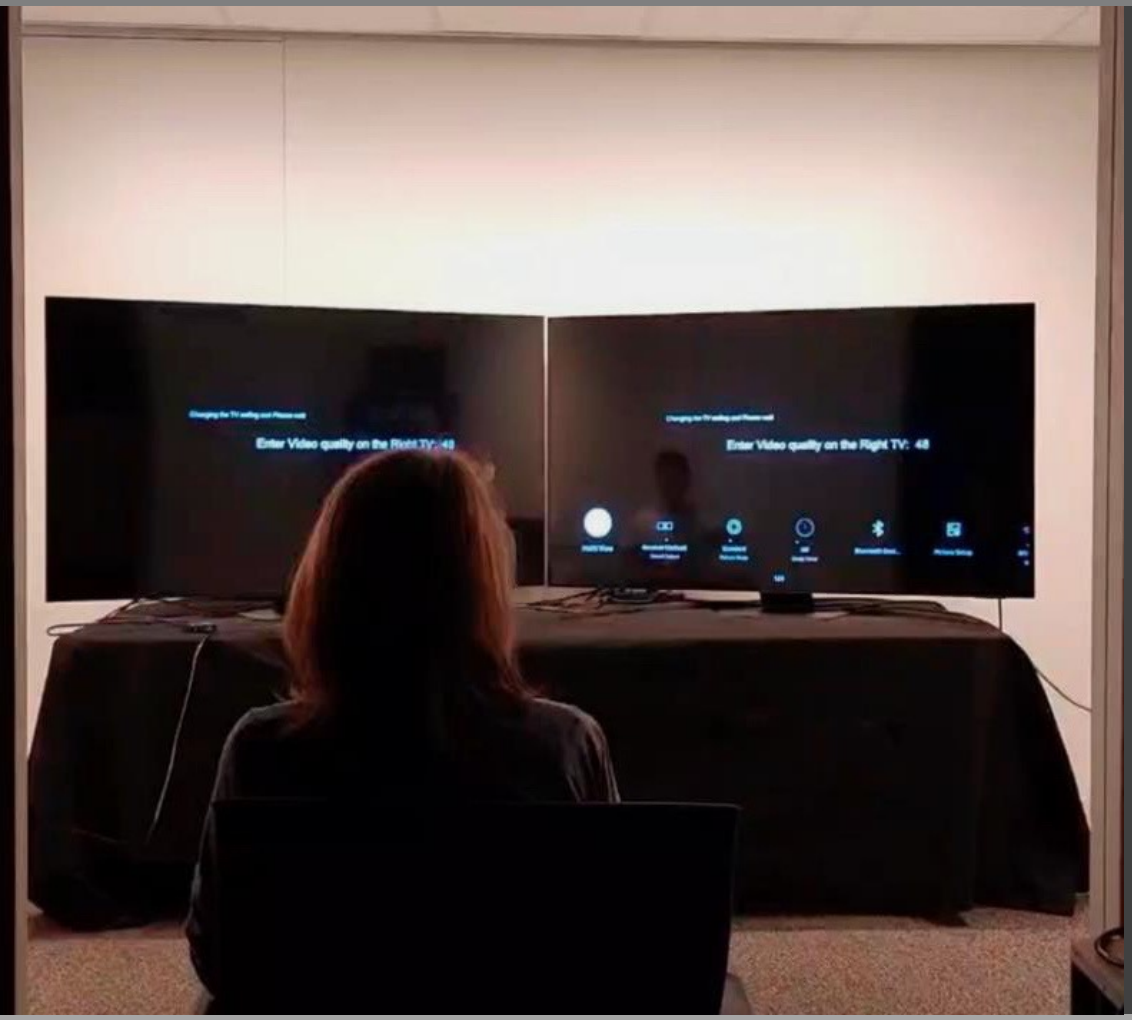
Research Highlight: **Color-accurate spectral imaging using filtered light**



Compared to traditional RGB capture, multispectral imaging (MSI) allows for the capture of more color-accurate images, which is essential in cultural heritage contexts. Previous research at this lab has worked on reducing the barriers to MSI by using narrow-band LEDs with common photography equipment, a technique known as two-light imaging. To further reduce costs, the possibility of replacing the LEDs with filtered white light is now being explored. A simulation was run using over 200 theatre gel filters, a small selection of white lights, and numerous cameras for the purpose of finding optimal filters for two-light imaging. Results were evaluated by the performance of colorimetric and spectral estimation of color targets, and consistency over different lights and cameras. Further research will involve physically evaluating the performance of the top ranked filters.

Sahara Smith, Leah Humenuck, Susan Farnand

Research Highlight: **Evaluation of Subjective Video Quality of Television Displays**

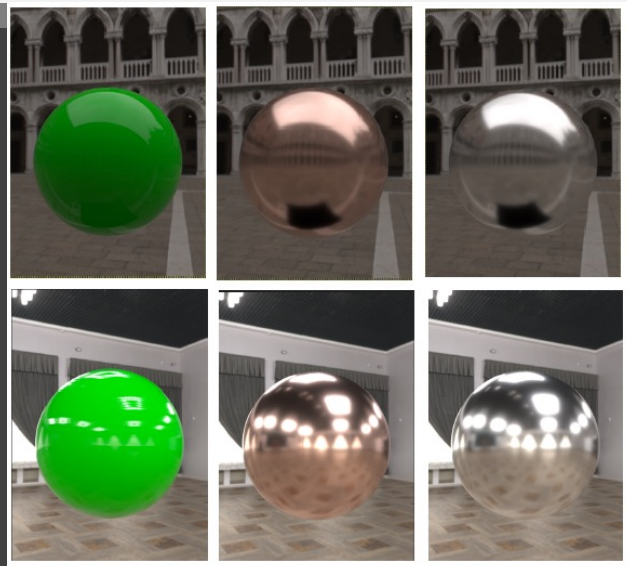


The experimental setup for the perceptual experiments. Room lighting was computationally controlled.

