

Current CIE TC8-18 work on HDR

Technical committee chair: Mekides Assefa Abebe

CIE TC 8 -18



26 TCMs

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8 countries
Experts from
Industry and
academia**



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**Working closely with other
related CIE TCs**

Introduction

- **Title**
 - CIE TC 8-18: Guidelines for Definition and Evaluation of High Dynamic Range Images and Image Sequences
- **Terms of Reference**
 - To propose a definition of High Dynamic Range (HDR) images and image sequences (Images, hereafter), including luminance level, contrast, and spatial/temporal distribution. To define luminance levels, observing environment, adopted white point, the kinds of Images to be used in research experiments and their assessment. To recommend methods of calculating key characteristics of the HDR Images.

Introduction

Scope

- Identification of Key Terminology: Defining essential terms related to HDR imaging and image sequences.
- Characterization of HDR Content: Explaining the primary attributes and characteristics of HDR images and sequences.
- Measurement Guidelines: Providing a framework for conducting both physical and perceptual measurements to assess the main characteristics of HDR images and sequences.

Working towards a general definition and guidelines to help clarify common confusion and misconceptions in the field.

Introduction

Technical Report

- Terms and definition
- CIE HDR imaging framework
- Color in HDR
- Perceptual and physical measurement guideline

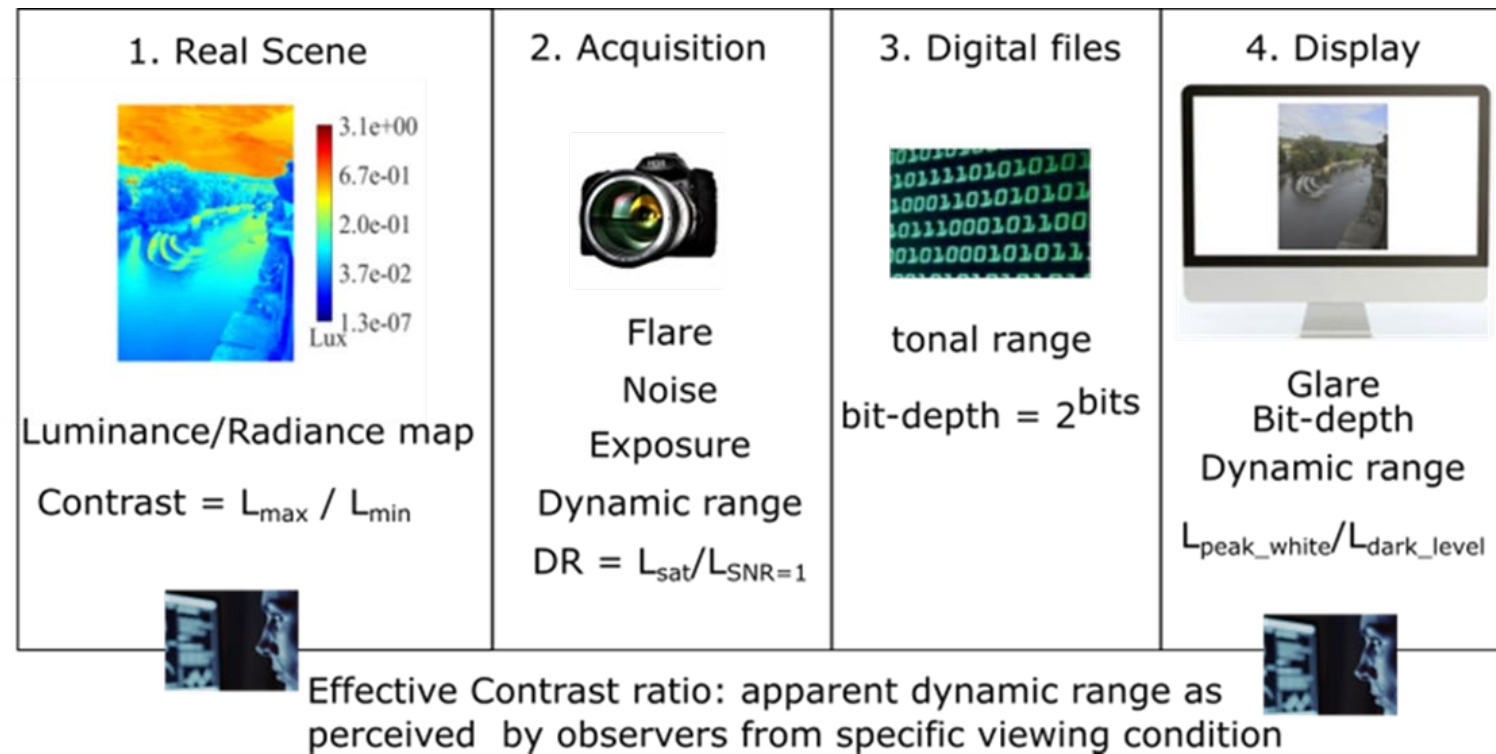
Terms and Definition

Measurement / Acquisition	Perception	Archiving / Storage	Reproduction	Rendering
