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TECHNICAL PROGRAM: SCHEDULE AND ABSTRACTS

WEDNESDAY 29 OCTOBER 2025

WELCOME AND OPENING KEYNOTE

Session Chair: Minchen (Tommy) Wei, The Hong Kong Polytechnic University (Hong Kong)

9:00 – 10:00

Recent Development and Challenges of Smartphone Digital Imaging,

Mingxue Wang, Huawei Technologies Co., Ltd. *

The rapid evolution of digital imaging has transformed smartphones into versatile tools for visual creation and display. Great efforts have been made on improving user experiences, including capturing, editing, transmission, and display. In particular, photography and HDR display are the two most outstanding examples. Unique photography technologies enhance low-light performance, long-distance capturing, and personalized editing, all of which are achieved with the rapid development of artificial intelligence (AI), better understanding about human perception, and user experiences. On the other hand, the realization of HDR VIVID, an HDR video/image technology released by the UHD World Association (UWA), on smartphones, allows the user to see more realistic images, richer colors, deeper shadows and details, and more high-lights. Looking forward, there are still many challenges awaiting better solutions, such as color reproduction under complex illumination conditions, consistency across devices, and controllability of generated color images.

METAMERISM

Session Chair: Eric Kirchner, Zhejiang University (China)

10:00 – 10:40

10:00 Recovering Stable Metamers Under a Varying Illumination,

Violet Mayne and Graham Finlayson, University of East Anglia (UK) 1

It is impossible to recover the actual reflectance that induces a given colour response: as many spectra—called metamers—will integrate to the same response values. For some applications it suffices to recover a good single metamer (satisfying a criterion such that it is the smoothest amongst all metamers). However, when the same surface is viewed under different lights—generating different RGBs—the corresponding reflectances recovered by Smoothest Reflectance estimation (SR) are not all the same. Indeed, there can be a large spectral variation. Recent work has demonstrated that more stable—illuminant insensitive—metamers can be produced by Colour Corrected Smoothest Reflectance estimation (CCSR): where camera RGBs are colour corrected to a canonical reflectance light with respect to which metamers are recovered. In this paper, we examine the relationship between the spectral sensitivities of the camera and both SR and CCSR metamer recovery. Empirically, the variation in recovered metamers for the worst camera for the SR method is found to be 2.5 times larger than the best camera using CCSR. We argue that the stability of metamer recovery in general (for either SR or CCSR) is linked to the extent that accurate colour correction is possible.

10:20 Deterministic Metamer Mismatch Body Computation, Alexander

Forsythe^{1,2} and Brian Funt¹; ¹Simon Fraser University (Canada) and

²Academy of Motion Picture Arts and Sciences (US) A-1

Metamer mismatching poses a significant challenge for accurate color reproduction, as objects that match under one illuminant can diverge under another. The widely used algorithm for computing Metamer Mismatch Bodies (MMBs), proposed by Logvinenko et al., suffers from run-to-run variability due to its reliance on random direction vectors for boundary searches. This can result in sparsely sampled boundary regions. The stochastic nature of the algorithm introduces uncertainty into computed metrics, such as the Metamer Mismatching Color Rendering Index (MMCRI), which depend on the Logvinenko method, thereby complicating interpretation and comparison.

We propose a deterministic framework that eliminates this variability by replacing random seeding with a Sobol low-discrepancy sequence. This approach ensures uniform initial coverage of the feasible reflectance space. To further improve the distribution and maintain determinism, a Gray code transformation is applied to the Sobol sequence. A boundary-seeking nonlinear optimizer then refines these seeds to trace the MMB surface. In tests, the new method yields identical MMBs on every run, eliminating run-to-run variability, and shows a small but statistically significant reduction in average runtime ($\approx 2\%$ faster on this dataset). The resulting repeatable output makes the approach suitable for critical applications such as sensor design, color-correction lookup tables, and tolerance analysis. This work provides a more reliable foundation for MMB-based analyses, addressing the reproducibility challenges inherent in existing methods based on randomized sampling.

10:40 – 11:20 COFFEE BREAK / EXHIBITS OPEN

SKIN COLOR

Session Chair: Maryam Azimi, Apple Inc. (US)

11:20 – 12:20

11:20 LUT-based Skin Spectrum Estimation System, Fangjia Du and

Minchen Wei, The Hong Kong Polytechnic University

(Hong Kong) 7

The measurement of diffuse skin reflectance spectrum has important applications, but require accurate and fast measurements. In this study, we proposed several methods for reconstructing the diffuse skin reflectance spectrum using several existing datasets. These methods can reconstruct the spectrum of an area by only capturing the images under several LED illuminations, instead of using comprehensive systems. A comprehensive system is being built to collect a ground-truth dataset, and also used to test the performance of the proposed methods.

*No proceedings paper or extended abstract associated with talk.

11:40 Skin Color Preference Under Multi-scene Demand,

Beijia Qin, Yuechen Zhu, and Ming Ronnier Luo, Zhejiang University (China) 13

This study discusses how scenes and model's appearance, gender and makeup status influence the preference facial skin tone of Chinese models for Chinese observers. This research also explores how the models' preference differ from the stranger observers. The results show that the makeup status can affect the scope of the preference area. The preference centers exhibit a trend of higher lightness and smaller hue angles than original ones. In all scenes except indoor scenes, a higher CCT correlates with a greater inclination angle of the ellipsoid projection on the a^*b^* plane, a narrower ellipsoid range, and a smaller hue angle of the ellipsoid center. Apart from the in-lab scenario, higher scene color temperatures are associated with a larger chroma increment and a smaller hue increment in the preference centers relative to the original

image skin tones. Also, the chroma of the preference centers of indoor and in-lab scenes is lower than that of the original images, distinguishing them from other scenes. The models' preference is influenced by their actual skin color to a larger extent.

12:00 Preferred Skin Color Reproduction Under Mixed Illumination,

Liqing Wang, Ming Ronnier Luo, and Yuechen Zhu, Zhejiang University (China) 19

Skin tone reproduction has long been a challenge in image processing due to illumination by multiple sources in real-world conditions. This paper describes an algorithm to achieve preferred skin tone reproduction. The work comprises two pivotal components including to develop: 1) a CCT-SPQ/D optimization model via controlled experiments to reveal the mapping relationships between correlated color temperature (CCT) and skin preference quality (SPQ) and chromatic adaptation degree (D), and 2) a novel white balance correction algorithm for skin regions under mixed illumination, which integrates local processing and spatial filtering with color temperature adaptive enhancement via the aforementioned model. Finally, a preference assessment experiment was conducted to demonstrate the superiority of the algorithm proposed.

EXHIBITORS



2-MINUTE EXHIBITOR PREVIEWS

Session Chair: Jan Morovic, HP Inc. (UK)

12:20 – 12:35

Exhibitors Colorspace Co. Ltd., Shanhai LumiChrome Intelligent Technology Co. Ltd., Jilin Qiushi Spectrum Data Tech. Ltd., Beijing Seetrum Technology Co., Ltd., Spectricity, and Thousand Lights Lighting (Changzhou) Limited share information about their products/services in short previews.

TWO-MINUTE INTERACTIVE PAPER PREVIEWS I

Session Chairs: Yuechen Zhu, OPPO, and Yuteng Zhu, Apple (China)

12:35 – 12:50

Relaxation Effect of Virtual Trees in Passthrough Space by Head Mounted Display, Daiki Kiyohara and Norimichi Tsumura, Chiba University (Japan) A-4

Stress is a growing concern in modern society, and exposure to natural environments has been shown to alleviate it. However, urban living often limits access to nature. This study explores the use of passthrough virtual reality (VR) to simulate natural elements in real-world settings. Passthrough VR refers to a mixed-reality approach in which cameras mounted on the outside of a head-mounted display capture the user's real environment in real time, allowing virtual objects to be superimposed onto it. We developed a passthrough VR environment and displayed virtual trees over the user's actual surroundings. Twelve male participants were tested with and without virtual trees. RMSSD rose significantly in the tree condition ($p < 0.05$), reflecting enhanced relaxation.

