

ICC HDR and Spectral Imaging Experts' Day
21 September - Gjøvik, Norway

HDR and glare

Glare as a Foundational Mechanism of HDR

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DI MILANO



Multimedia



Interaction



Perception



Society

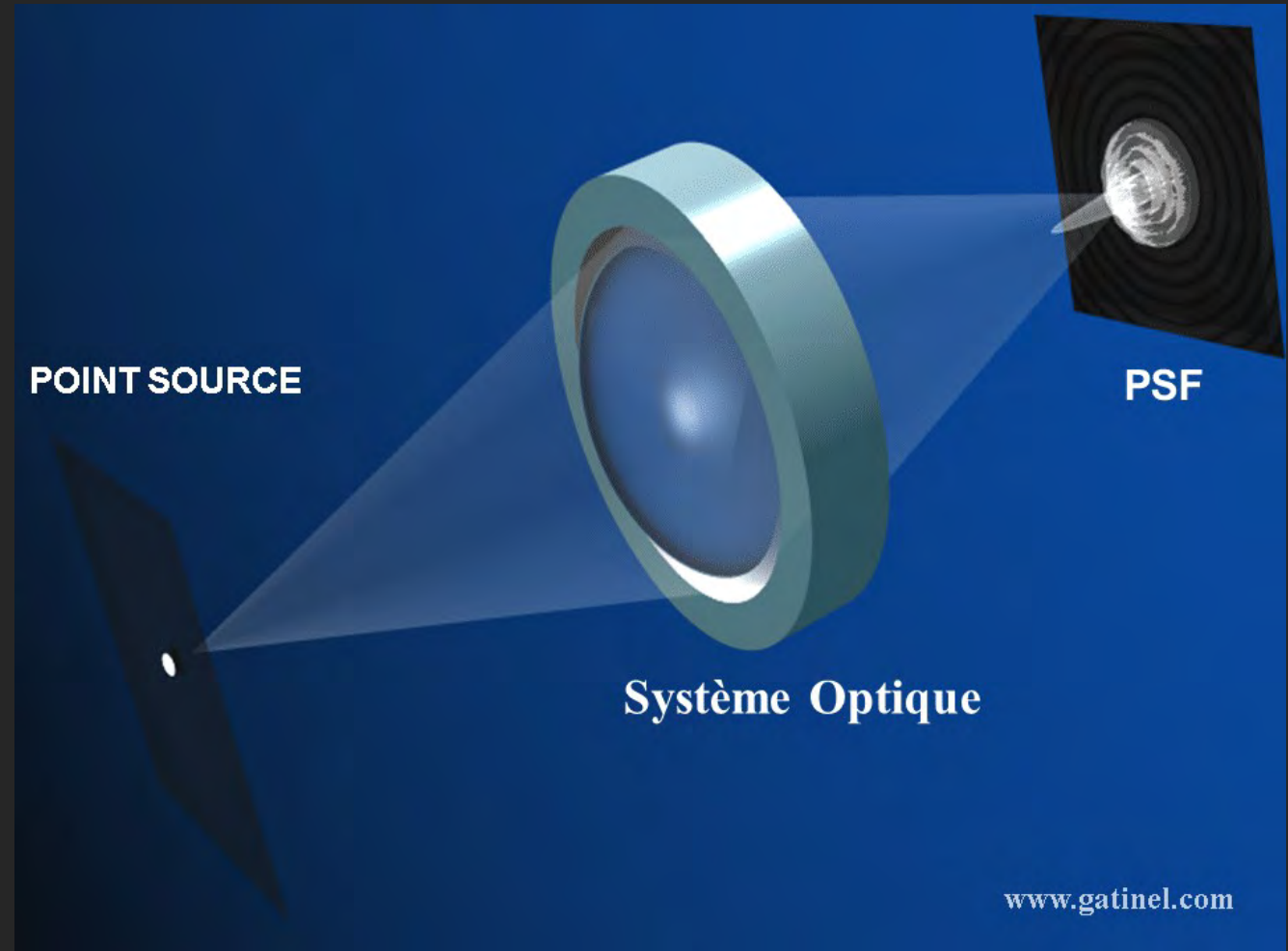
Veiling glare

ISO 9358:1994 DEFINITION:

<https://www.iso.org/obp/ui/#iso:std:iso:9358:ed-1:v1:en>

Unwanted irradiation in the image plane of an optical or electrooptical system, caused by a proportion of the radiation which enters the system through its normal entrance aperture.

The radiation may be from inside or outside the field of view of the system.



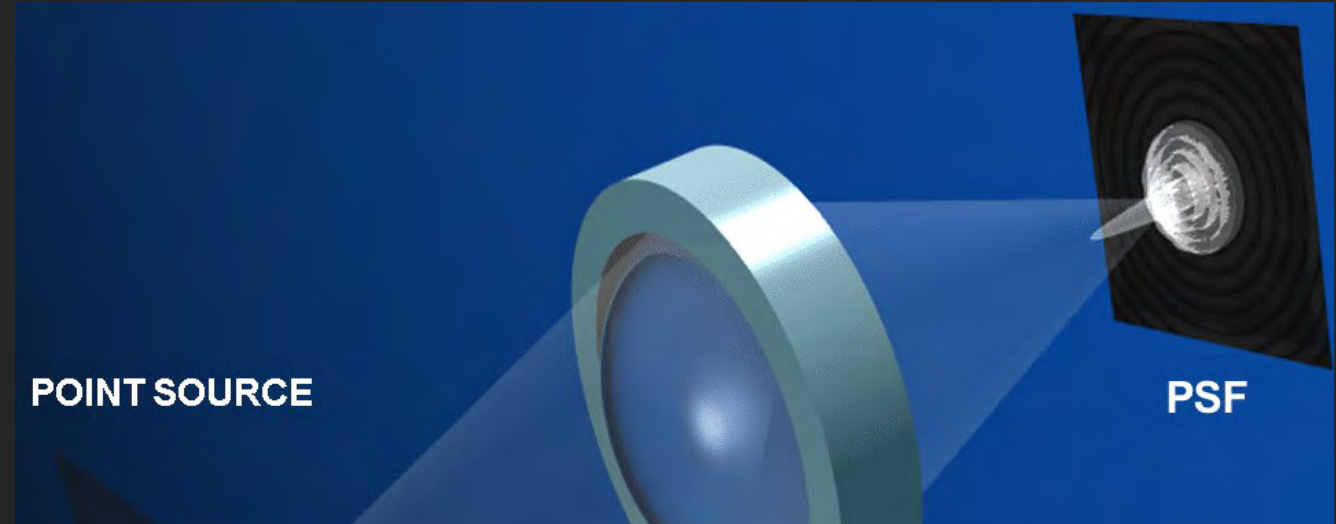
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REDUCE THE
DYNAMIC RANGE