• Dynamic range • Tonal range • Peak luminance • Black level • Contrast • Camera response function • OETF • OOTF • Flare • Glare • Haze • Halos • Reflective • Emissive • Transmissive	• Dynamic range • Contrast sensitivity • Glare • Bleaching • Adaptation • Flare • Glare • Haze • Apparent dynamic range • JND	• Bit depth • Quantization • Metadata • Dynamic range	• Perceptual connection space • Reference white • Graphics white • Diffuse white • Adapted white • adopted white • Specularity • Glossiness • Surface color • Light source color • Dynamic range	• Dynamic range • Peak luminance • Black level • Contrast • Bit depth • EOTF • OOTF • Apparent dynamic range

- Identify terms related to key characteristics of HDR contents
- An extensive survey of standard and literature definitions of ambiguous terms was conducted, followed by in-depth discussions.
- The TC's recommended definitions with respect to HDR contents and different intended applications are included.

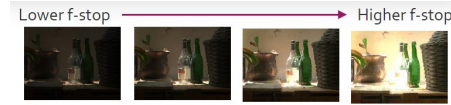
CIE HDR imaging framework

- Survey on HDR history
- Defining dynamic range and HDR characteristics following the proposed HDR imaging framework.
- HDR image formats
- HDR standards
- Color in HDR

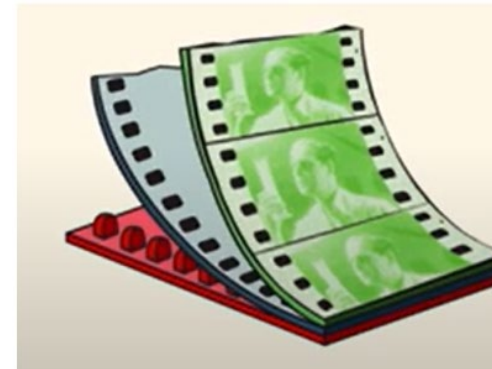


Background on HDR

- Ansel Adams' Zone System – artistic control of light and shadow through exposure & development
- Technicolor's Three-Strip Process – early cinematic attempt to expand color and dynamic range
- Digital Era – exposure fusion and HDR imaging reshape photography & video
- Today's Technologies and standards – from CRT to QOLED, 8-bit to 16-bit float, BT.709 to BT.2100



