



HDR Image Color Fidelity for the Web

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Color Reproduction in Color Imaging

Goal: Reproducing real world scene appearance as faithfully as possible to human observers.

Real world scene

Aquisition systems

Transmission systems

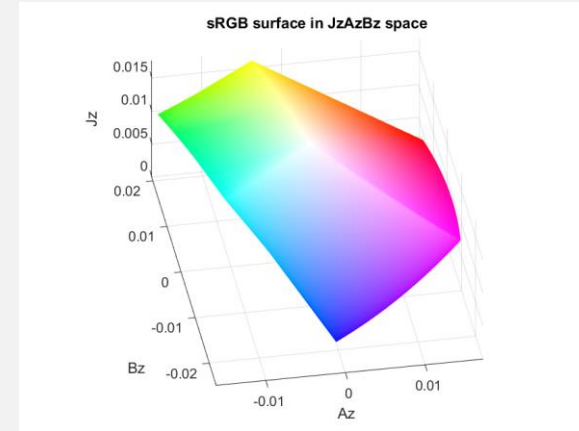
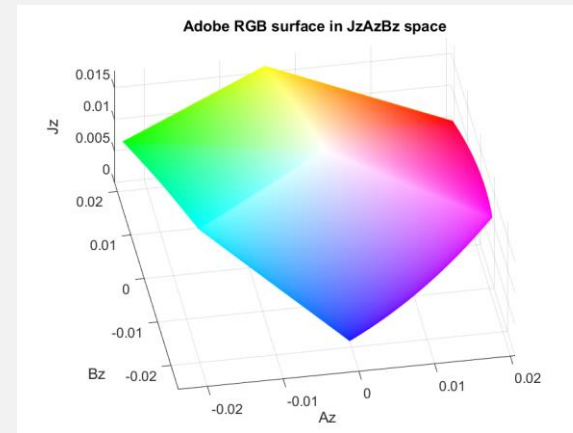
Output systems

Solution: Standard color specifications and color management solutions.

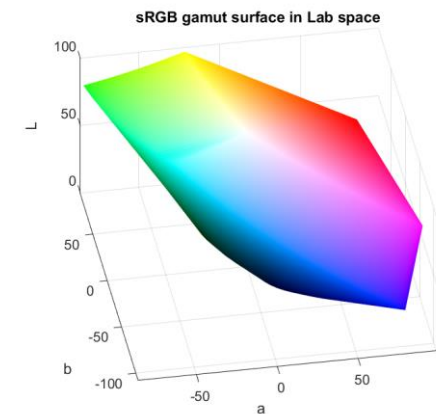
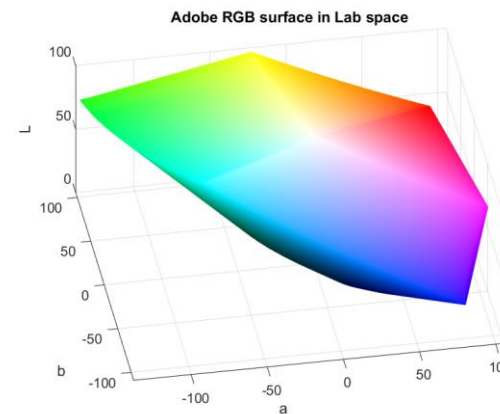
Challenge: Color imaging devices possess different capabilities.