SCENE-
DEPENDENT



UNAVOIDABLE,
ALWAYS PRESENT

Veiling glare



Tyndall
scatter filter
over lens



The three goals of HDR



Goal A:
Producing “Beautiful Images” (Aesthetic Choice)

**Ground Truth =
Aesthetic choice**



Goal B:
Accurate Radiance Reproduction (Physical Fidelity)
Capturing and reproducing every photon of the original scene

**Ground Truth =
Accurate radiances**



Goal C:
Mimicking the Visual System (Appearance Computation)

**Ground Truth =
Observer matches**

A. Limit in HDR aesthetic goal

Ground Truth =
Aesthetic choice



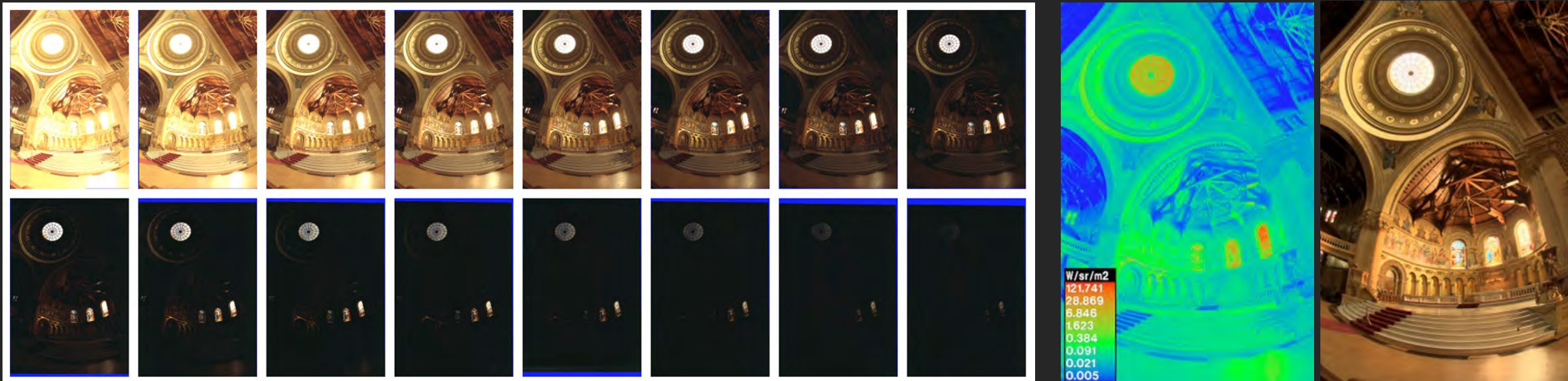
B. Limit in HDR radiance goal

Ground Truth =
Accurate radiances

Recovering high dynamic range radiance maps from photographs

Paul E. Debevec, Jitendra Malik (1997)

<https://doi.org/10.1145/258734.258884>



They do not consider GLARE!

B. Limit in HDR radiance goal

Scene-dependent camera response experiment

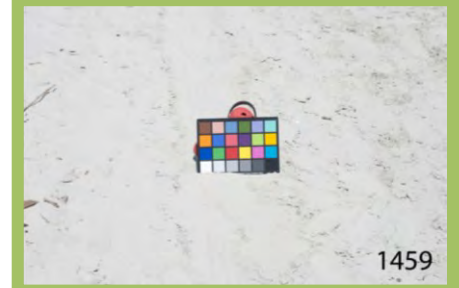
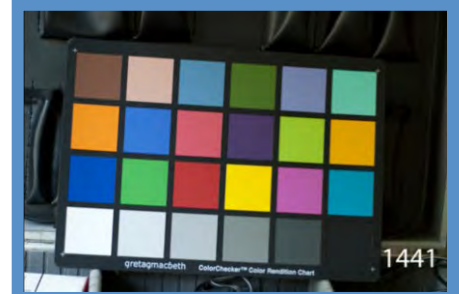
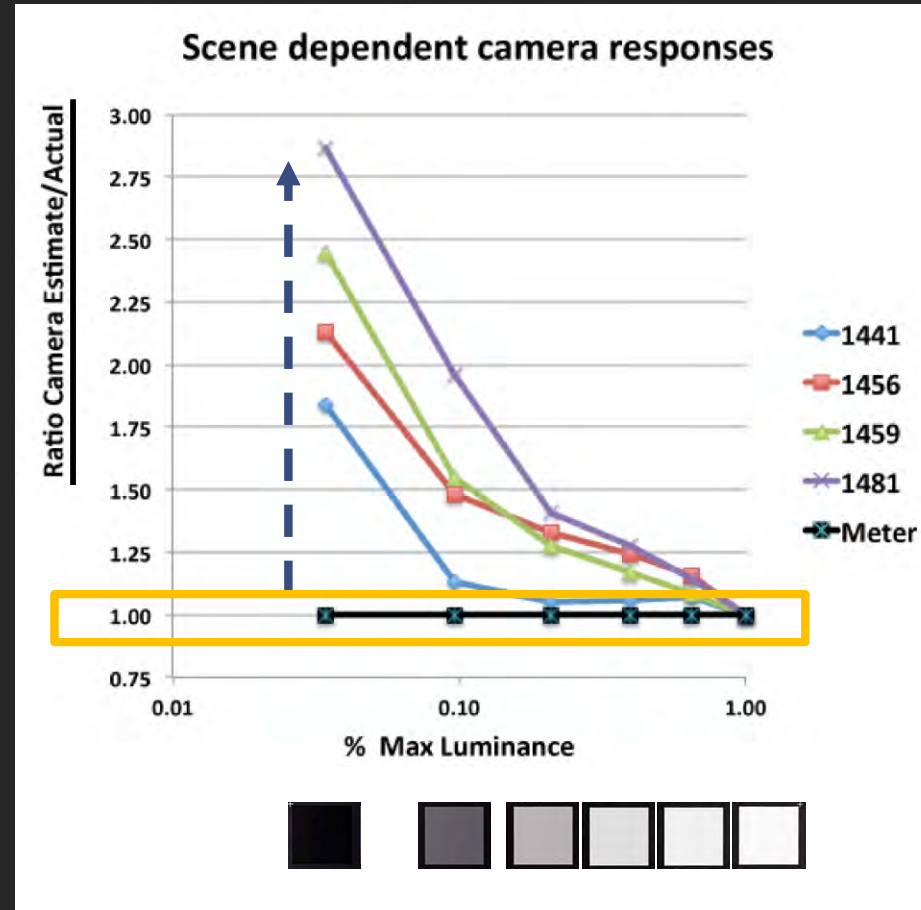
<https://doi.org/10.1002/9781119951483>