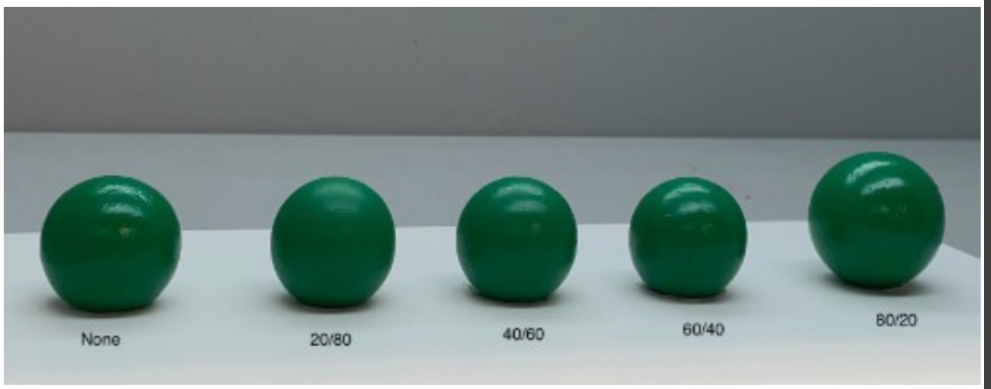
With evolution of video and display technologies, there is an interest in better understanding user preferences for video quality and the factors that impact these preferences. This study focused on the subjective video quality assessment (VQA) of TV displays, considering a range of factors that influence viewer experience. We conducted two psychophysical experiments to investigate the latent factors affecting human-perceived video quality. Our results offer insights into how different factors contribute to video quality perception. This research will guide researchers and developers aiming to improve display and environmental settings to give end-users an optimal viewing experience.

Eddie Pei, Hosub Lee (Samsung Research America), Elena Fedorovskaya, Susan Farnand

Research Highlight: **Perceptual Gloss measurement and reproduction**



Sample Virtual stimuli with different background and material types

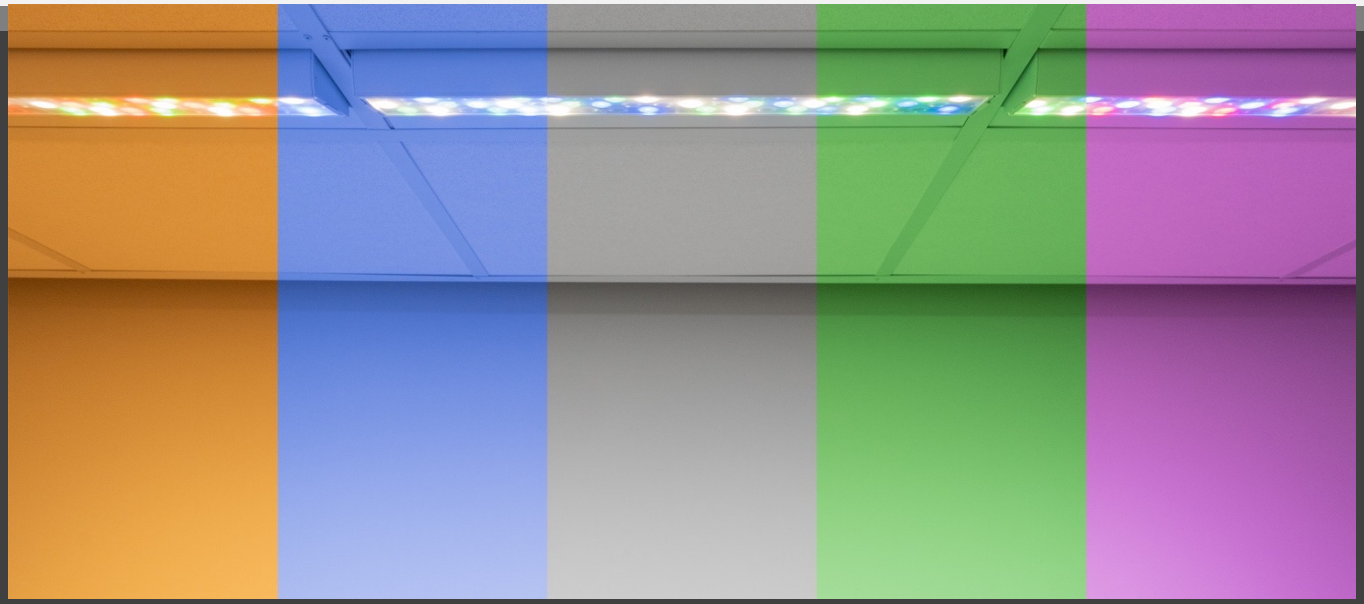


Examples of Real stimuli: with varnish coating with combinations of liquid gloss and matte varnishing.

Previous research has examined gloss perception, exploring factors such as the illumination field, background, and scene dynamic range, as well as the connection between reflection model parameters and perceived gloss. However, current studies often overlook diverse real-world environments and material types, tending to focus on scenes with limited dynamic range and achromatic samples. Most studies do not consider the measurement and reproduction of perceptual gloss across different application industries. To address these gaps, our study plans to investigate gloss perception across diverse backgrounds, materials, and extended dynamic ranges. We will conduct psychophysical experiments using real and virtual chromatic samples, a rarely explored approach, to gain a comprehensive understanding of perceptual gloss applicable to various contexts. As the next step, we will measure the physical material properties of our real samples and explore an efficient gloss reproduction approach based on the findings of our perceptual gloss study. The intended applications of this study include 3D printing and computer-generated imaging.