Testing the Acceptability Prediction of Color Difference Models using the Multiple Illumination Scenarios (MIS) Dataset, Zhiyu Chen¹, Chenyu Wang¹, Qiang Xu², and Qiang Liu¹; ¹Wuhan University and ²Honor Device Co., Ltd. (China) 25

With the rapid advancement of mobile imaging and the increasing demand for perceptually accurate white balance (WB) algorithms, the need for a comprehensive dataset providing perceptual acceptability assessments across diverse illumination conditions has arisen. To address this gap, we constructed the Multiple Illumination Scenarios (MIS) dataset, which spans both pure colors and complex objects under single and multiple illuminant conditions. Observer-based acceptability



ratings were collected and analyzed across 3,465 trials, revealing heightened sensitivity to chromatic deviations in regions of low lightness and chroma. Additionally, spatial and illuminance factors were found to modulate color acceptability judgments in multi-illuminant scenarios. Based on these findings, we proposed two new metrics to improve the performance of current color difference models: one weighted by color appearance attributes and another that incorporates spatial and illuminance factors. Evaluation results demonstrated that our proposed metrics showed improved correlation with perceptual judgments across all tested color difference models. By incorporating more realistic datasets and integrating alternative WB error evaluation metrics, we aim to advance research into the prediction of WB error acceptability under complex lighting environments.

Modeling Perceived Brightness in HDR Displays, Farnaz Agahian and Dale Stoltzka, Samsung Display America Lab (US) 31

This article presents an enhanced mathematical framework that builds on the existing XCR model to more fully account for the increase in perceived display brightness as saturation rises. By integrating modifications to the CIECAM16, our toolkit allows for intuitive graphical exploration of color appearance attributes across a display's full gamut.

Psychophysical Colour Calibration of Multiple VR/MR Head-mounted Displays via Instrument-free Methods, Jinbi Jiang and Stephen Westland, University of Leeds (UK) A-6

Accurate colour reproduction in immersive environments is a long-standing problem for both researchers and developers working with virtual-reality (VR) and mixed-reality (MR) head-mounted displays (HMDs). Recent studies document how difficult it is to apply conventional calibration workflows to near-eye optics and real-time renderers. Hardware obstacles include complex lens pipelines that distort radiometric measurements and luminance imbalance between left- and right-eye panels. MR headsets add two further complications: perceived colour depends on both the display and the front-facing cameras that capture the physical scene, and transparent wave-guide optics (e.g., HoloLens 2) have subtle iridescence. On the software side, inside game engines, post-processing tone mapping, automatic exposure, lighting models and colour-space settings further decouple RGB values from on-screen output. Moreover, practical measurement is nontrivial—MR headsets and spectroradiometers must be precisely aligned with angle and distance controlled. These issues also result in instrument-based measurements of HMD being unable to achieve the same level of accuracy as when measuring 2D monitors. Relatively few studies have examined perceptual calibration in HMDs, what remains under-explored is how material shaders, lighting configurations and the choice of lit versus unlit rendering affect perceptual calibration, and whether 2-D results extrapolate robustly to genuine 3-D scenes. This project addresses the limitations of instrument-based calibration by developing a visual method for calibrating MR devices. Rather than claiming higher accuracy than instruments, our goal is to provide a complementary, user-centred pathway that is more stable and uniform across rendering modes and scenes. We introduce a repeatable perceptual matching method on HMDs that pairs rendered and no-rendering conditions to capture how users experience luminance. We also propose a perception-based colour-space conversion routine that links engine input signals to perceived luminance/colour via interpolation. These elements constitute a practical framework that complements instrument-only workflows by improving repeatability and harmonisation in MR colour characterisation.

An Effective Workflow for Colour Style Transfer, Nanlin Xu¹, Lihao Xu², Miaosen Zhou¹, Liangwei Chen¹, and Ming Ronnier Luo¹; ¹Zhejiang University and ²Hangzhou Dianzi University (China) 35

To perform colour rendition in digital images for different atmosphere styles is becoming important for effectively communicating visual information. While different camera brands often possess their unique feature styles, precisely reproducing and evaluating colour style effects across diverse camera systems remains significant challenge such as fast mapping and effective evaluation between the source and target styles.

To address this issue, a workflow of colour style transfer has been developed. To begin with, multi-device image database including many images was built, comprising 1550 sRGB images, for which each includes two colour charts for calibration, and proposed transfer method using a 3DLUT precisely transfers colour styles, achieving a remarkably low ΔE_{00} of 1.09 in colour charts tests. Subjective evaluation with 10 volunteers showed a perceptible small visual difference, indicating the effect of workflow achieved satisfactory performance.

To overcome the limitations of subjective testing, a Siamese network-based EfficientNet Visual Difference Evaluation Model (EVDm) was introduced, which utilized a lightweight EfficientNet, achieved Pearson correlation coefficients of 0.90 (training), 0.88 (validation), and 0.92 (overall), significantly outperforming sophisticated baseline methods based on CIEDE2000 methods (max 0.76). This demonstrates EVDm's superior fitting, generalization, and consistency with human perception.

An Adaptive Model for Predicting Visual Comfort of Displays Accounting for Luminance Contrast in Various Ambient Light Conditions, Zhenzhen Li and Ming Ronnier Luo, Zhejiang University (China) 41

The ubiquitous use of mobile devices has underscored the importance of evaluating display visual comfort to reduce eye strain and fatigue. This developed and tested visual comfort model for display visual comfort, taking into account key factors such as ambient illuminance, display luminance, text-background luminance contrast. The VC_{ALL} model was built based on three psychophysical experimental datasets: Neutral Colour Combination (NC), Coloured Combination (CC), and Neutral Colour Combination with Dim Ambient Light (NCD), which involved 103 participants spanning various age groups. Two new experiments were conducted to verify the model's performance. One is to use the model to access displays' visual comfort, using an LCD and a QD_mini-LED, comparing with the results from various other testing methods. The other experiment was conducted to verify the performance of VC_{reverse} by computing optimal text-background luminance combinations for any display under varying ambient light.

Three Dimensional Non-local Anisotropic Diffusion, Ali Alsam and Hans Jakob Rivertz, Norwegian University of Science and Technology (Norway) 46

We present a novel anisotropic diffusion algorithm for noise reduction in Magnetic Resonance Imaging (MRI). The method integrates two key concepts: (1) diffusion is explicitly constrained to avoid increases in local image gradients, thereby preserving edges and fine structural details; and (2) a sequence of filters with exponentially increasing radii is applied, each maintaining a fixed number of non-zero coefficients. These filters allow the algorithm to evaluate whether pixels distant from the target location can contribute to smoothing without degrading local gradients. As a result, the method aims to balance between preserving local details and averaging global similarities.

In contrast to traditional denoising techniques based on local filtering or total variation minimization, the proposed algorithm enables controlled non-local diffusion and naturally extends to three-dimensional

voxel arrays, making it well-suited for volumetric MRI data. The framework also permits the integration of additional geometric constraints, such as curvature, further enhancing its ability to preserve anatomical structures and surfaces.

The effectiveness of the proposed method is demonstrated on real MRI data from a macaque monkey. The experimental results indicate PSNR values comparable to those of our previous approach, while providing substantially better suppression of low-frequency noise, absence of visible artifacts, and faithful preservation of critical image features.