Using only Lib RAW data with linear calibration

B. Limit in HDR radiance goal

- As the overall brightness of the scene increases, the camera estimation becomes less accurate on dark area.
- This is due to the contribution of glare



Using only Lib RAW data
with linear calibration

B. Limit in HDR radiance goal

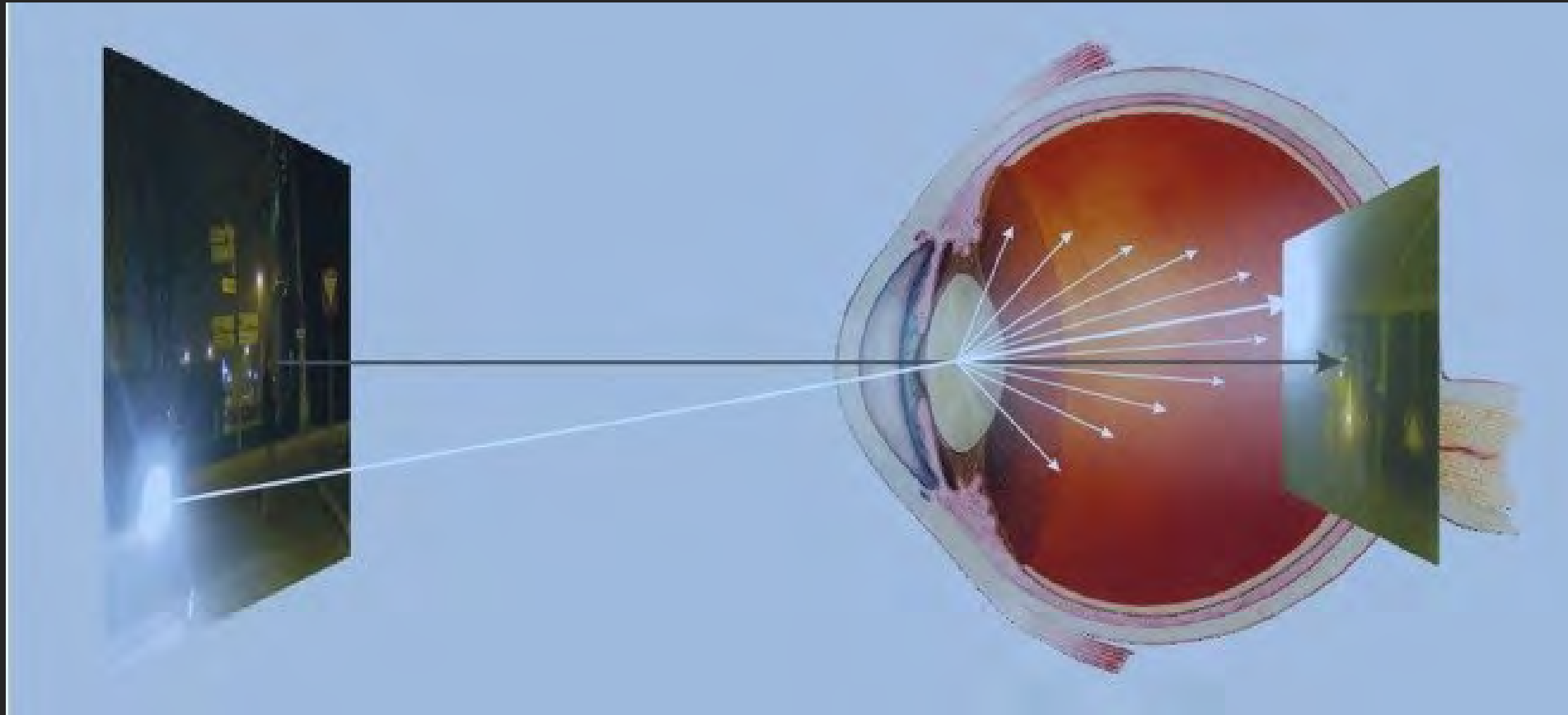
**Ground Truth =
Accurate radiances**

- Glare affect all the measures
- According to ISO 9358, the contribution of glare cannot be reliably separated from the measurement
- Glare limits the dynamic range that we are able to capture