Teton and the Snake River, Original Photograph by Ansel Adams



Defining HDR and Main Characteristics

Dynamic Range

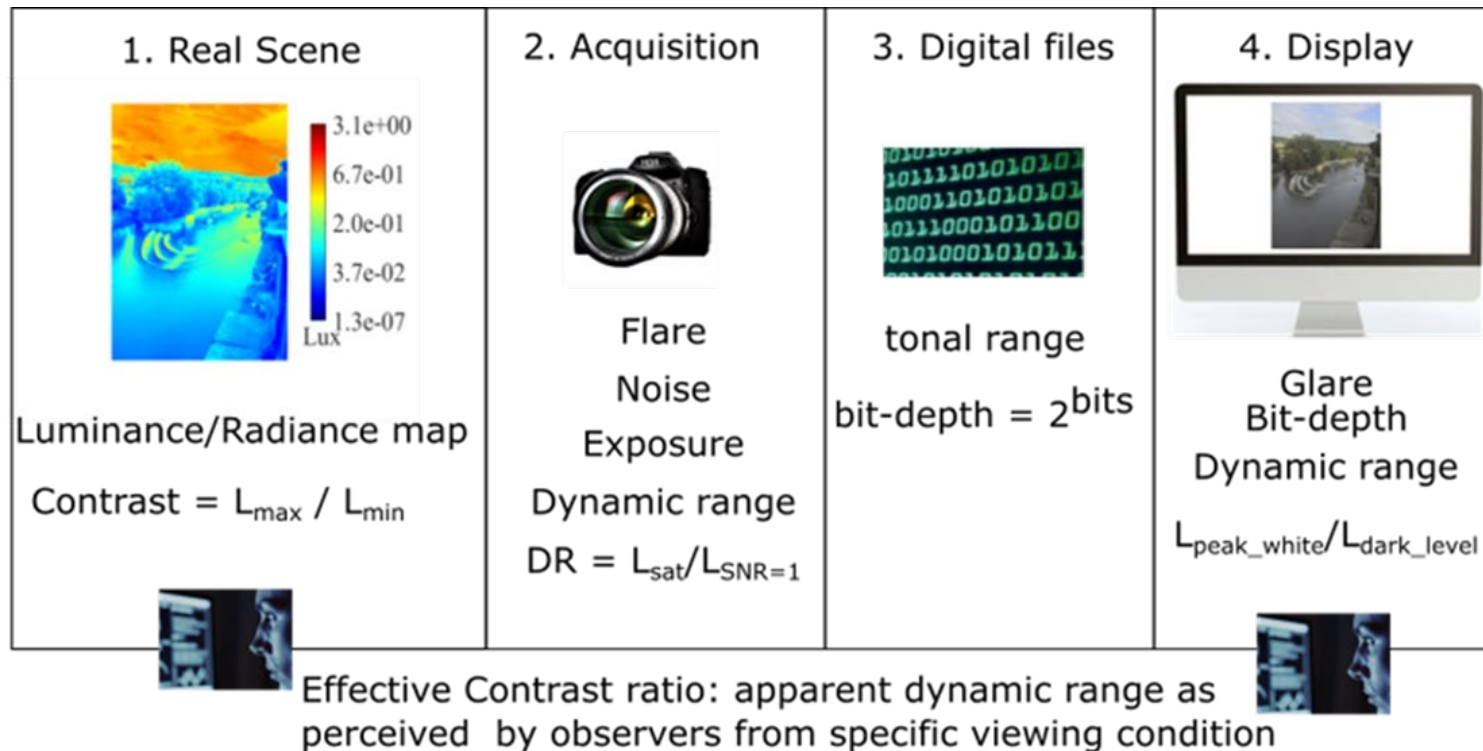
Formula	Example Notation	Industry
$[L_{min}; L_{max}]$	[0.1 ; 100] cd/m ²	Seldomly used to express dynamic range, but the minimum and maximum limits are often present in technical specifications of acquisition and display devices.
$1: \frac{L_{max}}{L_{min}}$	1:1000	Used in displays; most common way of expressing a DR.
$\left(\frac{L_{max}}{L_{min}} \right)$	≈ 10 EV (or “stops”)	Used in photography. EV means “Exposure Value” and also known as “stops”.
$20 \times \log \left(\frac{L_{max}}{L_{min}} \right)$	60 dB	Used in sensor or camera design.

• HDR Key Characteristics

- **Expanded Luminance Range**
- **Higher Bit-Depth Representation** (e.g., 10-bit, 12-bit, or floating-point representation)
- **Floating Adaptation:** Alignment with the human visual system's adaptation, ensuring a more natural and immersive experience across different lighting conditions.
- **Self-Luminous Colors:** provides the capability to reproduce colours that appear luminous

Defining HDR and Main Characteristics

HDR imaging is the acquisition and rendering process of such contents, including tone reproduction, which facilitates the conversion of HDR content to SDR and vice versa.

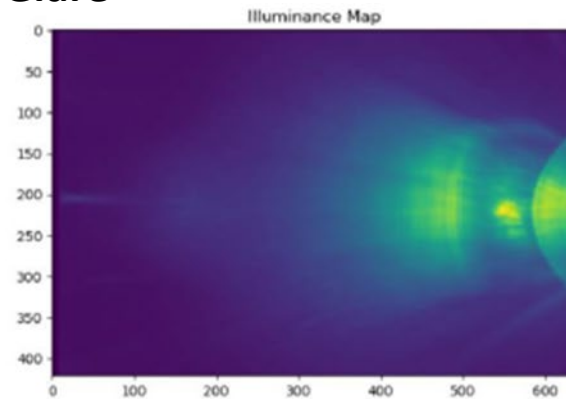


Defining HDR Imaging Across Different application Contexts.