12:50 – 14:00 LUNCH ON OWN

ICC

Session Chair: Jinbi Jiang, University of Leeds (UK)

14:00 – 15:20

- 14:00 Transforming Cone Fundamentals to Color Matching Functions for Use by iccMAX-based Color Management, Max Derhak, Onyx Graphics Inc. (US) 52**

The use of the 1939 standard colorimetric observer for modern display calibration and color management has proven to be problematic in that it doesn't adequately predict the color matching of actual human observers. Recent research has resulted in the ability to identify physiologically based Cone Fundamental (CF) curves that more accurately predict individual color matching. However, the challenge still remains of adapting CF curves for the use of imagery and color specification based on the 2-degree 1931 standard observer. The use of iccMAX based color management requires well defined relationships between custom observers and the 2-degree 1931 standard observer to be provided.

In this paper, mathematical relationships and principles between cone fundamentals and color matching functions relative to viewing primary lights are outlined. Methods of conversion between cone fundamentals and color matching functions are explored and compared along with the proposed use of Wpt based material adjustment transforms to create color matching functions that provide backwards compatibility with legacy standard observer colorimetry.

- 14:20 Toward Perceptual Rendering of Media with Different Amounts of Optical Brightening Agents, Moritz J. Feil, Andreas Kraushaar, and Donatela Saric, Fogra Forschungsinstitut für Medientechnologien e. V. (Germany) 58**

The established media relative and ICC-absolute colorimetric intents have been demonstrated to result in unsatisfactory visual matches when comparing prints on substrates with strongly differing amounts of optical brightening agents (OBA). This paper aims to contribute twofold toward the solution of this problem. First, a step toward a colour transformation is taken, which enables the most satisfying reproduction of pictures, printed on substrates with low amounts of optical brightening agents, on substrates with large amounts of OBAs. This is done on the basis of previous findings, which indicate that such a transform should consist of an absolute transform for colours with low lightness and a perceptual transform for colours of medium to high lightness. It is therefore, proposed that a new term be adopted for this colour transformation: perceptolute. In this paper, the previous findings are extended experimentally by investigating the progression of the perceptual part of the transform, via a colour matching experiment for exemplary achromatic colours. Secondly, since the fluorescence of OBA containing substrates strongly depends on the present UV amount, a practical tool to evaluate the UV amount in a given indoor lighting situation will be described. It is called "UV-Checker".

- 14:40 Investigating Soft-proofing Performance using Individual Color Matching Functions, Yu-Kai Hong and Chris Yi-Ho Bai, BenQ Corp. (Taiwan) 64**

CCFL displays have long been favored in professional applications for their spectral stability and neutral grayscale rendering. In contrast, LED-backlit monitors dominate the current market for their higher efficiency and wider color gamuts. Despite identical calibration settings, spectral differences between the two technologies often lead to significant perceptual mismatches, posing challenges in color-critical workflows such as soft proofing.

To investigate individual differences in color perception, we conducted a large-scale psychophysical experiment involving 45 observers. Each observer used custom software to adjust seven color images (white, red, green, blue, cyan, magenta, and yellow) to visually match corresponding printed targets. White image adjustments were performed using RGB gain controls, while chromatic images were adjusted using HSL sliders.

From these adjustments, individual color matching functions were derived for each observer. ΔE_{2000} values were computed to assess spectral curve differences between individuals and across groups. K-means clustering was applied to classify observer patterns. Results showed that individual color matching functions consistently outperformed the CIE 2° Standard Observer in terms of perceptual accuracy, except for magenta and yellow. Interestingly, several K-means cluster-based color matching functions also delivered good performance representing individual color matching functions.

Spectral differences across groups were visible directly through color matching functions comparisons, validating the effectiveness of clustering and supporting the use of perceptual group modeling.

This study demonstrates that incorporating individual color matching functions can significantly improve cross-media color matching. Observer-specific models built on K-means categories offer a scalable, perceptually based approach to user-aware color management.

- 15:00 ICC Profile-driven Adaptive GCR for High-fidelity Facsimile Reproduction of Music Manuscripts, Marcin Dąbrowski, Warsaw University of Technology (Poland) 70**

The faithful reproduction of historical art and music manuscripts lies at the intersection of color science, printing technology, and artistic interpretation. In such projects, the printed facsimile must be visually indistinguishable from the original, both to the trained eye and to the casual observer. This paper presents a methodology for creating dedicated ICC profiles for high-fidelity facsimile printing, developed through over a decade of reproducing Fryderyk Chopin's manuscripts. The approach is based on adaptive Gray Component Replacement (GCR), selectively tuned to different tonal and chromatic regions to preserve fine details, control local contrast, and mitigate issues such as show-through caused by the transparency of original paper. By mapping GCR levels according to the specific visual characteristics of each work, the method allows for targeted control over critical features such as ink density, edge sharpness, and tonal transitions. The process also accounts for substrate variability, press condition, and metameric effects under different illuminants. Results demonstrate that adaptive GCR, combined with context-driven communication between technical and artistic stakeholders, enables reproductions that maintain the visual fidelity, texture, and emotional impact of the original works.

15:20 – 16:00 COFFEE BREAK / EXHIBITS OPEN



COLOR CONSTANCY

Session Chair: Andreas Kraushaar, Fagra Forschungsinstitut für Medientechnologien e. V. (Germany)

16:00 – 17:40

- 16:00 **Facial-centric Color Constancy Dataset to Improve Scenario-specific White Balance Algorithms**, Yuyang Liu and Minchen Wei, The Hong Kong Polytechnic University (Hong Kong) 75

Eliminating the color cast of the illuminant is a critical step in modern image processing systems, which has been addressed with a great number of illuminant estimation algorithms. The algorithms are found not effective for some specific contexts and applications, which leads to the development of scenarios-specific algorithms leveraging domain-specific cues. This paper investigated how facial cues help illuminant estimation. A total of 1299 images were captured under various dual-illuminant conditions, including real-world environments and lab settings. Modifications were made on existing methods by considering the facial information, which resulted in better performance.

- 16:20 **Integration of RGB Image and ALS for Color Constancy**, Ruikai He and Minchen Wei, The Hong Kong Polytechnic University (Hong Kong) 80

Illuminant estimation plays a key role in computational color constancy, which typically relies on RGB images alone. In recent years, smartphones are commonly equipped with an ambient light sensor (ALS) next to the rear camera, which records low-resolution spectral information. This paper proposes several methods to estimate the illuminant using both RGB images and ALS signals, which are based on the state-of-the-art learning-based methods without significantly increasing computational cost. The proposed methods are found to result in better performance, in comparison to those only rely on RGB images.

- 16:40 **Color Adjustment of Brand Logos for Dark Mode Display**, Byeongjin Kim, Giyun Lee, and HyeonJeong Suk, KAIST (Republic of Korea) 86

We investigated how to optimally adjust brand logo colors for dark mode displays without compromising their original color identity. Through analyzing manual color adjustments of logos placed on black backgrounds ($N=31$), we figured out that designers tend to light up the dark-colored logo, while pale down the colors of bright logo. A tendency similar to that of their adjustments converging in a specific direction was obtained, so we derived a surface model that represents the direction in which original colors tend to shift. This model incorporates the L^* , C^* , and h^* attributes to guide the computational adjustment process. This study offers a structured method for adapting logo colors to contemporary display contexts, effectively linking algorithmic solutions with design intuition.

- 17:00 **Learning-free Cross-sensor Color Constancy Using Optimal Nonsingular Matrices**, Liangwei Chen and Minchen Wei, The Hong Kong Polytechnic University (Hong Kong), and Ming Ronnier Luo, Zhejiang University (China) 90

Automatic white balance (AWB) plays a crucial role in digital imaging, with modern learning-based methods achieving better performance. These methods, however, require extensive training data captured by a specific sensor, which cannot be directly deployed other sensors due to the different spectral sensitivity functions. This paper presents a novel cross-sensor adaptation method based on 3×3 color transformation matrices. By leveraging least-squares optimization and a Mahalanobis distance strategy, our approach constructs sensor-specific mapping matrices using 24-patch ColorChecker data. The results derived using the NUS dataset demonstrate that the proposed method has much smaller angular errors without requiring additional data collection or complicated network tuning.