C. Limit in HDR appearance goal

Ground Truth =
Observer matches

Intraocular glare

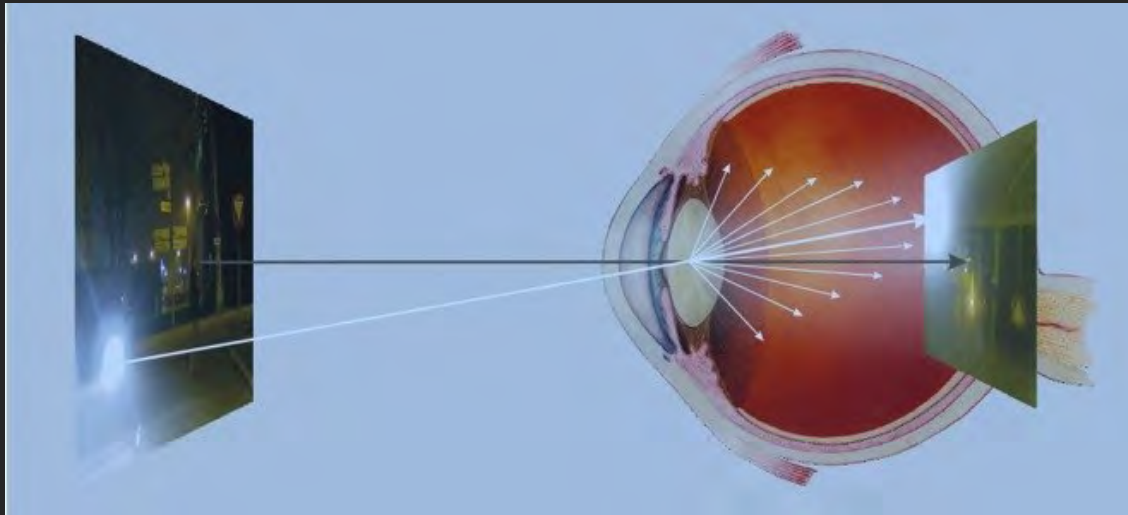


<http://dx.doi.org/10.1016/j.zemedi.2012.10.009>

C. Limit in HDR appearance goal

Ground Truth =
Observer matches

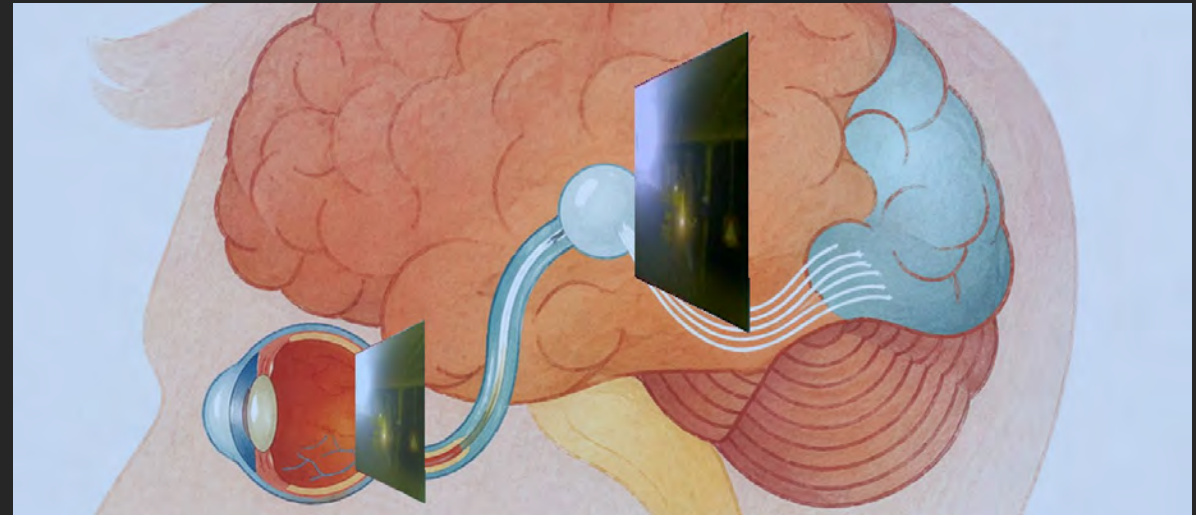
Intraocular glare



<http://dx.doi.org/10.1016/j.zemedi.2012.10.009>

Retinal mechanism
Lower the contrast

Spatial comparison



Neural mechanism (post-receptor)
Higher the contrast

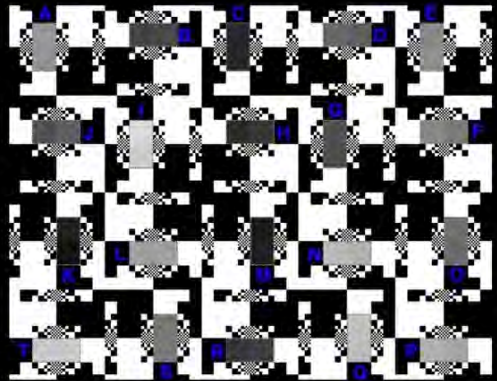
C. Limit in HDR appearance goal

Intraocular Glare Experiment

<https://doi.org/10.1002/9781119951483>

Scene

1 000 000 : 1



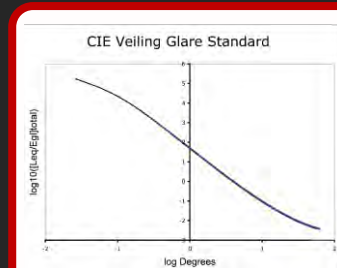
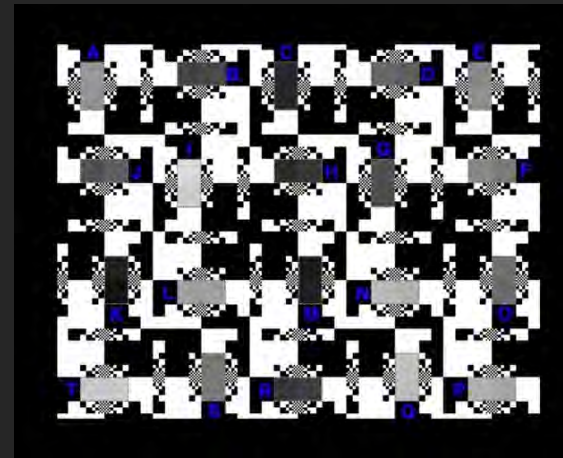
Retina