Yuan Tian and Mekides Assefa Abebe

Research Highlight: **Chromatic Adaptation in Dynamic Environments**



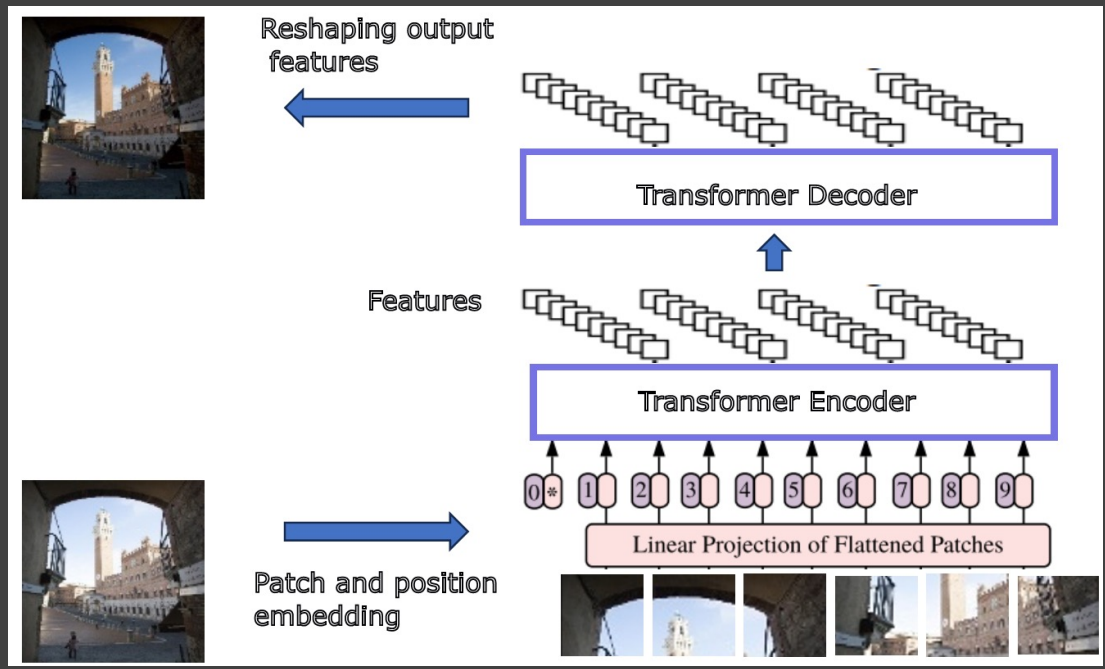
As augmented reality (AR) systems continue to develop, it is important to characterize visual perception within this framework, whether to present virtual elements accurately or manipulate them for a desired effect. Chromatic adaptation is a significant part of visual perception which is not well understood in the context of AR. Environmental lighting in AR applications is rarely constant, as illumination shifts and users move in the real world, and adaptation has not been thoroughly studied under such conditions. In order to address these issues, experiments are planned to measure chromatic adaptation to dynamically changing lighting and AR elements, both individually and together. In the upcoming experiment, we will track achromatic appearance on a physical display as the illumination changes gradually and smoothly. The transitions will be in four hue directions anchored at the chromaticity of D65 (see images above), and adaptation will be measured during the lighting change as well as during periods of constant illumination at either end point of transition. Later experiments will utilize a similar methodology but incorporating AR stimuli that will follow the same color changes. The data will be used to create a model of chromatic adaptation that can account for dynamic changes in both the illumination and augmented reality stimulus.

Abby Weymouth and Michael J. Murdoch

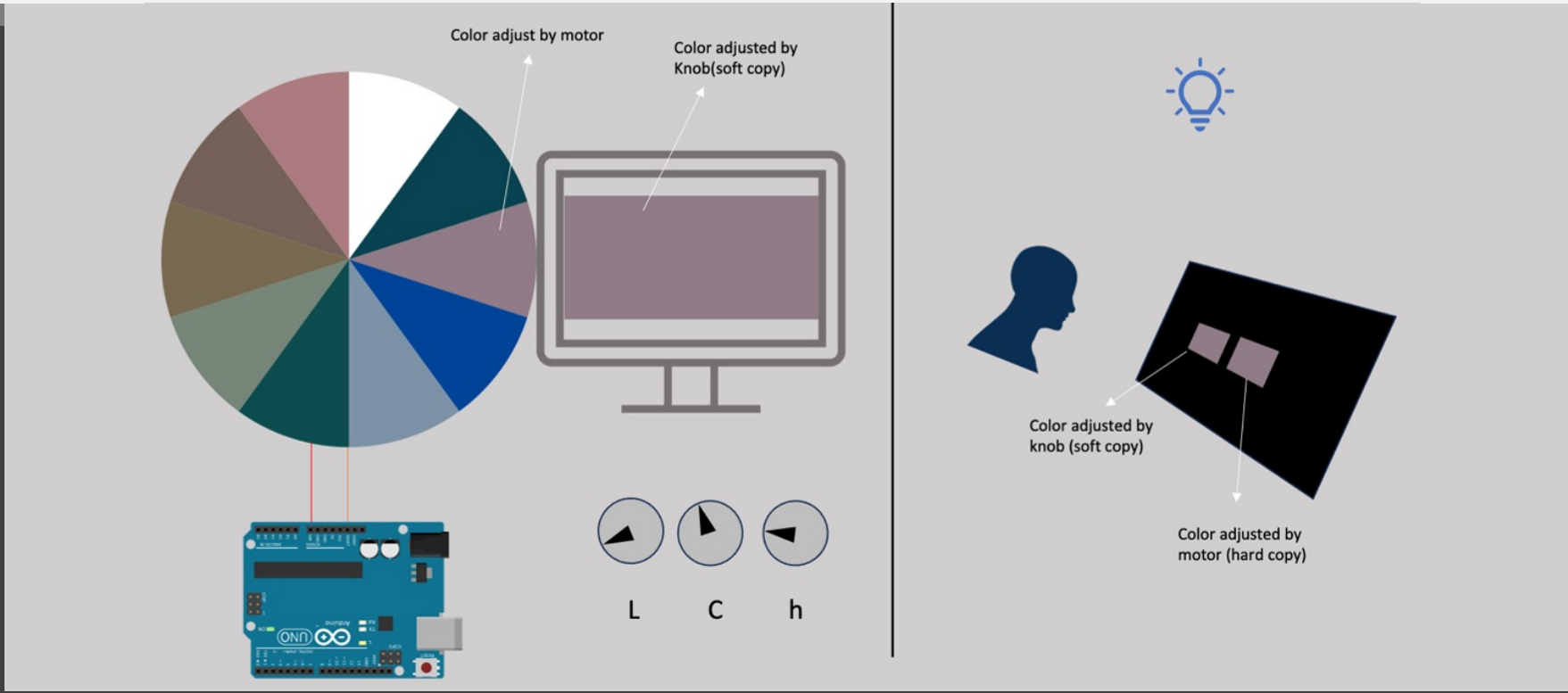
Research Highlight: **Application of deep learning models in HDR imaging**

The application of deep learning in High Dynamic Range (HDR) imaging has been increasing. It has been utilized to enhance HDR images by increasing dynamic range, color accuracy, and overall image quality. Deep learning algorithms process HDR images, learning intricate mappings between standard dynamic range (SDR) inputs and HDR outputs. This enables sophisticated tone mapping and dynamic range compression, even generating HDR content from SDR images. Our research focuses on reverse tone mapping and detail restoration, crucial for HDR applications with tone expansion feature. Conventional methods often fail in severe under- and over-exposure cases, necessitating advanced techniques. We explore the limitations of the convolutional neural networks (CNNs) and generative adversarial networks (GANs), addressing challenges like insufficient data and weak spatial representation. To capture global dependencies and contextual understanding, beyond local spatial variations, transformer models such as vision transformers will be applied. Additionally, we analyze the models' activations and attention mechanisms to gain deeper insight on key SDR and HDR image characteristics.