- 17:20 **Enhancing Local Automatic White Balance with Multi-spectral Imaging**, Johannes Keustermans, Robbe Van Beers, Jeroen Hermans, Alex Borgoo, and Michael Jacobs, Spectricity NV (Belgium) 95

Accurate white balancing (WB) remains a critical challenge in image signal processing. Particularly white point estimation for scenes with limited or ambiguous color information can lead to color casts and degraded visual quality. Moreover, many every-day scenes contain multiple relevant illuminants, further complicating illuminant estimation. Estimating multiple white points in a scene exacerbates the challenge and traditional RGB-based WB algorithms struggle with the limited information available for localized regions of a scene. We introduce a novel approach leveraging compact multi-spectral camera technology to improve local WB performance. By capturing additional, narrow-band spectral information beyond the RGB channels, our method provides more accurate white point estimation. We present comparative results demonstrating the advantages of multi-spectral sensing over conventional approaches, highlighting its potential to enable more intelligent and adaptive imaging pipelines in mobile, automotive, and industrial applications. Our approach is based on a relatively simple neural network, trained on simulated multi-spectral measurements. We developed a data collection protocol to establish a medium-sized validation dataset for which we report white point angles and color accuracy (DE2000) values. Our study includes a performance benchmark against a state-of-the-art deep learning-based algorithm for our new validation set and the publicly available Large Scale Multi-Illuminant (LSMI) dataset. From the results we observe that our network performs on par with the state-of-the-art algorithm on the LSMI dataset and outperforms the state-of-the-art algorithm on our validation dataset. Furthermore, the multi-spectral based network outperforms the RGB based network.

17:40 – 19:30 DINNER ON OWN

EVENING TALK

Session Chair: Paul Hubel, Apple Inc. (US)

19:30 – 20:30

- Light as Language: The Creative Use of HDR in Photography**, Reuben Wu, photographer and visual artist *

Photography has always existed in dialogue with technology, but progress in imaging often raises as many creative questions as it answers. As tools for capturing and reproducing light become more sophisticated, the artist's challenge is no longer simply to record reality, but to interpret it. High Dynamic Range (HDR) imaging introduces new expressive possibilities, expanding how light, color, and atmosphere can be experienced within a photograph.

This talk reflects on the evolving relationship between imagination and precision in contemporary photography. Through Wu's illuminated landscape work, he explores how emerging imaging capabilities can transform perception, deepen emotional impact, and redefine what visual fidelity means in an artistic context.

*No proceedings paper or extended abstract associated with talk.

THURSDAY 30 OCTOBER 2025

THURSDAY KEYNOTE

Session Chair: Ming Ronnier Luo, Zhejiang University (China)

9:00 – 10:00

TALK SPONSORED BY



Colorimetry and Image Reproduction of Fluorescent Objects,

Shaji Tominaga, Norwegian University of Science and Technology (NTNU), and Nagano University (Japan) *

Fluorescence improves the appearance of many object surfaces, which has led to fluorescent materials being commonly integrated into everyday objects today. While methods for measuring the color of non-fluorescent objects are established and colorimetric devices are widely available, fluorescent objects exhibit not only reflection, but also luminescence, so there are no easy methods or devices available to measure it. As such, reproducing fluorescent color images is difficult.

This talk presents a method for estimating the Donaldson matrix from image data of fluorescent objects captured with a spectral camera. This matrix can be described by three components: spectral reflectance, emission, and excitation. Also presented is a technique for appearance synthesis of fluorescent objects with a mutual illumination effect. This technique improves the spatial resolution of measurements using a spectral camera. Furthermore, it makes it possible to reproduce fluorescent colors under arbitrary lighting conditions and generate realistic images of fluorescent objects if their shape is known. Natural objects exist in addition to man-made ones that emit fluorescence. Finally, this talk shows a method for estimating fluorescence emission spectra from plant grain and leaves.

ILLUMINATION

Session Chair: Edward Yu-Kai Hong, BenQ Corp. (Taiwan)

10:00 – 10:40

10:00 An Adaptive Per-patch Weighted Regression for Target-based Color Correction of sRGB Images under Uncontrolled Outdoor Illumination,

Asel Esra Özyilmaz, Norwegian University of Science and Technology (Norway); Damien Muselet and Alain Tréneau, Jean Monnet University (France); and Mathis Cordier, Cindy Torres, Olivier Robert, Cyril Dambrine, and Ali Boudjedra, Vilmorin - Mikado / Limagrain Vegetable Seeds (France) . . . 101

Color-accurate digital imaging is critical for agricultural phenotyping, but the scientific literature predominantly assumes the availability of linear RAW sensor data. In some commercial workflows, only standard 8-bit sRGB JPEG images are available, which poses a significant challenge due to their non-linear encoding and information loss from in-camera processing. This paper presents a robust color correction pipeline designed specifically for such non-linear images captured in uncontrolled outdoor environments.

Our core contribution is a novel, per-patch adaptive weighting scheme for least-squares color correction. Instead of deriving a single global correction, our method generates a unique transformation for each patch on an in-frame ColorChecker. This is achieved through a leave-one-out approach where, for each target patch, a model is trained on the remaining 23 patches. Crucially, this training is guided by a

weighting matrix customized for the target patch. This adaptive process allows a simple linear model to outperform more complex polynomials. Through systematic evaluation on an unseen test set, we demonstrate this method reduces the mean color error ΔE_{00} from 11.23 to 3.79, providing a practical and effective solution for real-world agricultural imaging.

10:20 Improving the Color Accuracy of Lighting Estimation Models,

Zitian Zhang¹, Joshua Urban Davis², Jeanne Phuong Anh Vu², Jiangtao Kuang², and Jean-Francois Lalonde¹; ¹Université Laval (Canada) and ²Meta (US) 106

Advances in high dynamic range (HDR) lighting estimation from a single image have opened new possibilities for augmented reality (AR) applications. Predicting complex lighting environments from a single input image allows for the realistic rendering and compositing of virtual objects. In this work, we investigate the color robustness of such methods—an often overlooked yet critical factor for achieving visual realism. While most evaluations conflate color with other lighting attributes (e.g., intensity, direction), we isolate color as the primary variable of interest. Rather than introducing a new lighting estimation algorithm, we explore whether simple adaptation techniques can enhance the color accuracy of existing models. Using a novel HDR dataset featuring diverse lighting colors, we systematically evaluate several adaptation strategies. Our results show that preprocessing the input image with a pre-trained white balance network improves color robustness, outperforming other strategies across all tested scenarios. Notably, this approach requires no retraining of the lighting estimation model. We further validate the generality of this finding by applying the technique to three state-of-the-art lighting estimation methods from recent literature. Our project webpage is available at: <https://lvsn.github.io/coloraccuracy>.

10:40 – 11:20 COFFEE BREAK / EXHIBITS OPEN

COLOR VISION & NAMING

Session Chair: Begoña Acha, Universidad de Sevilla (Spain)

11:20 – 13:00

11:20 Validation Experiment for Individual Observer Color Matching Functions,

Jiaye Li^{1,2} and Kevin Smet¹; ¹KU Leuven University (Belgium) and ²Université de Lyon (France) 113

Color matching functions (CMFs) form the foundation of colorimetric calculations. Among color-normal observers, individual differences in visual perception lead to substantial variability in CMFs. While this variability was historically less critical due to the broad spectral characteristics of most stimuli, it has become increasingly important with the growing use of narrowband spectral sources in wide-gamut displays and lighting technologies. As a result, individual observer CMFs have become an important topic of study. Li et al. introduced modifications to Asano's Individual Colorimetric Observer Model (AICOM+), including the adoption of the 2012 CIE ocular media model and the removal of LMS normalization prior to CMF conversion. A rapid approach for estimating individual observer CMFs—a reduced model with fewer parameters—was also developed to avoid overfitting while maintaining high predictive accuracy. These individualized CMFs were previously validated using achromatic matches.