100 : 1



Appearance

1 000 : 1



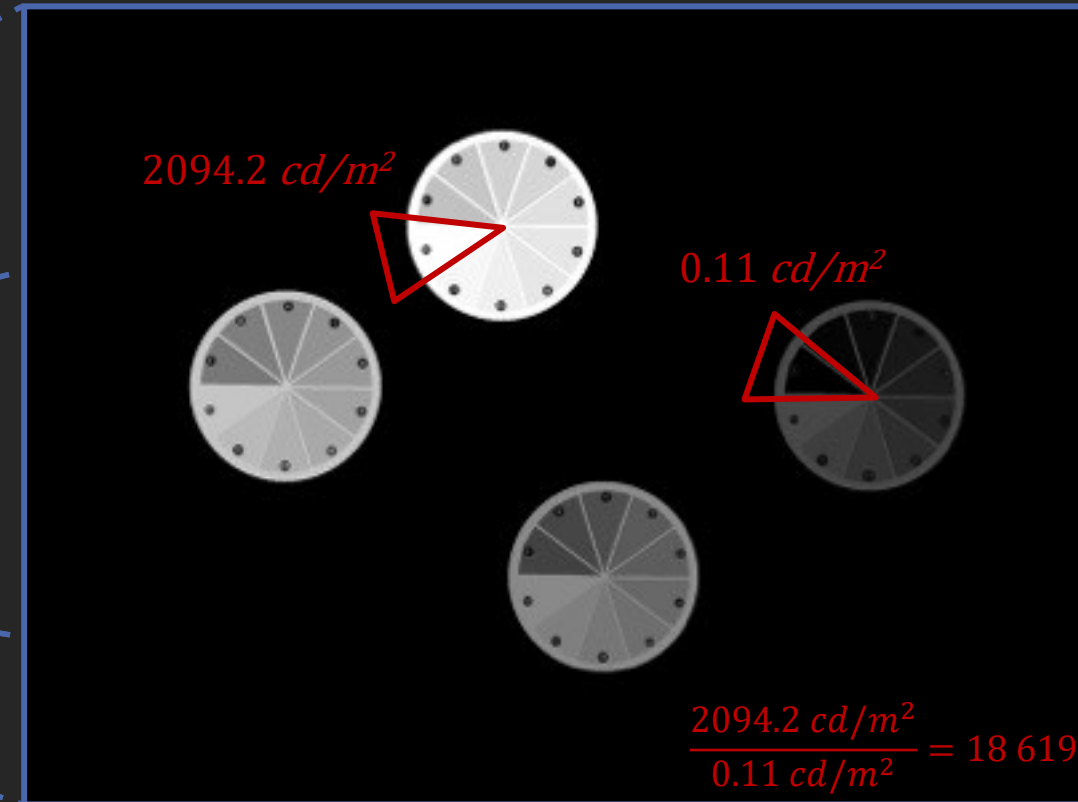
SPATIAL GLARE
Scene Dependent
Lower Contrast