Nima Rabbanifar, Soroush Shahbaznejad,
Mekides Assefa Abebe



Research Highlight: **Individualized Color Characterization**



Human color vision exhibits substantial variability, challenging the accurate measurement and reproduction of individual color appearances. Che's recent research introduces a novel cross-media color-matching experiment that combines physical pigments and digital displays, providing a practical and efficient solution to measure individual color matching functions (CMFs). By using the Kubelka-Munk theory to synthesize broadband spectral pigments, optimized metameric pairs can be created to significantly differentiate categorical observers. Psychophysical results reveal the superiority of specific CMFs (categorical observers) for individual observers, surpassing standard models like the CIE 1931 2-degree CMFs. This study also underscores the significance of employing CMFs for personalized color reproduction and explores the potential benefits of using higher bit-depth displays, narrower-band displays, and increasing repetition counts to enhance the accuracy of the color matching process.

Che Shen, Mark D. Fairchild

Research Highlight: **Hue and Brightness Scaling**

Two research studies were conducted in 2023. In the first, two types of hue scales were developed based on fundamental cone responses: hue discrimination (FHSh) and hue appearance (FHSH). The scales development and mathematical evaluation of scales were published in a paper. Then, two psychophysical experiments were conducted to visually evaluate the linearity and spacing of hue scales. The second study considers the effect of stimuli size on perceived brightness. For this purpose, three pilot experiments and one main experiment were conducted. A model was developed based on the results of visual experiments which incorporate the size of stimuli. The model was evaluated and the results showed that it can successfully predict the perceived brightness considering the stimuli size. A paper is in preparation to be published.

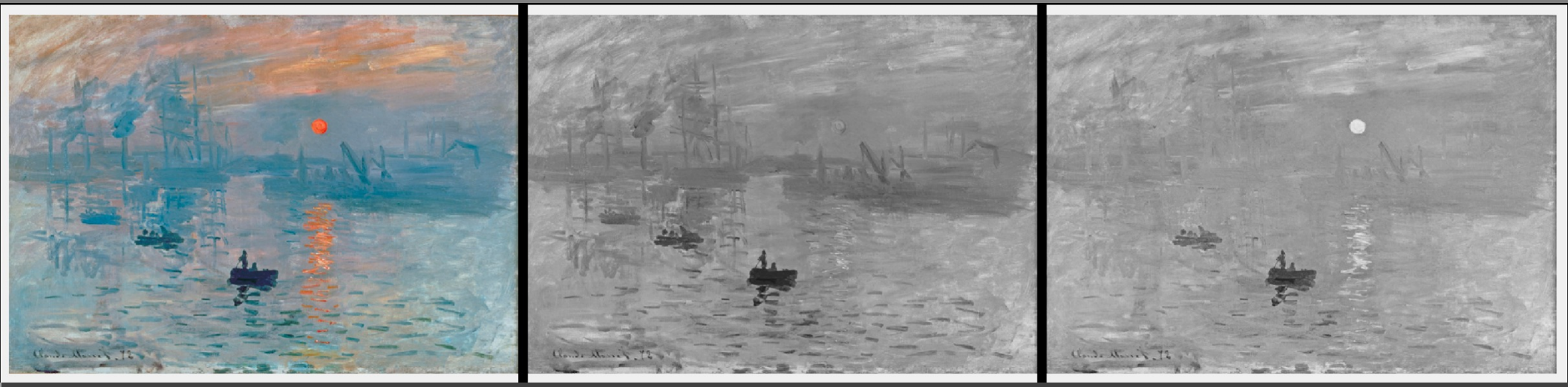
Saeedeh Abasi, Mark D. Fairchild

Research Highlight: **Faces in Spaces: Transparency Perception of Faces in AR**

Seeing and interacting with human faces is an important component of remote social interaction, including in virtual- and augmented-reality meeting spaces. Optical see-through augmented reality (OST-AR) presents unique challenges in displaying objects; Due to OST-AR's additive light mixture of real-world with virtual objects, many virtual objects are unable to be displayed with full opacity, with low-lightness stimuli in particular introducing significant amounts of perceived transparency when displayed. This is especially problematic for displaying faces, since the perceived transparency of faces will differ based on the natural differences in skin lightness among the human population. In this research, we are evaluating how to modify OST-AR's display to produce similar amounts of perceived transparency among different faces and non-face objects, as well as evaluating how perceived transparency contributes to acceptability judgments about the appearance of faces and non-face objects.

Sofie Herbeck, Michael J. Murdoch,
Chris Thorstenson

Research Highlight: **Independent Color Scales**



Hao wrapped up his dissertation, after collecting G0-based brightness and saturation scales, by investigating their independence relations. Using maximum likelihood conjoint measurements, two-dimensional manipulations in terms of brightness and saturations were done to evaluate the observer's ability to judge one attribute without interference from the other. For the average observer, saturation as constant chromaticity is independent of luminance changes, while brightness receives a small positive contribution from the physical saturation dimension (a residual amount of H-K effect). This work further supports the feasibility of representing color as multiple independent scales and provides the framework for further investigation of other color attributes. Hao has been invited to present his dissertation at a few conferences, and keeps pondering about the grand illusions, the moon or Monet's sun.

Hao Xie, Mark D. Fairchild

Research Highlight: **Illumination Discrimination on Mars**

Geologists consider it crucial to work on faithful images of Mars. However, no systematic color correction is done on those images. Due to fluctuating weather and the low gravity of the planet, varying amounts of dust in the atmosphere leads to ground illumination variations. Low discrimination of light variations by the Human Visual System is explained by Chromatic Adaptation (CA). Color image processing therefore often accounts for a step related to CA. This study investigated whether this step has to be applied to Mars images as well and is done through an illumination discrimination task performed on 15 observers for stimuli along daylight locus and solight locus (lights of Mars planet) generated through a 7-channel LED lighting system. The results agree with each other on the daylight locus while showing small differences between results under daylight and solight. This study was performed in the frame of a postdoc in collaboration with the Centre National d'Etudes Spatiales (CNES – i.e the French space agency) and the Integrated Image Sensors research team at ISAE-SUPAERO, both located in Toulouse, FRANCE.

Emilie Robert, Mark D. Fairchild

Publications 2023

Journal Papers

S. Abasi and M.D. Fairchild, Fundamental scales of hue appearance and discrimination, *Color Research and Application* 48, 10.1002/col.22895 673-688 (2023).

Anku and S. P. Farnand, (under review). "Preferred white balance for skin tones in multi-illuminant scenes", *Journal of Perceptual Imaging*.