In the present study, the colorimetric accuracy of the individual observer CMFs derived from both the full AICOM+ model and its reduced version was validated, using a rating-based experimental method with the same setup. Nine observers, randomly selected from the original cohort, participated. Their individual CMFs were compared to the CIE 2015 10° CMFs using the rating data. The reduced AICOM+

*No proceedings paper or extended abstract associated with talk.



model yielded more accurate predictions than both the full model and the CIE 2015 10° CMFs for 7 out of 9 observers. Future work will apply recent improvements to individual observer models to evaluate potential further gains in predictive accuracy.

- 11:40 **Robert W. G. Hunt Best Paper Award A New Perspective on Color Vision Deficiency Diagnosis: Individual Color Matching Functions and Illuminations to Improve Color Discrimination,**
Siyuan Song, Hong Yang, and Ming Ronnier Luo, Zhejiang University (China) 119

In this study, a comprehensive test on 20 observers with color vision deficiencies was performed, including the standard Ishihara color vision test, the Farnsworth Panel D-15 test, and the anomaloscope test. In addition, a visual tricolorimeter to measure the individual color matching functions (ICMFs) of these observers was employed. The results showed that, except for the D-15 test, which exhibited some false negatives, the outcomes of the other three tests were completely consistent. This indicates the potential of ICMFs in diagnosing color vision deficiencies. Furthermore, the color discrimination abilities of these observers were tested under four specific light sources. The findings suggest that the vision for both Protan and Deutan observers can be significantly improved by one type of light source, especially for the Deutan observers.

- 12:00 **The Changes of Memory Colours Under Different Environmental Conditions,** *Yixuan Lou, Yuechen Zhu, and Ming Ronnier Luo, Zhejiang University (China)* 125

This study investigates the sky and grass memory colours. Experiment was conducted to perform preferred and naturalness judgements by 21 subjects on images having sky and grass contents according to different environmental conditions. Thirty-three scene images were selected from 7 world wide websites. Thirty-one images were generated surrounding the original image. Each image was assessed in terms of naturalness and preference using the force choice method. The results were used to construct model to obtain memory colour centers, to compare the results between preferred and natural perceptions, and to model colour changes over environmental conditions. A model was developed to predict sky memory colour according to the cloud information in each image.

- 12:20 **The Colonisation of Colour Categories: How European Colour Concepts Have Invaded Polynesian Languages,** *Neil Dodgson, Victoria Chen, Tia Neha, and Meimuna Zahido, Victoria University of Wellington (New Zealand)* 130

Berlin and Kay propose that there are basic colour terms in any language. These terms split the range of all colours into categories and different languages may have different categories. A meeting of cultures can lead to changes in how a language categorises colour. Across Polynesia, today, we see educational material that purports to teach colour in the indigenous languages, but that categorises colour into the Western European categories, using loan words or repurposed indigenous words to describe colour categories that did not exist in that language prior to colonisation. We describe an ongoing project that tracks changes in language use in Polynesian languages, both before and after colonisation. We present our initial findings.

- 12:40 **Ghibilification and Color Richness in Material Appearance: How Human Observers and Image Quality Metrics Perceive Them?,**
Mabina Mobini, Olga Cherepkova, and Davit Gigilashvili, NTNU (Norway) 136

Distortions introduced during the reproduction of digital images can lead to substantial changes in their color composition. The motivations for altering images range from practical purposes, such as image com-

pression and color quantization to reduce file size, to more aesthetic applications like style transfer using generative AI. In this work, we investigate how the reproduction of color images affects material appearance, in particular, the perception of gloss and translucency. We applied different image quality distortions to natural images of glossy and translucent objects. Additionally, we Ghibilified them—a recent viral social media phenomenon of mimicking the Japanese anime style using generative AI style transfer. Afterward, we conducted a series of user studies to evaluate the fidelity of gloss and translucency reproduction. The experimental results represent how the reproductions are perceived by image quality metrics and open up a new direction for material appearance studies.

13:00 – 14:15 LUNCH ON OWN

DISPLAYS

Session Chair: Norimichi Tsumura, Chiba University (Japan)

14:15 – 15:15

- 14:15 **Spectral Definition of Standard Color Space Primaries for Display,** *Yuteng Zhu, Yanjun Li, Po-Chieh Hung, Adria Fores Herranz, Tyler Pruitt, Yanming Li, Francisco Imai, Will Wu, and Shahram Peyvandi, Apple Inc. (US)* 142

To calibrate a display, a standard color gamut is defined by the target chromaticity coordinates of RGB primaries in CIE 1931 color space, e.g. DCI-P3 and Rec.709. Due to lack of spectral information of such standard target gamut primaries, transformation of target color gamut from CIE 1931 color space to another color space associated with a different observer (defined by a different set of CMFs) is not possible. In this paper, we introduce a novel method for transforming target primary colors from CIE 1931 color space into a new target color space with improved color appearance consistency for typical observers. Our approach represents each primary with a simple spectral definition across the visible range. Results demonstrate that this spectral definition significantly reduces inter-observer variation, thereby offering a practical solution to cross-observer display color space transformation.

- 14:35 **Optimizing Mobile Display Perception in Dim-light Environments: Observer-driven Adjustments of Backlight Luminance and Image Lightness and Chroma,** *Xinye Shi, Ming Ronnier Luo, and Yuechen Zhu, Zhejiang University (China)* 147

Adjustment of the backlight luminance of mobile phones in dim lighting has been challenging due to the setting of low lighting levels. The present experiment is aimed to reveal the suitable brightness for viewing images under six low light conditions (0, 0.5, 1, 2, 3, 4, 5, 10, 25, 50 lux).

Twenty participants adapted to each light level in ascending order. For each level, they adjusted: 1) backlight luminance for comfortable viewing on a white background image with black text, and 2) the lightness and chroma of a test image for optimal appearance on color images. The results reveal distinct trends. Firstly, preferred backlight luminance increases non-linearly with rising ambient illuminance. Secondly preferred image lightness and chroma gains both exhibit a small but consistent increase with rising ambient illuminance. Finally, the magnitude of these preferred gains for both lightness and chroma showed a negative correlation with the average lightness and chroma of the original images. These findings offer new insights into how observers adapt displays under near-dark to low-light (mesopic) conditions and provide practical guidance for refining display adaptation algorithms.

- 14:55 **Does D65 Illuminant or D65 Chromaticities Produce Neutral White Appearance?**, Yuetong Shen and Minchen Wei, *The Hong Kong Polytechnic University (Hong Kong)* **153**
- D65 plays a critical role in color reproduction, specification, and characterization. Displays commonly use D65 chromaticities as the white point, but many studies shown that a stimulus produced by displays having a slightly higher CCT was perceived to produce neutral white appearance. Moreover, our two recent studies found that LCD/OLED displays need to produce a stimulus having a slightly higher CCT to match the appearance of a high quality D65 illuminant that was produced by a 14 channel spectrally tunable LED device. We hypothesize that a higher CCT required by displays to produce a neutral white appearance was caused by the CIE 1931 Color Matching Functions and a D65 illuminant can indeed produce a neutral white appearance. In this study, we use the 14 channel LED device to produce a series of high quality daylight simulators. The observers generally selected the stimulus having a CCT between 6346 and 6906 K to produce the neutral white appearance. When using an LCD display to match the color appearance of the selected stimulus, the average CCT was between 7209 and 7943 K. Such a finding suggests the importance of color matching functions in display specification and calibration.