Defining HDR and Main Characteristics

Discussions of other related characteristics within the HDR framework are included.

Flare and Glare

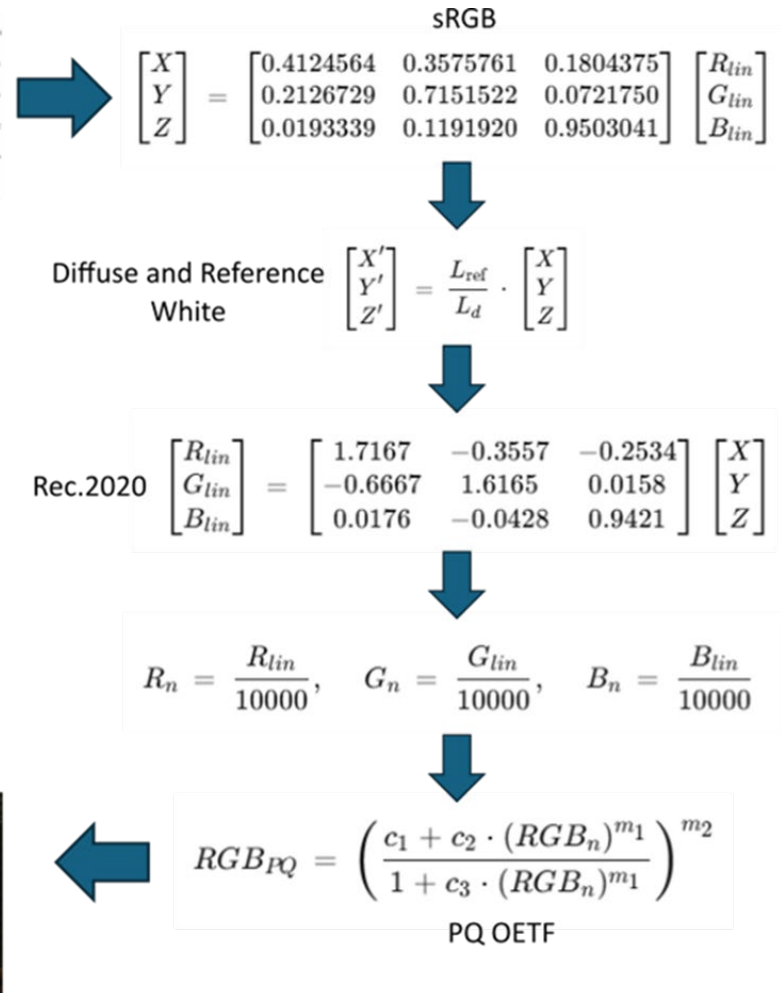
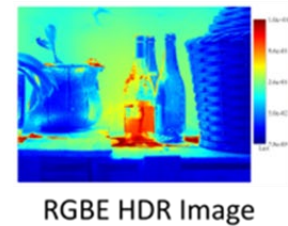


Michelson Contrast:

$$C = \frac{L_{max} - L_{min}}{L_{max} + L_{min}}$$

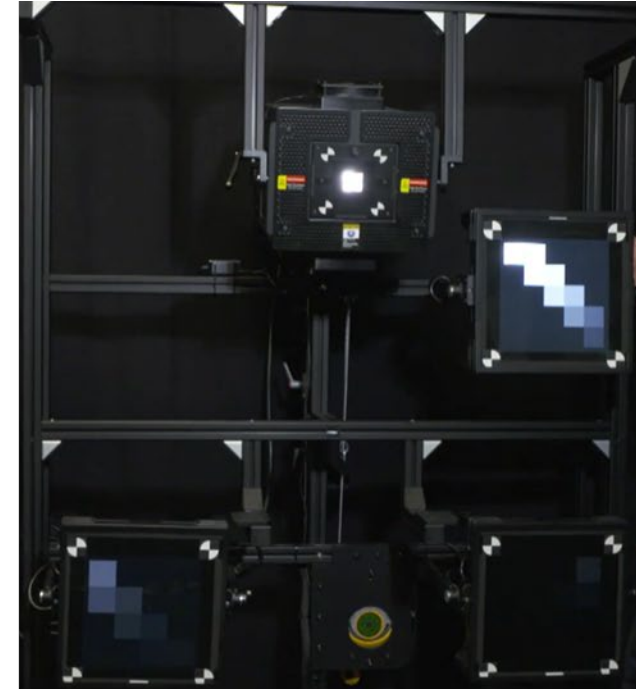
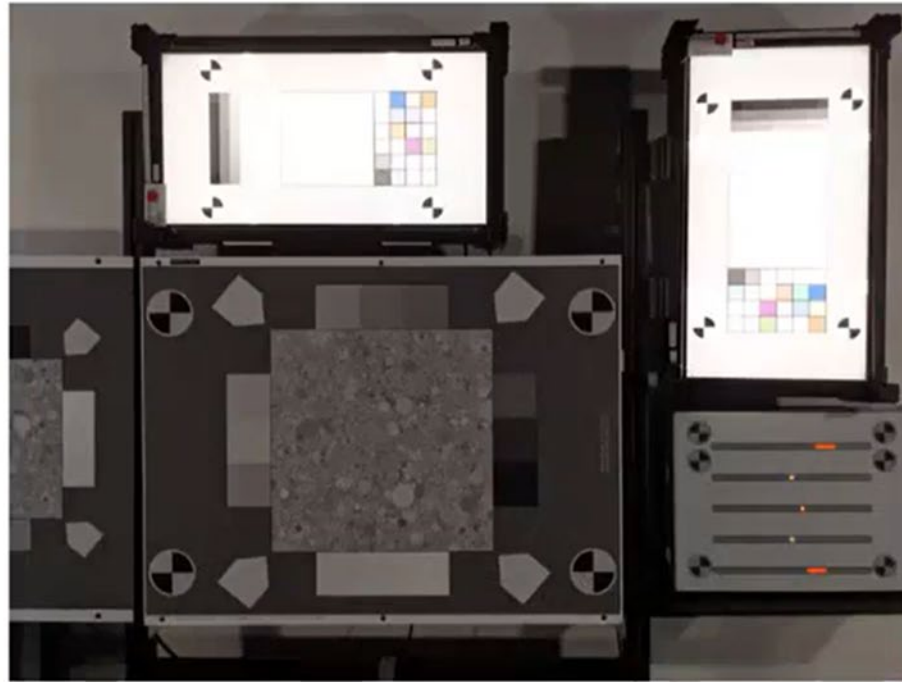
Weber Contrast (Local):

$$C = \frac{L_{target} - L_{background}}{L_{background}}$$



Defining HDR and Main Characteristics

- HDR Acquisition
- Key characteristics definition and measurements
 - Dynamic range
 - Flare
 - Noise level
 - Exposure level
 - Bit-depth – Tonal range
 - Quantization
 - Gamma, OETF
 - Color Volume