E. Fedorovskaya, R. Chung, D. Hunter, P. Urbain, and D. Hutchison. Defining Consistent Color Appearance for Print Images. *International Circular of Graphic Education and Research*, 11 (revision).(2023)

M.D. Fairchild, On the questionable utility of color space for understanding perception, *Color Research and Application* 48, 10.1002/col.22853 260-266 (2023).

M.D. Fairchild, Visual and photographic assessment of wine color, *Color Research and Application* 48,10.1002/col.22787 21-31 (2023).

L. Hellwig, D. Stolitzka, and M.D. Fairchild, The brightness of chromatic stimuli, *Color Research and Application* 48, 10.1002/col.22910 113-123 (2023).

D. Jonauskaite and C. A. Thorstenson, Special collection: Color and emotion. *Color Research and Application* (2023).

A.D. Pazda, C. A. Thorstenson, and A. K. Fetterman, Colorfulness influences perceptions of valence and arousal. *Journal of Experimental Psychology: General*. (2023).

E. Robert, C. Shen, M.D. Fairchild, M. Estribeau, and E. Cucchetti, Color correction of Mars planet images: A study of illumination discrimination along solight locus, *Journal of Imaging Science and Technology* 67(5), 1-9 (2023).

M. Royer, M. J. Murdoch, K. Smet, L. Whitehead, A. David, K. Houser, T. Esposito, J. Livingston & Y. Ohno, “Improved Method for Evaluating and Specifying the Chromaticity of Light Sources,” *LEUKOS* 19(1), (2023).

C. Shen and M.D. Fairchild, Weighted geometric mean (WGM) method: A new chromatic adaptation model, *PLOS One* 18, e0290017 (2023).

S. Sreekantaswamy, M. Baghchechi, S. Siddiqui, J. Lester, S. Farnand, L. Zukley, K. Abuabara. (under review). Comparison of Fitzpatrick Skin Type Methodologies and Photographic Skin Color Assessment, *Journal of the American Academy of Dermatology*.

H. Xie and M.D. Fairchild, Deriving and dissecting an equally bright reference boundary, *Optics Express* 31, 15637-15652 (2023).

H. Xie and M.D. Fairchild, Representing Color as Multiple Independent Scales: Brightness versus Saturation, J*ournal of the Optical Society of America A* 40, 452-461(2023).

Publications 2023

Conference Proceedings

M.A. Abebe, J.Y. Hardeberg, B. Hafslund, S. Asghari. Natural hair color appearance and classification analysis. In Proceedings of the International Colour Association (AIC) Conference (2023).

R.S. Berns and D.R. Wyble, Improving Color Accuracy When Imaging Cultural Heritage Using a Bi-Color LED Source. In IS&T Archiving Conference, Vol. 20, pp. 57-61 (2023).

L. Hellwig, D. Stolitzka and M.D. Fairchild, Improvements to CIECAM16 and future directions, CIE 30th Quadrennial Session, Slovenia, PP11 (2023).

L. Hellwig, D. Stolitzka and M.D. Fairchild, Novel methods of brightness and saturation testing for High-Dynamic-Range Images, IS&T 31st Color and Imaging Conference, Paris (2023).

L. Humenuck, and S.P. Farnand. Beyond RGB 1.5: Improvements to a Free, Opensource, Spectral Image Processing Software Application for Cultural Heritage Studio Photography. In IS&T Archiving Conference, Vol. 20, pp. 48-52 (2023).

E. Robert, C. Shen, M.D. Fairchild, M. Estribeau and E. Cucchetti, Color correction of Mars planet images: A study of illumination discrimination along solight locus, IS&T 31st Color and Imaging Conference, Paris (2023).

J. Serra, M. A. Abebe, M. J. Murdoch, Virtual reality to evaluate the amplitude of interiors with different colors, in XX International Congress of Architectural Graphic Expression. Coruña-Porto, Portugal (2023).

Book Chapters

M. Assefa Abebe, “High Dynamic Range Imaging” in Fundamentals and Applications of Colour Engineering, Ed. Phil Green, John Wiley & Sons, Ltd. (2023).

M. J. Murdoch, “Colour in AR and VR” in Fundamentals and Applications of Colour Engineering, Ed. Phil Green, John Wiley & Sons, Ltd. (2023).

Other Presentations

S. Abasi and M.D. Fairchild, Talk: Modeling hue perception, ISCC Color Impact 2023 (2023).

M. A. Abebe, Y. Tian, and E. Fedorovskaya, Perceptual gloss measurements: Exploring real and virtual colored samples within complex backgrounds and extended dynamic ranges, TAGA Annual Technical Conference, 2024.

R. S. Berns, Keynote: Why does my artwork reproduce so poorly? ISCC Color Impact 2023, Rochester (2023).

G. Brogle, and S.P. Farnand. Incorporating High Dynamic Range into Multispectral Imaging for Cultural Heritage Documentation; ISCC Color Impact 2023, Rochester (2023).

M.D. Fairchild, Munsell meets Thoreau: A season of leaves and colors, P, Thoreau Society Annual Gathering 2023, Concord, MA (2023).

M.D. Fairchild, Munsell Trees: A Season of Leaves and Colors, Photographs in Juried “Completely Color” Exhibition, ISCC Color Impact 2023, Rochester (2023).

M.D. Fairchild, Workshop: Is color space a thing? OR There’s no such thing as color space: Prove me wrong, ISCC Color Impact 2023, Rochester (2023).

E. Fedorovskaya and M. Nguyen, Interactive Neuroanatomy in Virtual Reality, demo #302, presented at Imagine RIT 2023.

L. Hellwig, D. Stolitzka, and M.D. Fairchild, Talk: The brightness of chromatic colors, ISCC Color Impact 2023, Rochester (2023).

S. Herbeck, M. Murdoch, and C.A. Thorstenson, Demo: Faces in spaces: Transparency perception in AR. 8th Annual Frameless XR Symposium, Rochester, NY (2023).

M. J. Murdoch, Keynote: Mastering Light: Reproduction, Reality, and Augmentation, IS&T 31st Color and Imaging Conference, Paris, France (2023).

M. J. Murdoch, Talk: Color Appearance in Optical See-Through Augmented Reality, ISCC Color Impact 2023, Rochester (2023).

M. J. Murdoch, Talk: Color Science and Augmented Reality, Voices of XR Speaker Series, Studio X, University of Rochester (2023).