TWO-MINUTE INTERACTIVE PAPER PREVIEWS II

Session Chairs: Yuecheng Zhu, Zhejiang University, and Yuteng Zhu, Apple (China)

15:15 – 15:30

A Pilot Study Investigating How Individuals with Varying Sensory Characteristics Perform in Virtual Reality Environments,

Mina Shamohammadi, Chihiro Hiramatsu, Kana Miyazato, Hiroyuki Matsuguma, Naoto Nakamura, and Naoko Takahashi, *Kyushu University (Japan)*. **156**

Diversity in visual perception, particularly due to age and color vision types, has been widely studied in fields such as cognitive psychology and human-computer interaction. Variations in color perception, such as those arising from dichromatic or trichromatic vision, can significantly influence object-finding tasks and overall performance in virtual environments. Recent studies suggest that while Virtual Reality (VR) environments can be designed with universal accessibility, understanding how individuals process visual cues in these environments remains underexplored.

This study investigates how individuals with diverse visual perception perform object-finding tasks in a VR environment. As part of a pilot study, participants completed tasks in two types of VR environments: one rendered in full color and the other in grayscale. The aim was to explore how different visual settings might support future research involving a more diverse participant group. While preliminary results indicated better performance in the color environment across participants, the primary focus was to assess the suitability of the experimental design and environment setup for investigating sensory interactions in VR.

By understanding how visual differences affect performance, designers can create more inclusive virtual spaces for uses like education, gaming, and training. This interdisciplinary approach, combining elements of psychology, sensory studies, and technology design, suggests a more inclusive framework for addressing diversity in VR environments. By systematically analyzing visual perception, the study not only advances academic understanding but also provides a practical roadmap for implementing inclusive VR solutions across industries.

A Pigment-based Spectral Imaging Sensor Approach for AWB: Outperforming Flagship Smartphones in Challenging Scenes,

Zhilei Huang¹, Jiawei Yang², Hong Zhang¹, and Xinle Guo¹; ¹Beijing Seetrum Technology Co. and ²Tsinghua University (China) **A-8**

We propose a camera-independent illuminant estimation algorithm for Auto White Balance (AWB) base on pigment-based spectral imaging sensors, achieving over 30% accuracy improvement compared to flagship smartphone solutions, especially in traditional challenging scenes such as single-color dominated scenes and non-white-dominant scenes. We use quantitative metrics including error angle $\Delta\theta$ and color difference ΔE_{00} for AWB evaluation, demonstrating superior performance across 382 real scenes with an average error angle of 3.26° and an average ΔE_{00} of 3.77. The results show great application potential of spectral imaging sensors for AWB in consumer electronic imaging devices such as smartphones.

Modeling the Relationship between Haze and Attenuation Coefficient from Image-based Measurements of Translucent Liquids,

Lu Xu¹, Davit Gigilashvili¹, and Jean-Baptiste Thomas^{1,2}; ¹Norwegian University of Science and Technology (Norway) and ²Université Bourgogne Europe (France). **161**

This study focuses on exploring the relationship between haze and the intrinsic optical properties of translucent materials through image-based measurements conducted in a real-world setting. The research adopts water-based samples mixed with milk and black tea, enabling the investigation of materials with varying absorption and scattering properties. We quantify haze using an image-based measurement system and estimate lateral attenuation coefficient with a translucency meter device. A linear regression model was established, relating haze to the logarithm of the product of sample thickness and the effective lateral attenuation coefficient. This finding contributes to advancing the understanding the appearance of translucent materials and has potential industrial applications.

Smartphone Color Quantification from a Clinical Perspective: Accuracy and Precision, Yifan Zhang and Terence S Leung,

University College London (UK) **167**

Smartphones, with their built-in cameras, are increasingly employed in clinical applications, e.g., screening patients for jaundice or anemia. In these applications, the color values of the target are converted into a biomarker using a regression or AI model. This paper investigated the accuracy and precision of x and y chromaticity values influenced by image noise and environmental factors, which could affect diagnostic performance. Accuracy was represented by the mean xy error distance (MED), and precision by the standard deviation (SD) of the xy chromaticity measurements. Using a Samsung S22 smartphone to take photos of the same color patch in 9 positions over 20° , we found that even for the same target, taking a photo from different angles caused the xy chromaticity values to change. However, the accuracy could be maintained by averaging these color measurements. The xy chromaticity measurements could also be affected by a neighboring color object and its impact on accuracy depended on the colors of the neighboring object and the target. We also investigated the scenarios with 3D graphics software Blender and found similar trends. Understanding factors influencing the accuracy and precision of color quantification can lead to improvements of smartphone imaging-based diagnostic techniques.



JIST-First The Lower the Bumps, the Higher the Translucency:

How Editing Perceived Bumpiness Affects Material Appearance,

Seyedeh Kimia Arfaie Oghani, Davit Gigilashvili, and Mobina Mobini, Norwegian University of Science and Technology (Norway), and Midori Tanaka and Takahiko Horiuchi, Chiba University (Japan) . . . **237**
DOI: 10.2352/J.ImagingSci.Technol.2025.69.5.050401

A recent work proposed a methodology to effectively enhance or suppress perceived bumpiness in digital images. We hypothesized that this manipulation may affect perceived translucency due to similarity in affected image cues. In this work, we test this hypothesis experimentally. We conducted psychophysical experiments and found a correlation between perceived bumpiness and perceived translucency in processed images. This not only may have implications when digitally editing the bumpiness of a given material but also can be taken advantage of as a translucency editing tool unless the method produces artifacts. To check this, we evaluated the naturalness and quality of the processed images using subjective user study and objective image quality metrics, respectively.

3D CG HEVC Images Attention Mechanism Based on Vision

Transformer, Norifumi Kawabata, Kanazawa University (Japan) . . . **173**

When creating media content, it is important to understand in advance where people focus their attention and what they are interested in when viewing images. Thus far, we have measured the area using saliency maps to determine the relationship between picture coding and gaze points. However, as an evaluation metric, it is not enough to consider factors other than area, and the accuracy was not enough. Therefore, we thought that we could achieve higher accuracy in estimating areas of interest by using the knowledge of Vision Transformer, which was developed in the field of computer vision based on natural language processing. In this study, we experimentally examined the evaluation of regions of interest in images by performing region of interest estimation using the attention mechanism of Vision Transformer on HEVC encoded 3D CG images and then analyzing the images.

HDR Printing, How to Produce and Display Extreme Contrast Levels,

Reiner Fageth, CEWE Stiftung & Co. KGaA, and Dietmar Wueller, Image Engineering GmbH & Co. KG (Germany) . . . **A-10**

The maximum density that can be achieved with today's printing technologies on reflective material is about 2.4. This results in a contrast range of 250:1. Applying a specialized coating increases the maximum density to around 3, but does not improve the ability to differentiate detail between densities 2.4 and 3.

To achieve larger dynamic ranges, backlit transparencies are essential. However, even with these, the dynamic range of available materials is limited to a maximum density of approximately 3, which equals a displayable contrast range of up to 1000:1 and is classified as SDR.

Higher contrast levels require multi-layer technology in conjunction with a bright, uniform light box. It is necessary to determine how to generate the required tone curve and manage colors to achieve the desired result. ICC color management is referenced to diffuse white and is therefore not defined for real HDR applications. Another challenge is registering multiple layers with each other, especially when they are applied to both sides of the same substrate.

INTERACTIVE PAPER SESSION / EXHIBITS OPEN

15:30 – 17:00

Discuss the Interactive (poster) Papers with their authors and help select the CIC33 Cactus Award winner. Exhibits are also open during this time.

HONG KONG HARBOUR CRUISE AND BUFFET DINNER

19:00 – 22:00

Join colleagues for dinner and a lovely cruise of Hong Kong Harbour.