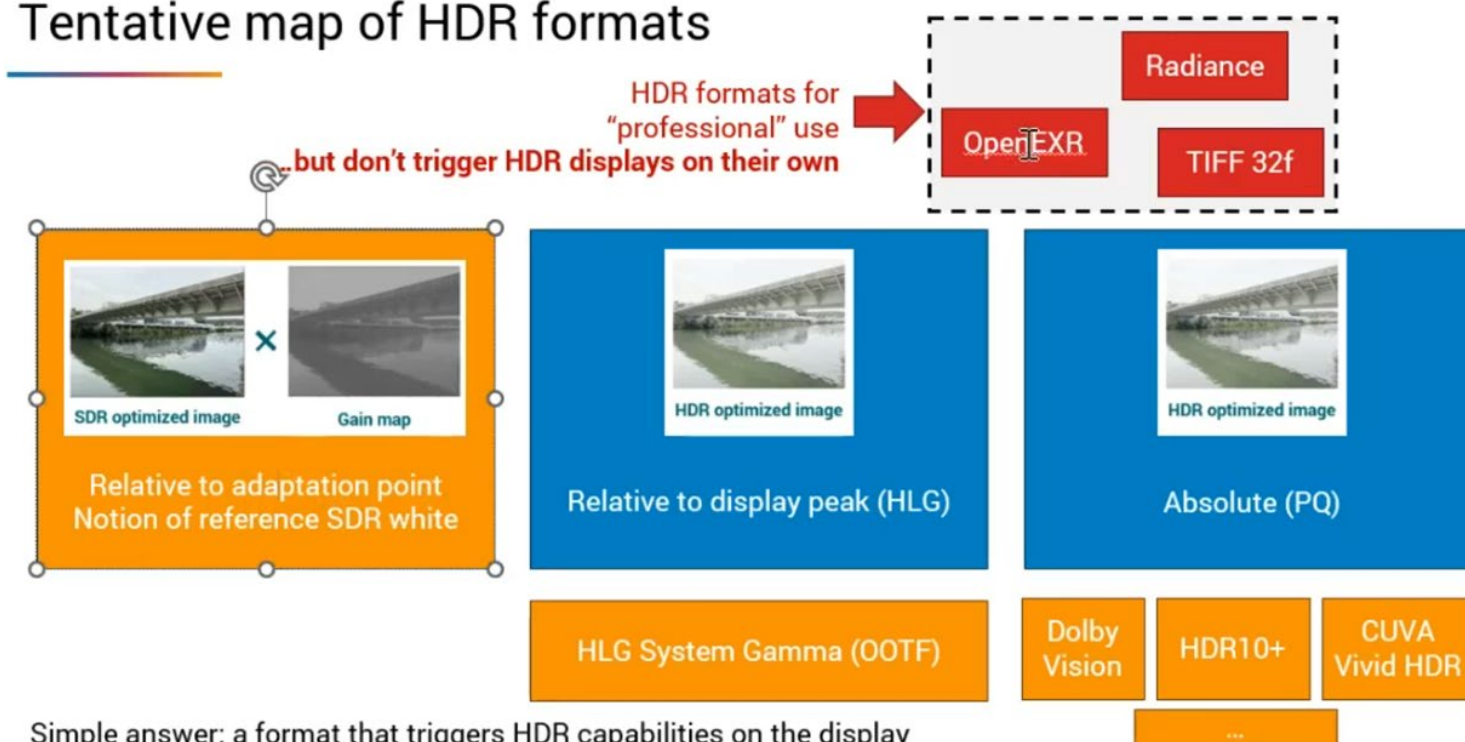


Defining HDR and Main Characteristics

The discussion will address how existing HDR image and sequence formats and standards represent and describe the identified HDR characteristics.

- Key characteristics and measurements
 - Scene referred - metadata
 - Display referred - metadata
 - Contrast
 - Spatial
 - Temporal
 - Perceptual
 - Diffuse white, Reference white, Graphics white, Adapted white
 - Bit-depth
 - Color gamut

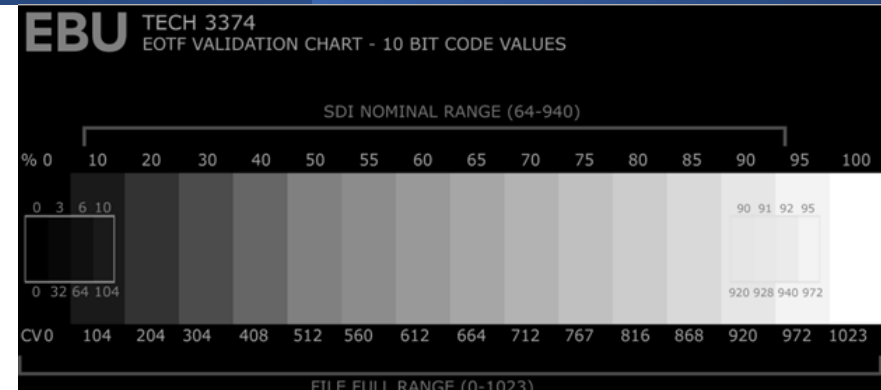
Tentative map of HDR formats



Simple answer: a format that triggers HDR capabilities on the display

Defining HDR and Main Characteristics

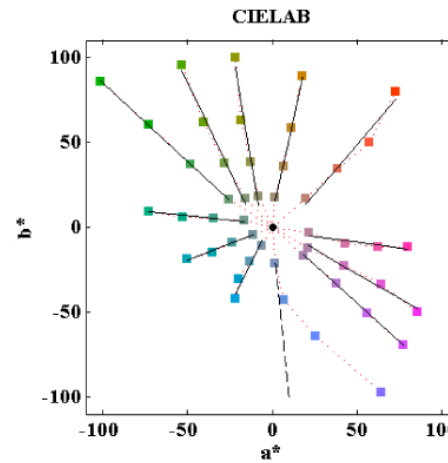
- HDR Rendering
- Key characteristics and measurements
 - Dynamic range
 - Peak luminance
 - Reference and diffuse white
 - Dark level
 - Glare/Flare
 - Ambient light and adaptation
 - Color gamut
 - Gamma or EOTF
 - Bit-depth and quantization
 - TMO/rTMO
 - Color appearance