L. Nagahanumaiah, S.P. Farnand, Metrics for Evaluating Protective Eyewear Lens Performance, Center for Imaging Science Industrial Associates (2023).

A. Rabbanifar, P. K. Chelladurai, M. Assefa Abebe, and E. Fedorovskaya, Visuo-tactile interaction in XR, presented at the 8th Annual Frameless Labs XR Showcase, November 17, 2023.

C.A. Thorstenson, Talk: Using color to convey emotions in social robots. ISCC Color Impact 2023, Rochester, NY (2023).

Publications 2023

Other Presentations

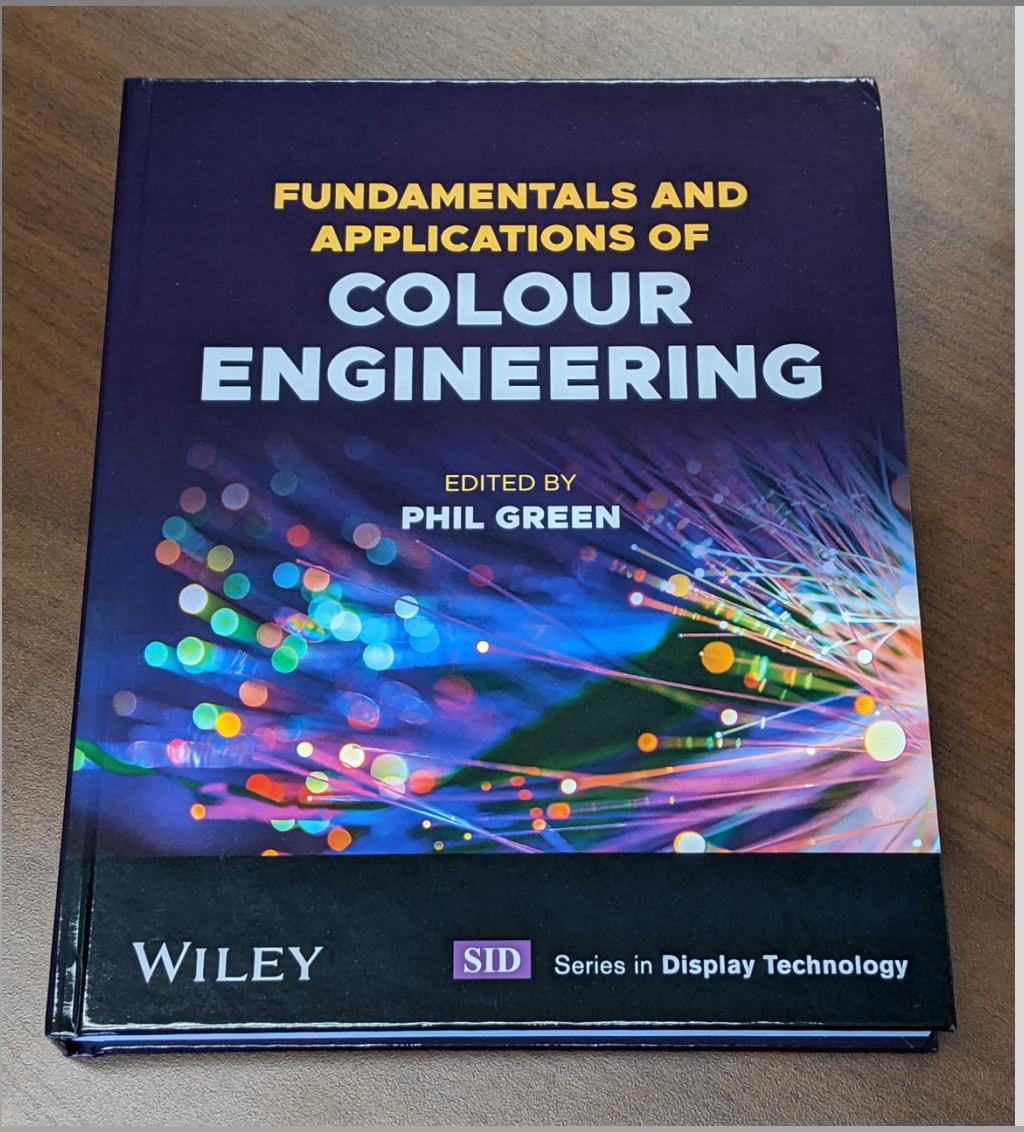
Y. Tian and C. A. Thorstenson, Poster: The influence of gloss on color perception in artificial human faces. ISCC Color Impact 2023, Rochester, NY (2023).

J. Versteden and C. A. Thorstenson, Poster: Evaluating facial skin appearance in social robots. ISCC Color Impact 2023, Rochester, NY (2023).

J.A.S. Viggiano and M.D. Fairchild, Workshop: Beyond the pale (ale) and behind the blush (wine): The colors of potent potables, ISCC Color Impact 2023, Rochester (2023).

S.P. Farnand, Quoted in the New York Times article “Watches That Can Reflect the Colors of the Rainbow” by Anders Modig Davin, Reporting from La Chaux-de-Fonds, Switzerland; Jan. 18, 2024.

Publication Highlight: **Textbook Contributions**



MCSL faculty **Mekides Assefa Abebe** and **Michael J. Murdoch** each contributed chapters to the new book **Fundamentals and Applications of Colour Engineering.**

This all-new textbook covers many aspects of color reproduction and color measurement, including colorimetry, color appearance, color encoding, gamut mapping, color management, device characterization, and more. In total, sixteen experts from around the globe participated in the writing.

Assefa Abebe's chapter focuses on High Dynamic Range Imaging, and Murdoch's dives into Color in AR & VR. As a reference or textbook, check out this book for the latest and greatest!