SPATIAL CONTRAST

Scene Dependent
Higher Contrast

HDR Target Experiment

<https://doi.org/10.1117/3.2315540>



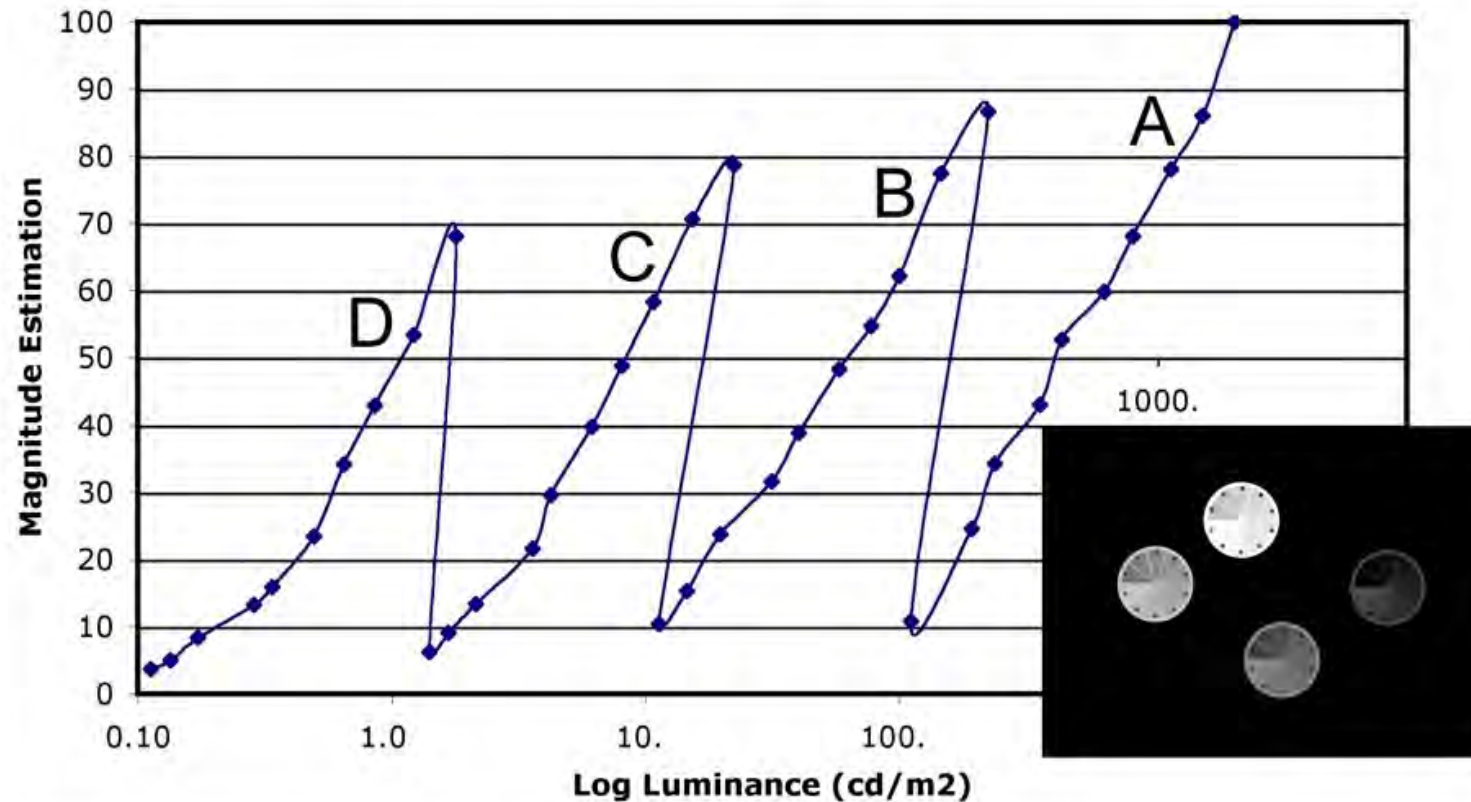
C. Limit in HDR appearance goal

HDR Target Experiment

<https://doi.org/10.1117/12.703042>

<https://doi.org/10.1117/3.2315540>

Appearance vs. Luminance



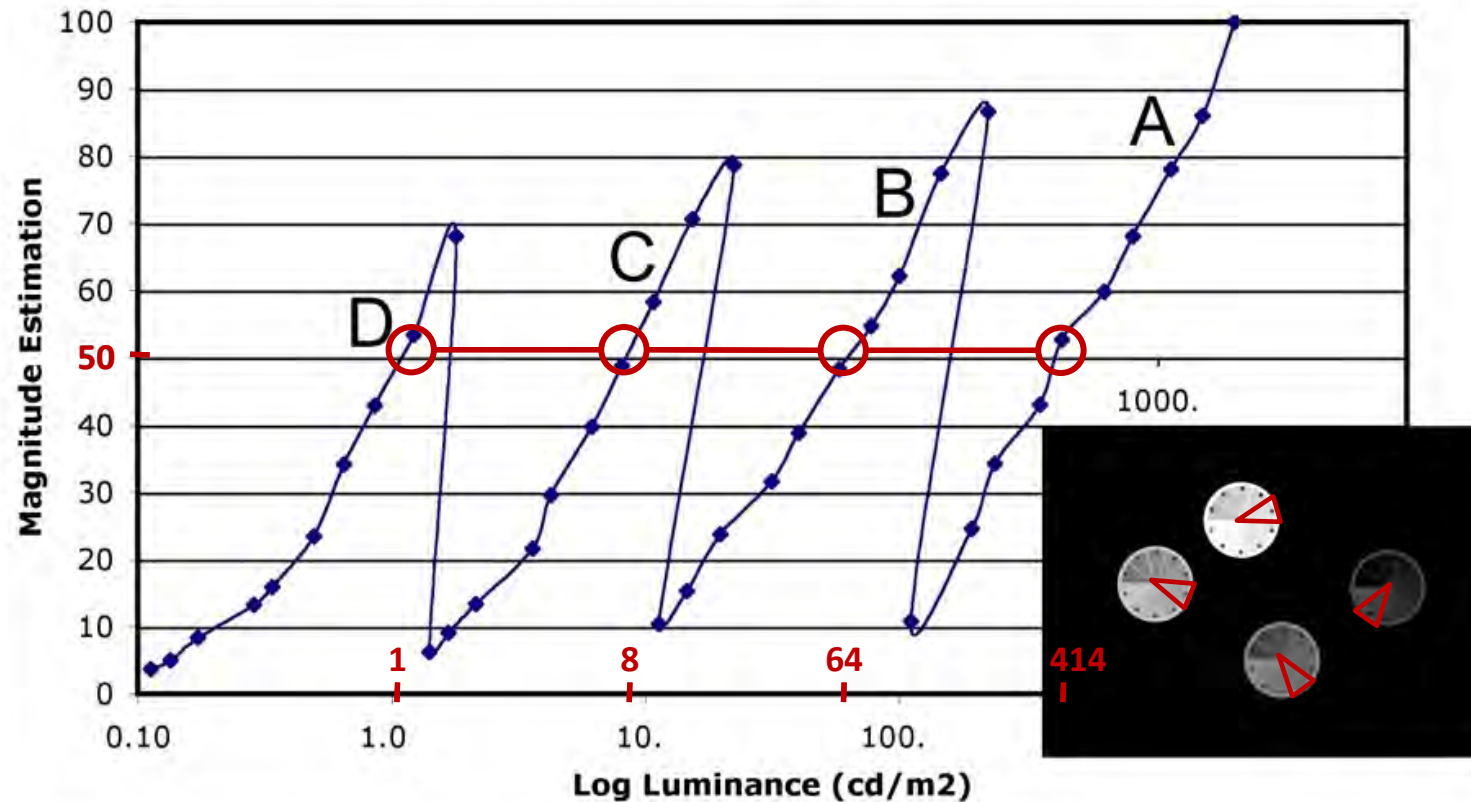
C. Limit in HDR appearance goal

HDR Target Experiment

<https://doi.org/10.1117/12.703042>

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Appearance vs. Luminance



- Observers assign the same magnitude estimate (lightness value) to sectors that have completely different physical luminances