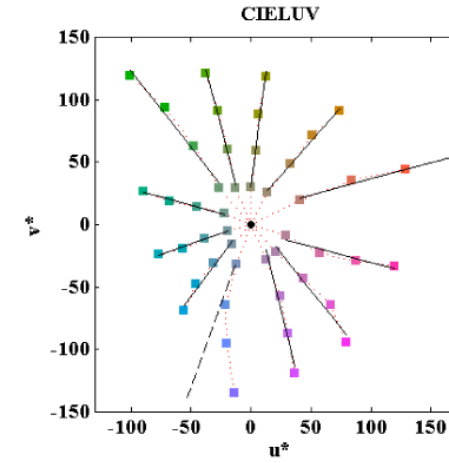
	Minimum Peak Luminance	Range of Color	Static Contrast Ratio	Maximum Black Level Luminance	Max ΔTP Color Patch Error
	Brightness in cd/m^2	DCI-P3 (D65) Coverage		Brightness in cd/m^2	
DisplayHDR 400	400	90%	1,300 : 1	0.4	8
DisplayHDR 500	500	95%	7,000 : 1	0.1	8
DisplayHDR 600	600	95%	8,000 : 1	0.1	8
DisplayHDR 1000	1000	95%	30,000 : 1	0.05	6
DisplayHDR 1400	1400	95%	50,000 : 1	0.02	6
DisplayHDR True Black 400	400	95%	N/A	0.0005	8
DisplayHDR True Black 500	500	95%	N/A	0.0005	8
DisplayHDR True Black 600	600	95%	N/A	0.0005	8
DisplayHDR True Black 1000	1000	95%	N/A	0.0005	6

Color in HDR

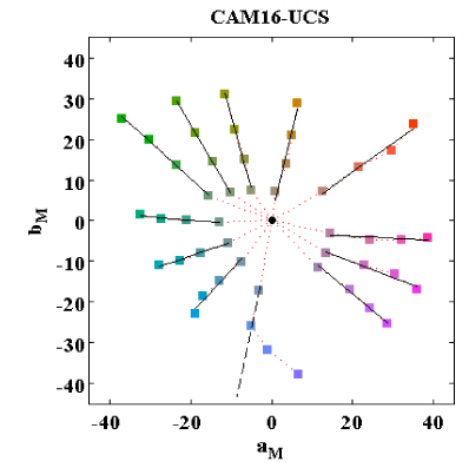
- Survey on HDR Color Spaces
- Survey on HDR color appearance models
- Discussion on current challenges and
- Recommendations on future research directions



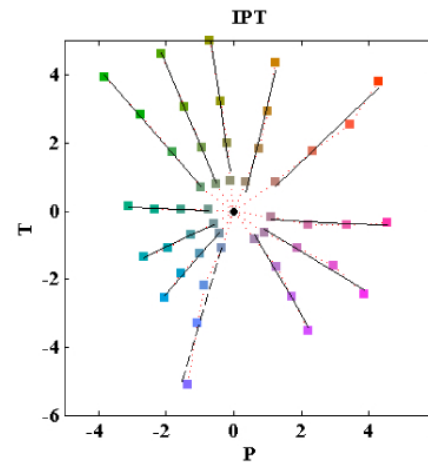
(a)



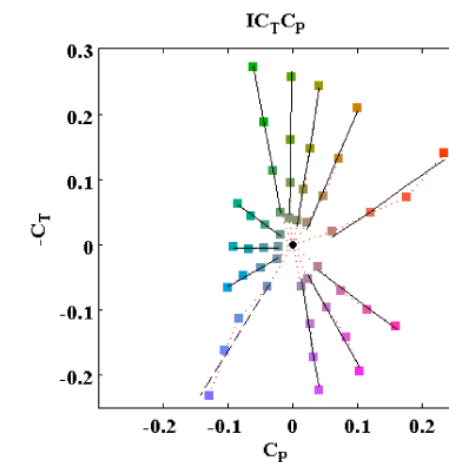
(b)



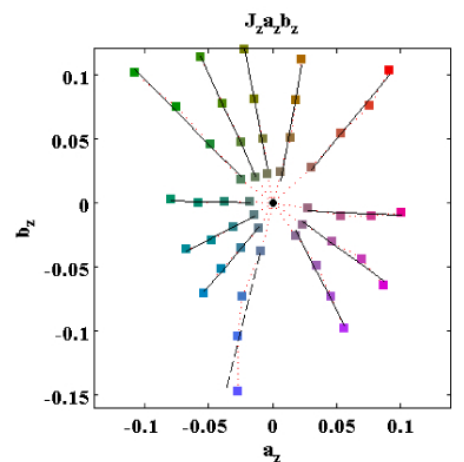
(c)