Students, Visitors, & Graduate Alumni

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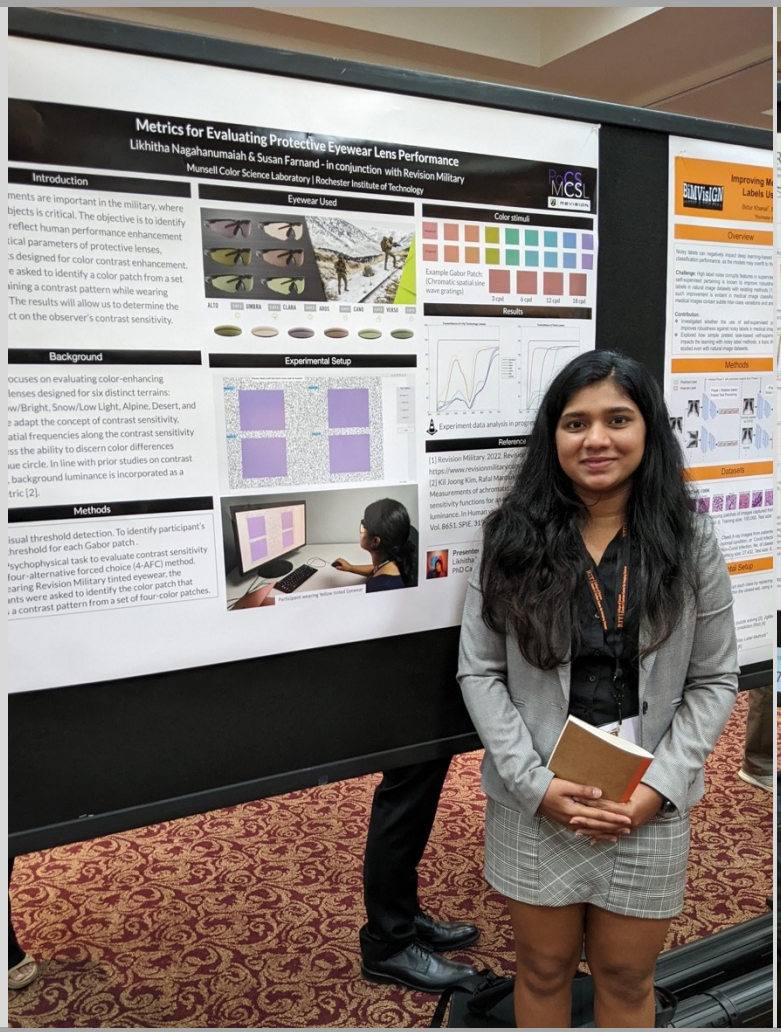

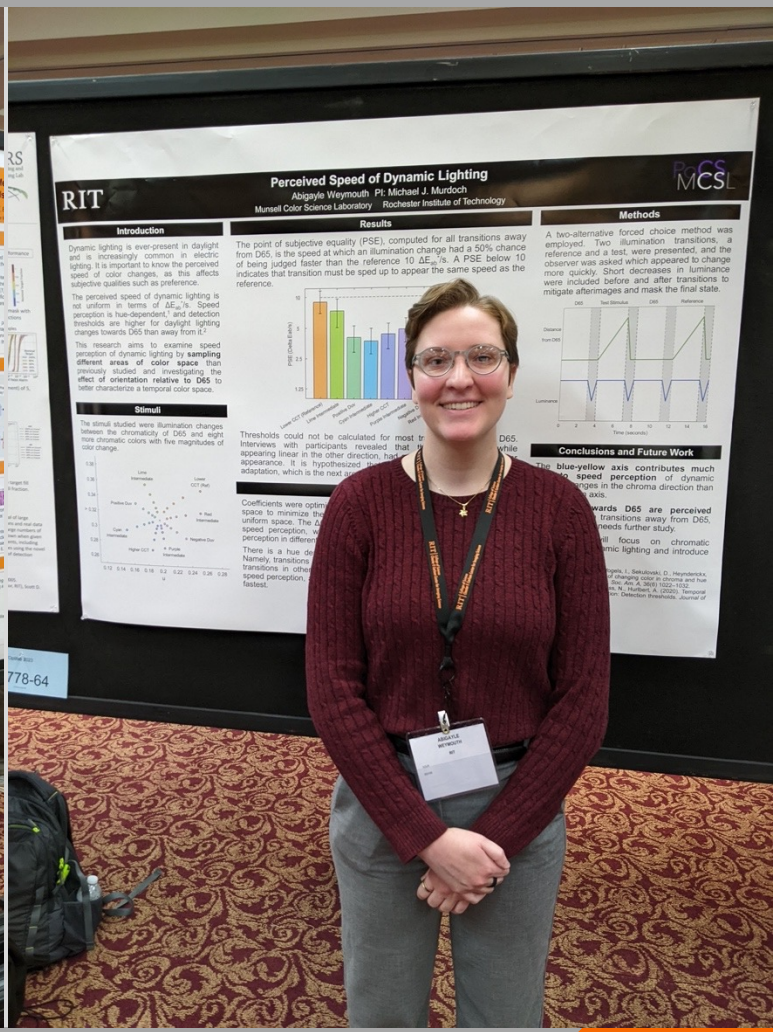

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Wayne Farrell, MS, IS

1986 Alumni
Mark Fairchild, MS, IS

Key
BS: Bachelor of Science
CS: Color Science
IE: Industrial Engineering
EE: Electrical Engineering
IPT: Imaging and Photo Technology
IS: Imaging Science
MS: Master of Science
PhD: Doctor of Philosophy
PM: Print Media
VR: Visiting Researcher