FRIDAY 31 OCTOBER 2025

CLOSING KEYNOTE AND CIC AWARDS

Session Chair: Paul Hubel, Apple Inc. (US)

9:00 – 10:00

TALK SPONSORED BY

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Skin Color in Culture and Technology, Hyeon-Jeong Suk, Korea

Advanced Institute of Science and Technology (KAIST) (Republic of Korea)*

Human skin color lies along a narrow pathway from dark brown to light beige within the wide gamut of human vision. Despite this limited range, even subtle variations carry disproportionate weight—affecting perceptions of beauty, social class, and identity. These interpretations are not fixed; they evolve across cultures and historical periods.

In Asia, lighter skin was historically associated with status and attractiveness, while today's trends emphasize authenticity and diversity. Reflecting this shift, cosmetic brands now release anywhere from 15 to more than 200 foundation shades, enabling individuals to express identity as well as appearance. Makeup thus becomes not only a cosmetic tool but also a means of self-definition.

Recent advances in color science and digital technology are accelerating this transformation. Imaging systems, AI-driven analysis, and smartphone applications can measure and recommend skin tones beyond the limits of the eye. Digital-first brands are leading the way with personalized services. Yet an essential question remains: Should skin color be captured with maximal precision, or tuned to reflect self-perception and context?

From the mirror to social media, from stage presence to XR avatars, each version of the "self" reveals a different shade—bridging science, culture, and technology.

SAMPLING

Session Chair: Farnaz Agahian, Samsung Display America Lab (US)

10:00 – 10:40

10:00 ΔE -uniformity-tuned Color Sets, Jan Morovic, HP Inc. (UK), and Peter Morovic, HP Inc. (Spain) . . . **179**

Color charts are used in many color imaging contexts to sample a color space or the effects of a color transformation. A rich variety of approaches exist here for determining the set of colors contained in a color chart and the specific choices of colors and their cardinality both then impact the goodness of the color imaging processes that use them. A key example here are the color charts used for building ICC color profiles. Such charts are often variations on uniform samplings in either an RGB or a CMYK device color space. At the same time, the accuracy of an ICC profile is judged in terms of color difference (ΔE s), and a chart that is uniformly distributed in those terms would be advantageous. This paper presents an approach to explicitly tuning color charts for uniformity in arbitrary color spaces and for arbitrary color difference metrics, using computational optimization over a hexagonally close packed mesh. Results show a substantial improvement in the uniformity of ΔE differences between each chart color and its neighbors.

*No proceedings paper or extended abstract associated with talk.

10:20 An Empirical Evaluation of Down- and Up-sampling in Jacobi Retinex, Afsaneh Karami and Graham Finlayson, University of East Anglia (UK) 184

The McCann99 Retinex is a particular algorithmic implementation of Retinex theory. Retinex algorithms attempt to compress the dynamic range of an input image to make an output which can be displayed and has a pleasing rendition. The McCann99 Retinex algorithm employs a multi-grid structure, processing the image in a pyramidal manner from coarse to fine resolutions. This hierarchical approach is designed to enhance computational efficiency and accelerate convergence. In recent work, the structure of the McCann99 Retinex has—by appealing to classical work in numerical analysis—been modified to be a per pyramid level Jacobi iteration and as such is not only faster, but aligns Retinex with other theories of early visual processing (including centre-surround operators and path-based theories).

In this paper, we conduct a complementary systematic investigation into how images are down- and up-sampled as part of the multi-grid computation. The McCann99 and Jacobi Retinex algorithms use a simple box-filter approach, which means that down-sampled image data must be aliased. We investigate a set of other commonly used sampling methods, including bilinear, bicubic, Lanczos2 and 3, sinc with rectangular, Hamming and Kaiser windows. We are interested in using image quality metrics to determine whether substituting a different sampling approach into the Jacobi Retinex leads to better quality outputs being generated. Our investigation leads us to an interesting conclusion: while more complex down- and up-sampling algorithms can improve image quality, the simple box method performs well. If image quality is the primary concern, sinc is found to be the best method for down- and up-sampling. However, it requires an appropriate window function to taper the truncation and avoid ringing artefacts.

10:40 – 11:20 COFFEE BREAK

GENERATIVE AI

Session Chair: Zhilei Huang, Beijing Seetrum Technology Co., Ltd. (China)

11:20 – 12:40

11:20 LLMs Speak LAB, Ján Morovic, HP Inc. (UK), and Peter Morovic, HP Inc. (Spain) 191

Large Language Models (LLMs) are advanced neural networks designed to interpret and generate human-like text thanks to their structure and to having been trained on vast amounts of data. They can perform a wide range of natural language processing tasks, including text generation, translation, summarization, and question-answering, and are the engines of conversational AI platforms like ChatGPT, Gemini or Claude. A key feature of such LLMs is their inference of a subsequent piece of text from preceding pieces of text. As such, their computational structure lends itself to making other, similar sequential inferences. While the acquisition of color measurements may at first seem far removed from the domain of LLMs, it too can be thought of as a sequential process, consisting of the measurement of a sequence of stimuli, and therefore open to sequential inference. The present paper introduces an adaptation of LLMs to color data, and more broadly to sensor data, and their application to generating measurements from a preceding sequence, based on pre-training transformers with sensor data sequences. Promising first results are shared that point to low color differences when models are prompted with similar magnitude data to those being constructed using generative AI (GenAI).

11:40 Color Encoding in Latent Space of Stable Diffusion Models, Guillem Arias, Ariadna Solà, Martí Armengod, and Maria Vanrell, Universitat Autònoma de Barcelona (Spain) 197

Recent advances in diffusion-based generative models have achieved remarkable visual fidelity, yet a detailed understanding of how specific perceptual attributes—such as color and shape—are internally represented remains limited. This work explores how color is encoded in a generative model through a systematic analysis of the latent representations in Stable Diffusion. Through controlled synthetic datasets, principal component analysis (PCA) and similarity metrics, we reveal that color information is encoded along circular, opponent axes predominantly captured in latent channels $\rightarrow c_3$ and $\rightarrow c_4$, whereas intensity and shape are primarily represented in channels $\rightarrow c_1$ and $\rightarrow c_2$. Our findings indicate that the latent space of Stable Diffusion exhibits an interpretable structure aligned with a efficient coding representation. These insights provide a foundation for future work in model understanding, editing applications, and the design of more disentangled generative frameworks.

12:00 JIST-First Automatic Image Colorization with Semantic Segmentation and Multipath Deep Networks, Jie-Sen Wang¹, Hung-Chung Li², and Pei-Li Sun¹; ¹National Taiwan University of Science and Technology and ²National Chung Hsing University (Taiwan) 247

DOI: 10.2352/J.ImagingSci.Technol.2025.69.5.050402

A fully automated colorization model that integrates image segmentation features to enhance both the accuracy and diversity of colorization is proposed. In the model, a multipath architecture is employed, with each path designed to address a specific objective in processing grayscale input images. The context path utilizes a pretrained ResNet50 model to identify object classes while the spatial path determines the locations of these objects. ResNet50 is a 50-layer deep convolutional neural network (CNN) that uses skip connections to address the challenges of training deep models. It is widely applied in image classification and feature extraction. The outputs from both paths are subsequently fused and fed into the colorization network to ensure precise representation of image structures and to prevent color spillover across object boundaries. The colorization network is designed to handle high-resolution inputs, enabling accurate colorization of small objects and enhancing overall color diversity. The proposed model demonstrates robust performance even when training with small datasets. Comparative evaluations with CNN-based and diffusion-based classification approaches show that the proposed model significantly improves colorization quality.

12:20 Language-based Color ISP Tuning, Owen Mayer¹, Shohei Noguchi², Alexander Berestov¹, and Jiro Takatori²; ¹Sony Corporation of America (US) and ²Sony Corporation (Japan) 203

We propose a method for tuning the parameters of a color adjustment Image Signal Processor (ISP) algorithmic "block" using language prompts. This enables the user to impart a particular visual style to the ISP-processed image simply by describing it through a text prompt. To do this, we first implement the ISP block in a differentiable manner. Then, we define an objective function using an off-the-shelf, pretrained vision-language-model (VLM) such that the objective is minimized when the ISP-processed-image is most visually similar to the input language prompt. Finally, we optimize the ISP parameters using gradient descent. Experimental results demonstrate tuning of ISP parameters with different language prompts, and compare the performance of different pretrained VLMs and optimization strategies.