(d)



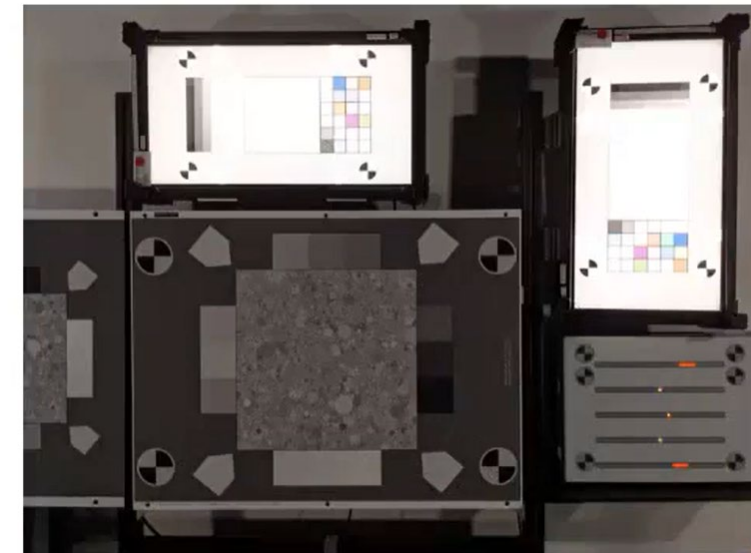
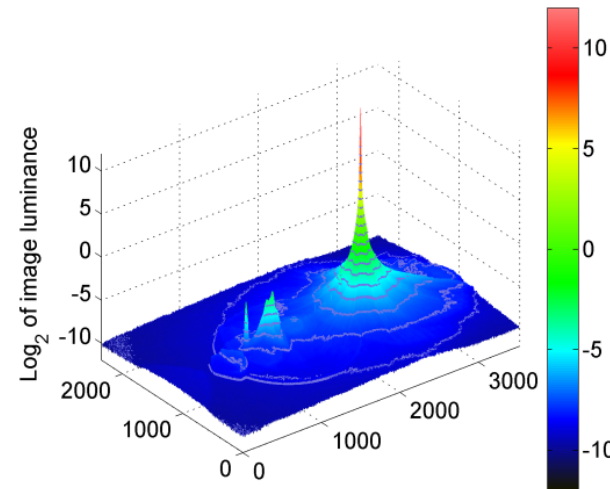
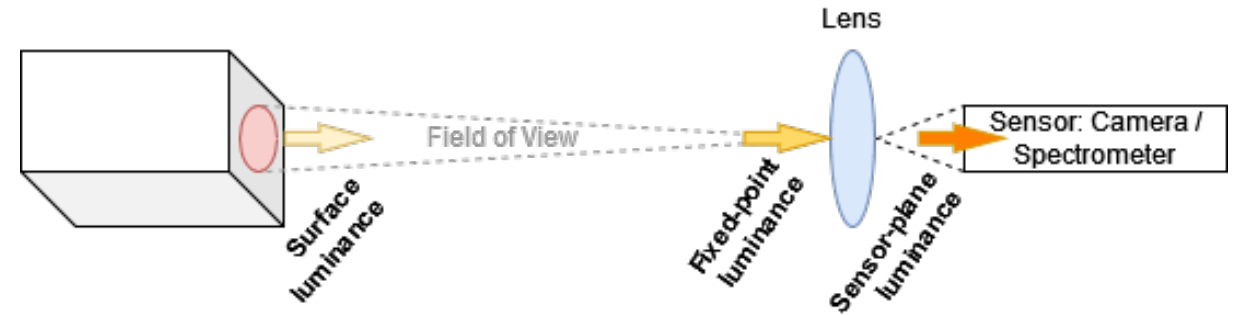
(e)



(f)

Perceptual and physical measurement guideline

- Dynamic range
 - Physical
 - Digital
 - Perceptual
- Flare and Glare
 - Camera
 - Display
 - Perceptual
- Contrast
 - Global
 - Local
- ...



[illegible]



Thank you!

Technical committee chair: Mekides Assefa Abebe