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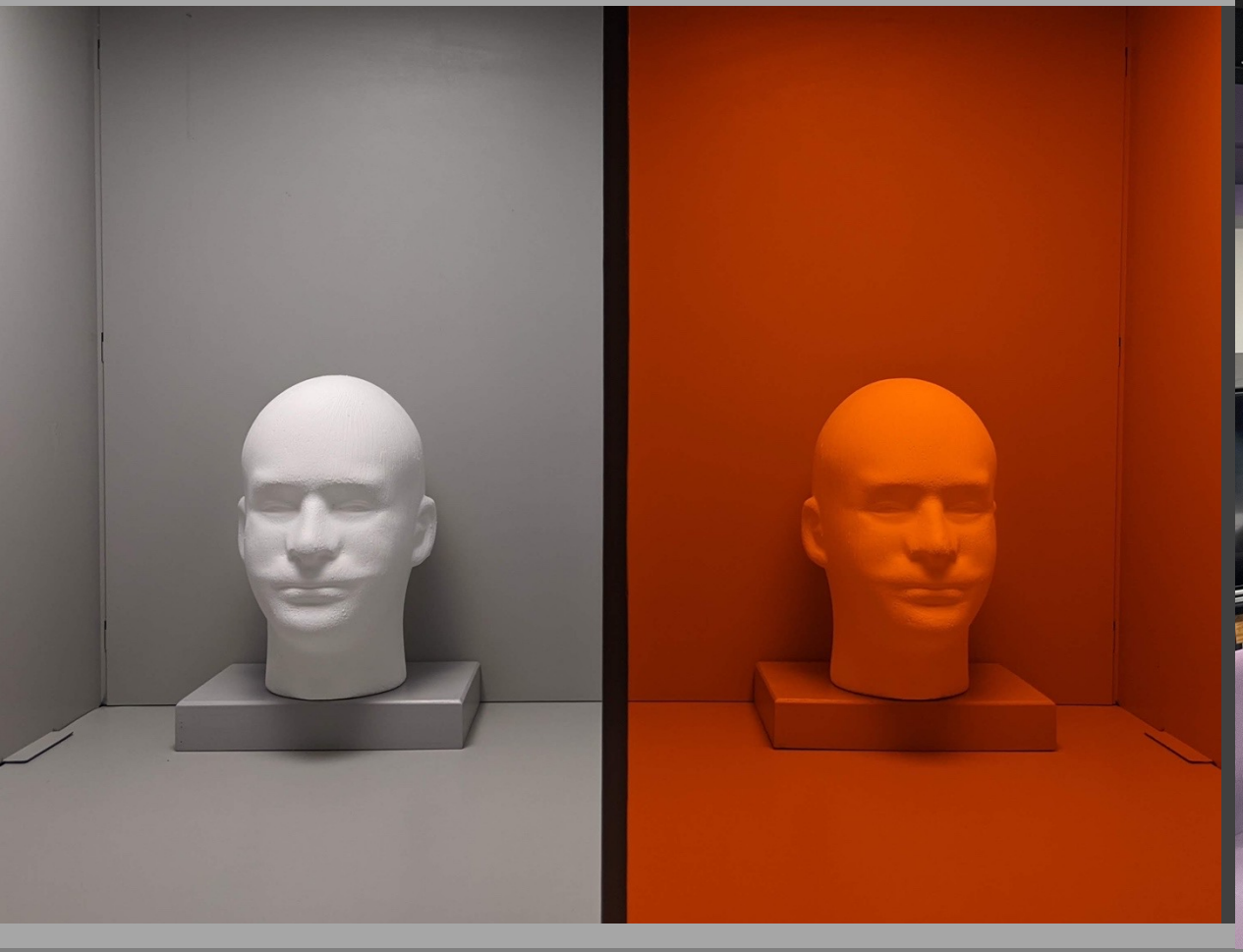
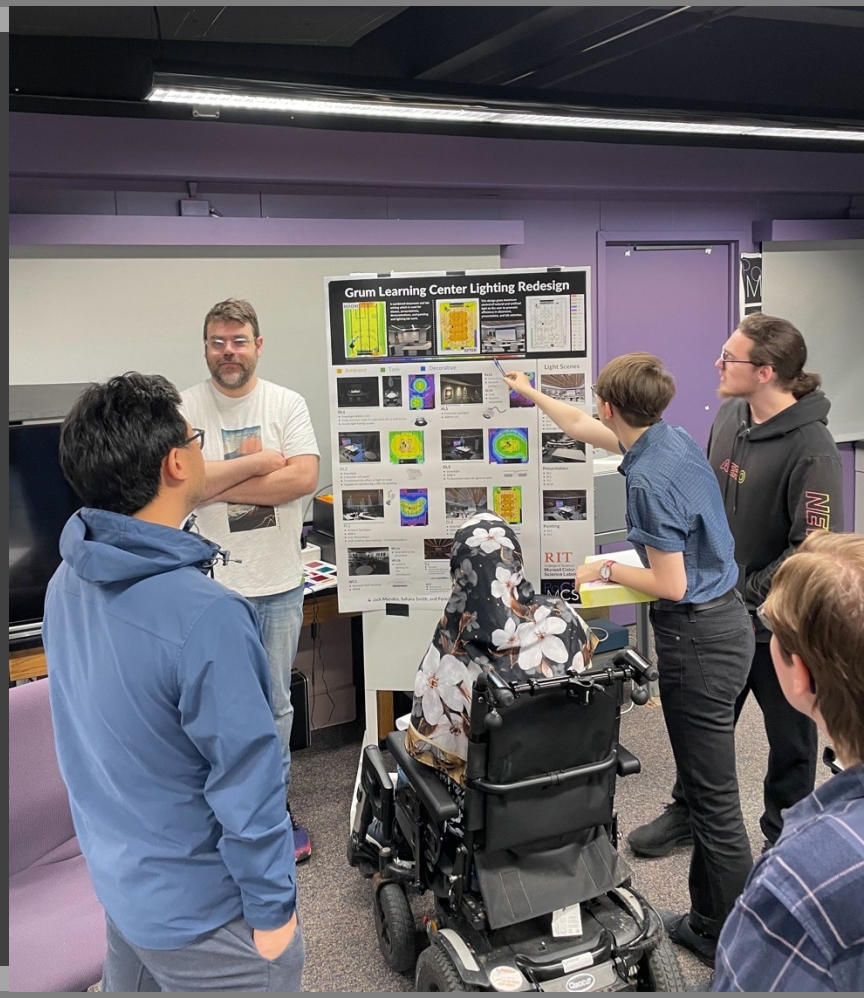
EUROPA
The Language of Light
R·I·T Program of Color Science
COLOR IN AR




Grum Learning Center Lighting Redesign
RIT


SUNDAY, APRI
St. Paul's Episc


Camera Phone Improvement Over Time
December 2004
Early flip phone with camera
640 x 480 (VGA)
January 2014
Xiaomi Mi 3
4280 x 3120 (13 MP)
CIS/MCSL, RIT, April 14, 2023
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Tongbo Chen Endowed Fellowship

Your donation enlarges the principal of the Endowed Fellowship, which provides consistent annual returns in perpetuity.

The returns from the fellowship provide support, such as stipends and conference travel funds, to RIT students enrolled in the Color Science Ph.D. program, with special consideration to those Color Science students who are researching color in cultural heritage applications.

http://www.rit.edu/giving/TongboChenEndowedFellowship

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Your donation provides immediate funds directly to MCSL, valuable for short-term needs and flexibility.

The MCSL Fund is a general-purpose account that is used for flexibility and strategic investment. Funds are typically used to support M.S. and Ph.D. student stipends if their work is not directly for a funded project, or to purchase equipment for the lab.

http://www.rit.edu/giving/MunsellColorScienceLab

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If the expertise of our amazing MCSL students could help your company, we are happy to discuss opportunities for contract or gift funding. This can be a great way to gain perspective on a problem, connect with MCSL faculty, and get to know students before they're on the job market!

Questions about any of these opportunities: Michael Murdoch (michael.murdoch@mail.rit.edu) or Susan Farnand (susan.farnand@rit.edu).

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Munsell Color Science Laboratory

40 Years of Color Science Education & Research

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