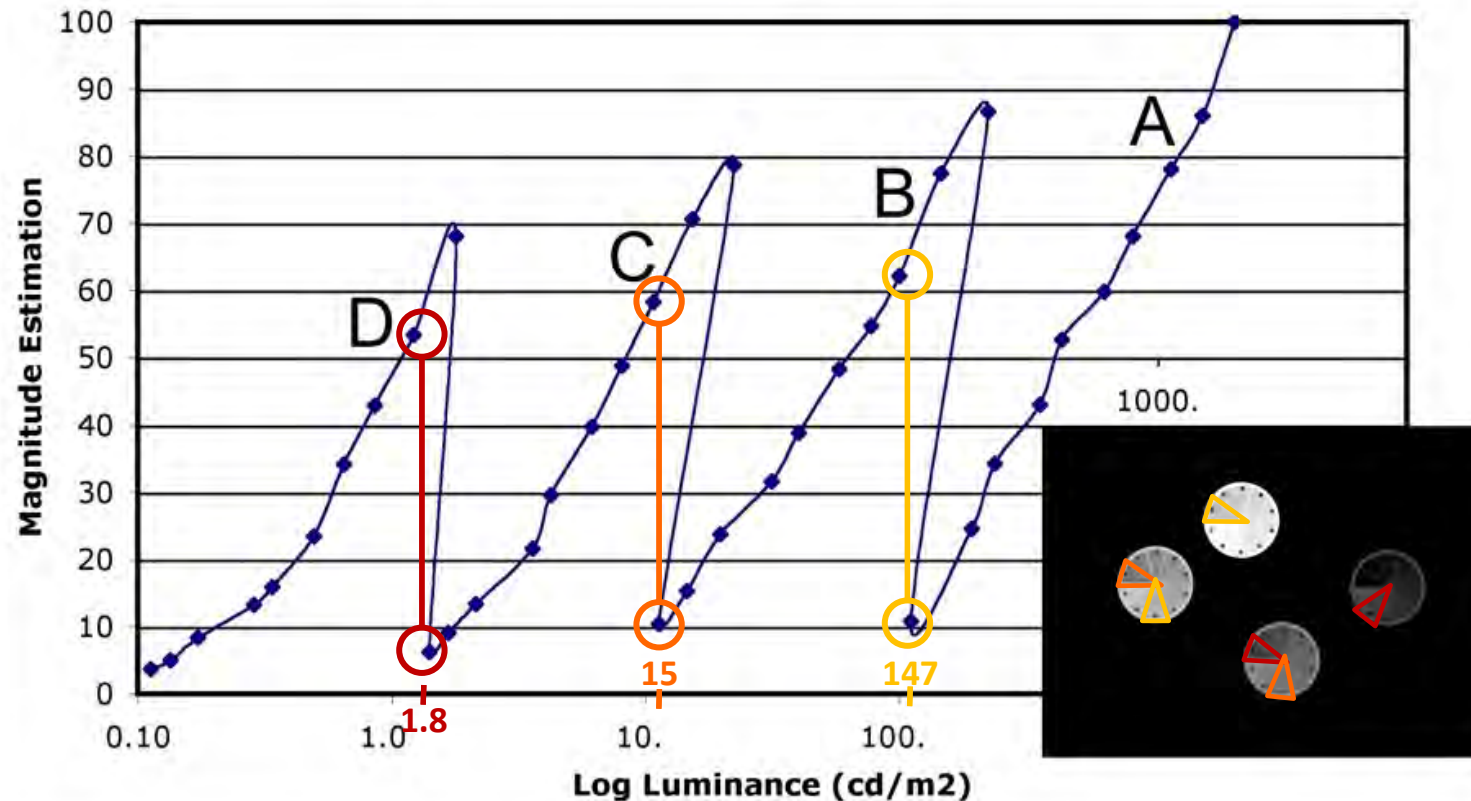
C. Limit in HDR appearance goal

HDR Target Experiment

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Appearance vs. Luminance



- Observers assign the same magnitude estimate (lightness value) to sectors that have completely different physical luminances
- Identical luminances resulted in different appearances

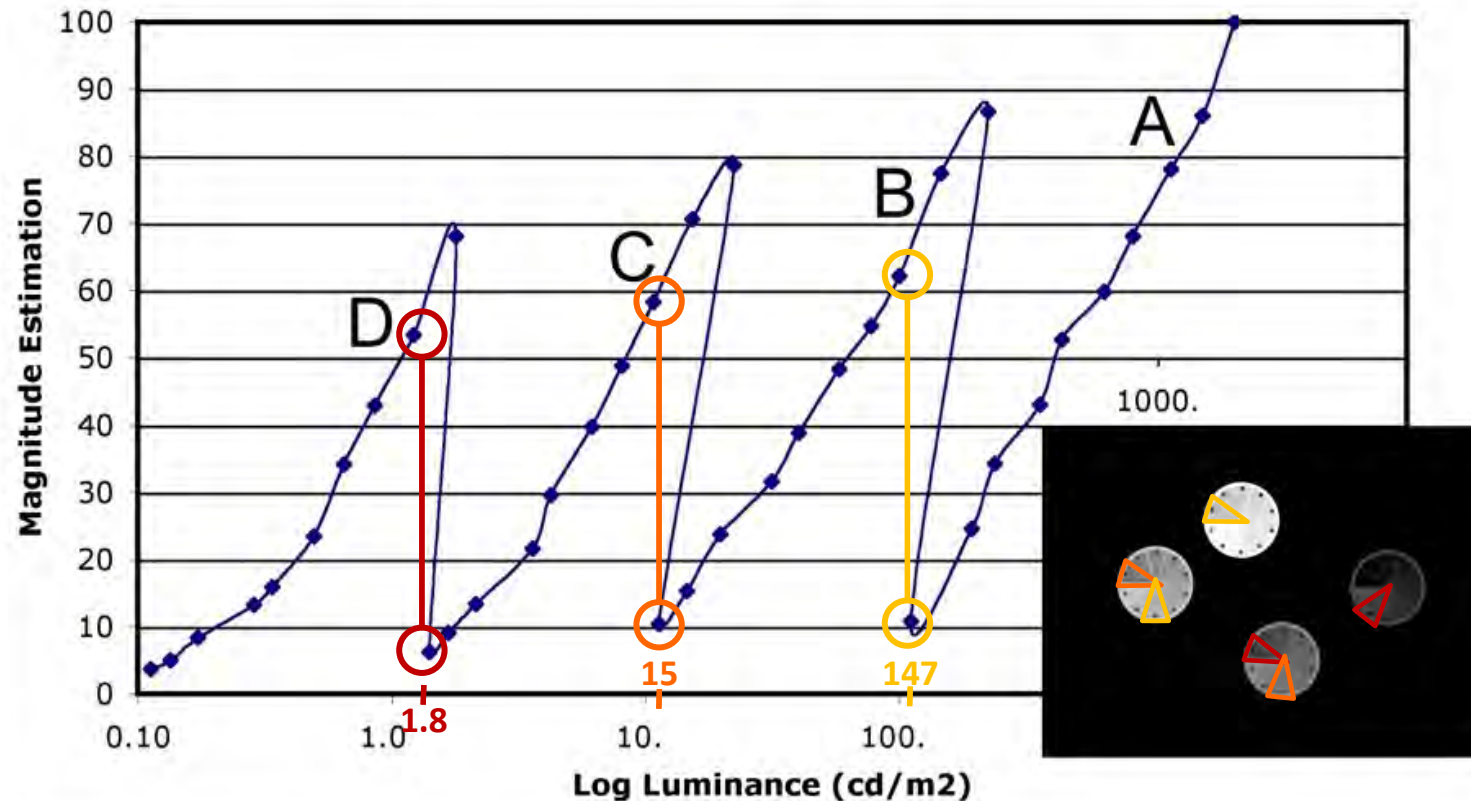
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CONCLUSION:

A global tone curve cannot map appearance regardless of the chosen mapping

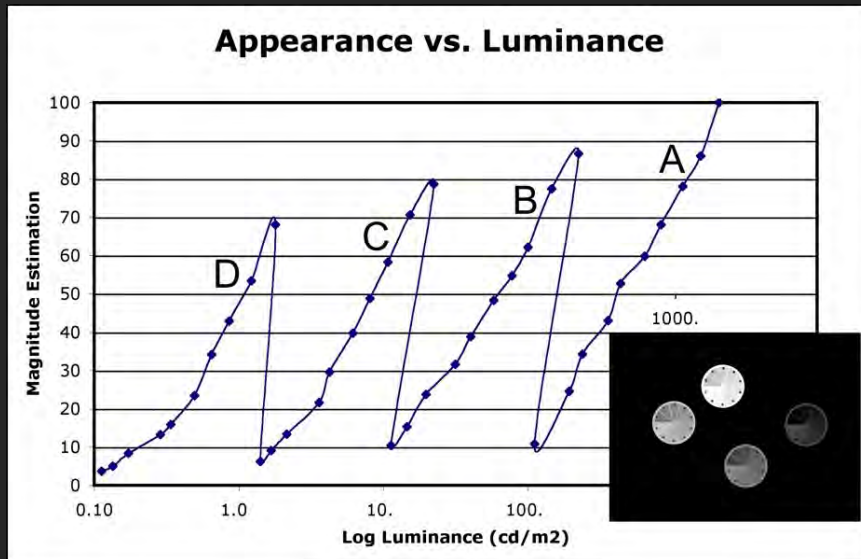
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HDR Target Experiment

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Human Visual System



Global + Local tone mapping

HDR Tone Mapping Methods

PQ-Based HDR Standards

- Static Metadata:
 - HDR10
- Dynamic Metadata:
 - HDR10+
 - Dolby Vision
- Fixed Curve:
 - SMPTE ST 2084 (PQ)

Hybrid Log-Gamma (HLG)

- Broadcast HDR:
 - HLG
 - HLG10
- Flexible Curve:
 - HLG + OOTF

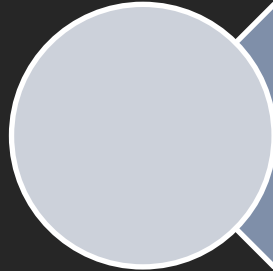
Filmic & Rendering Tones

- Game & CG Rendering:
 - ACES
 - Filmic Tone Mapping

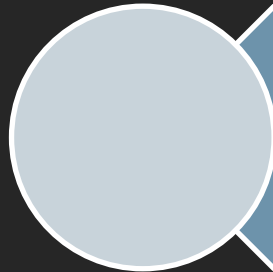
Global tone mapping

- Global models treat pixels in isolation, but appearance is spatial.
- Any global tone mapping is inherently insufficient to describe appearance: necessity of spatial locality to account for how the brain counteracts glare.

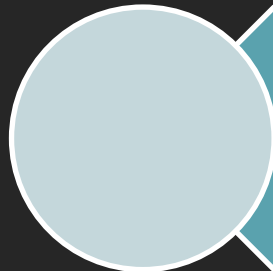
Conclusion and Take-home message



Glare defines what we can capture and what we can perceive
→ It is not a defect but a base mechanism



HDR imaging works not because it is accurate but because it preserves the spatial differences



The question is not how to remove glare but how to include it in HDR research

References

- McCann, J. J., & Rizzi, A (2007). *Veiling glare: The dynamic range limit of HDR images*. In *Human Vision and Electronic Imaging XII* (Vol. 6492, pp. 394-403). SPIE. DOI: [10.1117/12.703042](https://doi.org/10.1117/12.703042)
- McCann, J. J., & Rizzi, A (2007). *Camera and visual veiling glare in HDR images*. *Journal of the Society for Information Display*, 15(9), 721-730. DOI: [10.1889/1.2785205](https://doi.org/10.1889/1.2785205)
- McCann, J. J., Vonikakis, V., & Rizzi, A. (2017). *HDR Scene Capture and Appearance*. SPIE. ISBN: 9781510618534. DOI: [10.1117/3.2315540](https://doi.org/10.1117/3.2315540)
- McCann, J. J., & Rizzi, A. (2012). *The Art and Science of HDR Imaging*. John Wiley & Sons. ISBN 9781119951483. DOI: [10.1002/9781119951483](https://doi.org/10.1002/9781119951483)
- Plutino, A., Bagnati, M., & Rizzi, A. (2024). *Camera Dynamic Range Measurement: The Role of Lenses and Target Spatial Distribution*. *IEEE Transactions on Instrumentation and Measurement*, 73, 1-9. DOI: [10.1109/TIM.2024.3400303](https://doi.org/10.1109/TIM.2024.3400303)
- Rizzi, A., & McCann, J. J. (2012). *Glare-limited appearances in HDR images*. *Journal of the Society for Information Display*, 17(1), 3-12. DOI: [10.1889/JSID17.1.3](https://doi.org/10.1889/JSID17.1.3)
- Signoroni, A., Conte, M., Plutino, A., & Rizzi, A. (2020). *Spatial–Spectral Evidence of Glare Influence on Hyperspectral Acquisitions*. *Sensors*, 20(16), 4374. DOI: [10.3390/s20164374](https://doi.org/10.3390/s20164374)

Thank you for your attention

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