12:40 – 14:00 LUNCH ON OWN



HDR

Session Chair: Eric Walowitz, consultant (US)

14:00 – 15:20

- 14:00 **HDR Image Reconstruction from Saturated LDR Images of Dielectric Objects**, Shoji Tominaga, Norwegian University of Science and Technology (Norway) and Nagano University (Japan), and Takahiko Horiuchi, Chiba University (Japan) . . . **209**

This paper presents a method for reconstructing the original high dynamic range (HDR) image from a saturated low dynamic range (LDR) image with missing physical information, specifically for single dielectric objects. A deep neural network approach is employed to map an 8-bit LDR image directly to its corresponding HDR representation. We begin by analyzing the reflection and saturation characteristics of dielectric materials and then construct an HDR image database using a diverse set of dielectric objects. Each HDR image is clipped to generate a set of 8-bit LDR images. All HDR-LDR image pairs are normalized to a fixed resolution and used for training and validation. A deep convolutional neural network (CNN) is designed in the form of an autoencoder architecture with skip connections. The entire network is implemented using MATLAB's machine learning toolbox, with the ADAM optimizer employed for training. The performance of the proposed method is evaluated using a separate validation set. Comparative experiments with existing methods demonstrate that our approach achieves significantly higher reconstruction accuracy and better histogram fitting.

- 14:20 **HDR Image Visual Matching and Tone Mapping based on CAM16-UCS**, Miaosen Zhou and Ming Ronnier Luo, Zhejiang University (China) . . . **215**

A controlled experimental setup used multichannel LED lighting to create HDR scenes. Ten observers performed visual matching tasks between real illuminated scenes and HDR display content across eight lighting conditions. $J_z a_z b_z$, CIECAM16, and CAM16-UCS were evaluated, analysis using STRESS metrics showed CAM16-UCS achieved the best performance for both lightness and colorfulness predictions. Based on these findings, a tone mapping operator was developed utilizing CAM16-UCS color space with local adaptation and gamma adjustments derived from experimental data. The results demonstrate that CAM16-UCS provides superior color appearance prediction for HDR content and serves as an effective foundation for tone mapping applications.

- 14:40 **Very Simple Tone Curves**, James Bennett and Graham Finlayson, University of East Anglia (UK) . . . **221**

Tone mapping algorithms are used to compress dynamic range, make image details more conspicuous and generally enhance the image for preference. Global tone mapping manipulates the brightnesses of pixels by applying a single function - or tone curve - to every pixel in the image. Tone curve generation algorithms often constrain the shape of their tone curves and it has been argued that tone curves should be simple, meaning they have one or zero inflexion points. In this work, we investigate whether tone curves should be simplified even further. We present our method which finds the zero inflexion tone curve - which we call a Very Simple (VS) curve - that best approximates a potentially complex tone curve. For the MIT-Adobe FiveK dataset, comprising 25,000 expert tone adjustments, we calculate the best VS approximations and find these curves produce visually similar images compared with more complex counterparts.

- 15:00 **High Dynamic Range – The Last Frontier of Digital Imaging**,

Guoping Qiu, The University of Nottingham (UK and China) *

Despite decades of research and significant investment, digital imaging technology still struggles in certain real-world scenarios—such as capturing a photo at an evening gathering in a dimly lit restaurant—where either shadows appear completely dark or bright areas become oversaturated, losing vital details. Even with modern HDR (High Dynamic Range) features now standard in smartphones, these issues often persist. And yet, the human eye can perceive detail across both shadowed and brightly lit areas in such scenes with ease.

This talk explores the fundamental reason behind this discrepancy: the inherent limitations of digital sensors in handling high dynamic range light intensities. Professor Qiu will revisit the HDR problem from first principles, arguing that it remains one of the most critical—and often misunderstood—challenges in digital imaging. He will critique common misconceptions in recent literature, particularly those relying on deep learning-based “black-box” approaches to low-light enhancement. Through theoretical insights and practical demonstrations, the talk will make the case that HDR remains the last great frontier in the evolution of digital photograph.

15:20 – 16:00 COFFEE BREAK

MATERIAL APPEARANCE

Session Chair: Davit Gigilashvili, NTNU (Norway)

16:00 – 17:00

- 16:00 **Color Co-occurrence Matrix based on Color Appearance Model CIECAM16. Application to Dermatological Images**, Begoña Acha and Carmen Serrano, Universidad de Sevilla (Spain) . . . **227**

New color texture features have been designed based on second-order statistics features that are calculated from a new color co-occurrence matrix (CCM). These CCM features have three main novel design aspects. First, they incorporate perceptual color differences in their computation. Second, the second-order probability distributions are based on the CIECAM16 color appearance model and its derived Uniform Color Space (CIECAM16-UCS). Third, to avoid high-dimensional and sparse cooccurrence matrices, low-dimensional CCMs are calculated using perceptual clustering for color quantization. The ability of these new CCM metrics to analyze colored textures has been validated in two experiments using biomedical color texture images: Basal Cell Carcinoma (BCC) dermoscopic pattern detection and hemangioma depth estimation from color photographs. Both experiments demonstrated that the proposed CCM features outperformed other texture analysis methods.

- 16:20 **How Color Influences Gloss and Gloss Influences Sparkle and Graininess in Metallic Coatings**, Eric Kirchner, Zhejiang University (China) . . . **232**

Three main aspects of the appearance of metallic coatings are color, gloss and texture (including graininess and sparkle). All three aspects can now be objectively measured using instruments according to ASTM and other international standards. However, there is no reason why these three aspects would be independent from each other. Indeed, it is known for more than a century that variations in color influence the perception of gloss. Here, we present the first systematic investigation

*No proceedings paper or extended abstract associated with talk.

We created a new, dedicated set of 462 solid and metallic paint samples, with systematic variations in color and gloss. We measured multi-angle reflectance properties for all samples. Our results confirm that color strongly influences measured gloss values, especially for metallic coatings. We also show that there is a substantial influence from glossiness to the measured graininess and sparkle properties. For example, by applying a matte clearcoat instead of a more common high-gloss clearcoat on top of a metallic basecoat, the measured graininess reduces by 0.6 ± 0.3 units and the sparkle grade at 15° by 3.3 ± 1.7 units. This is in line with visual assessments on matte car paints: matte metallic paints hardly show sparkle. A physical explanation for these trends is presented.

One central challenge in modeling material appearance perception is the creation of an explainable and navigable representation space. In this study, we address this by training a StyleGAN2-ADA deep

generative model on a large-scale, physically based rendered dataset containing translucent and glossy objects with varying intrinsic optical parameters. The resulting latent vectors are analyzed through dimensionality reduction, and their perceptual validity is assessed via psychophysical experiments. Furthermore, we evaluate the generalization capabilities of StyleGAN2-ADA on unseen materials. We also explore inverse mapping techniques from latent vectors reduced by principal component analysis back to original optical parameters, highlighting both the potential and the limitations of generative models for explicit, parameter-based image synthesis. A comprehensive analysis provides significant insights into the latent structure of gloss and translucency perception and advances the practical application of generative models for controlled material appearance generation.

Minchen (Tommy) Wei, The Hong Kong Polytechnic University (Hong Kong) and
Ming Ronnier Luo, Zhejiang University (China)

The conference concludes with closing remarks from the chairs and the presentation of the Best Student Paper Award.

This image shows a full page of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page, providing a template for handwriting practice. There are no margins, text, or other markings on the page.