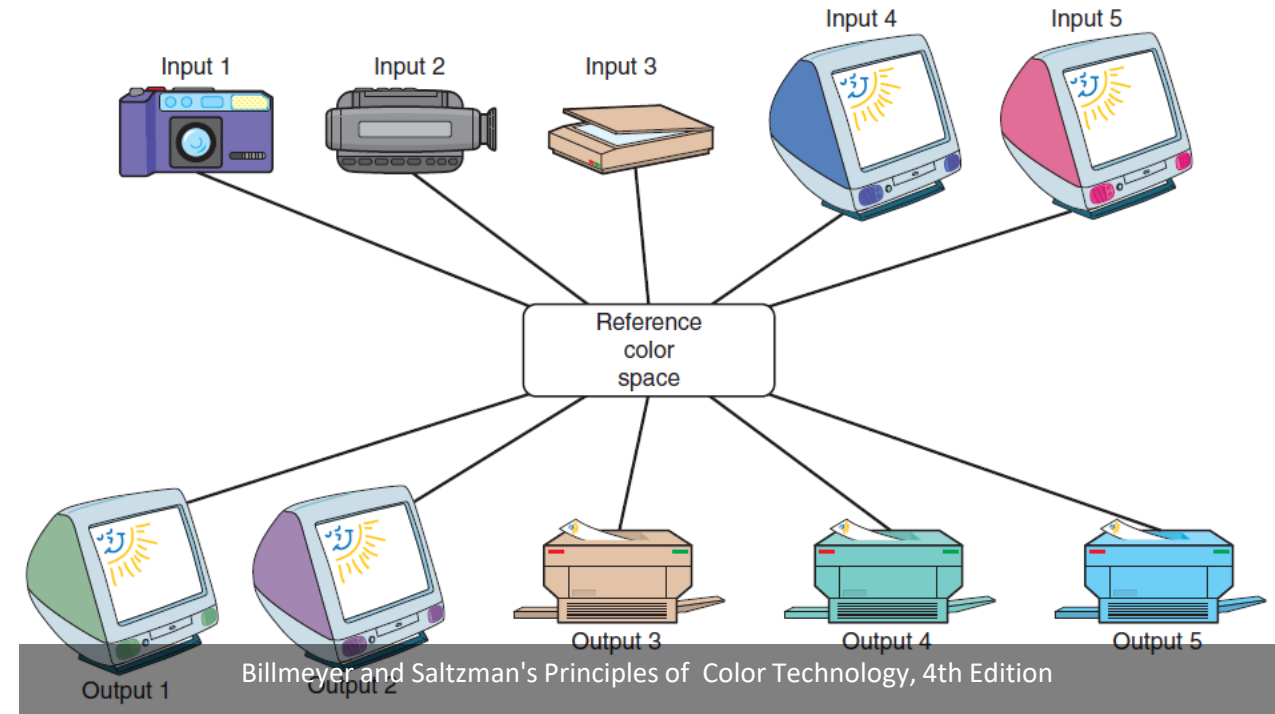
Color Satandards



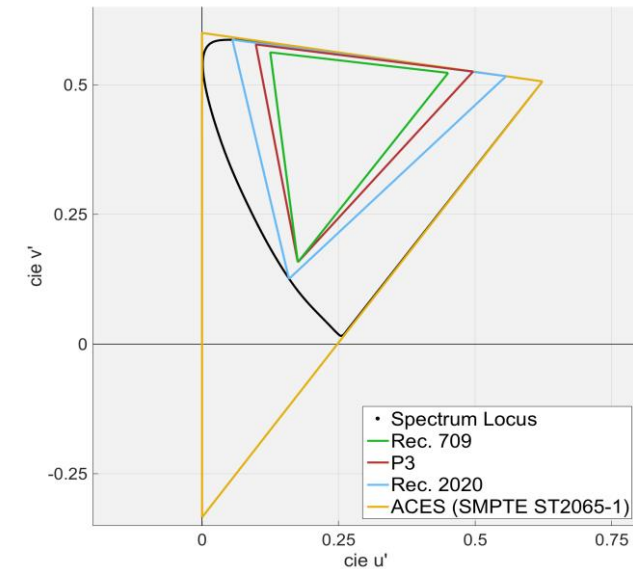
- Define
 - System colorimetry /color space
 - Primaries (Chromaticities)
 - White point
 - Transfer functions
 - OETF, OECF, EOTF, OOTF
 - Bit depth, Frame rates
 - Resolution, ...
- Common standards
 - ITU Rec. BT.709
 - ITU Rec. BT.2020
 - ITU Rec. BT.2100



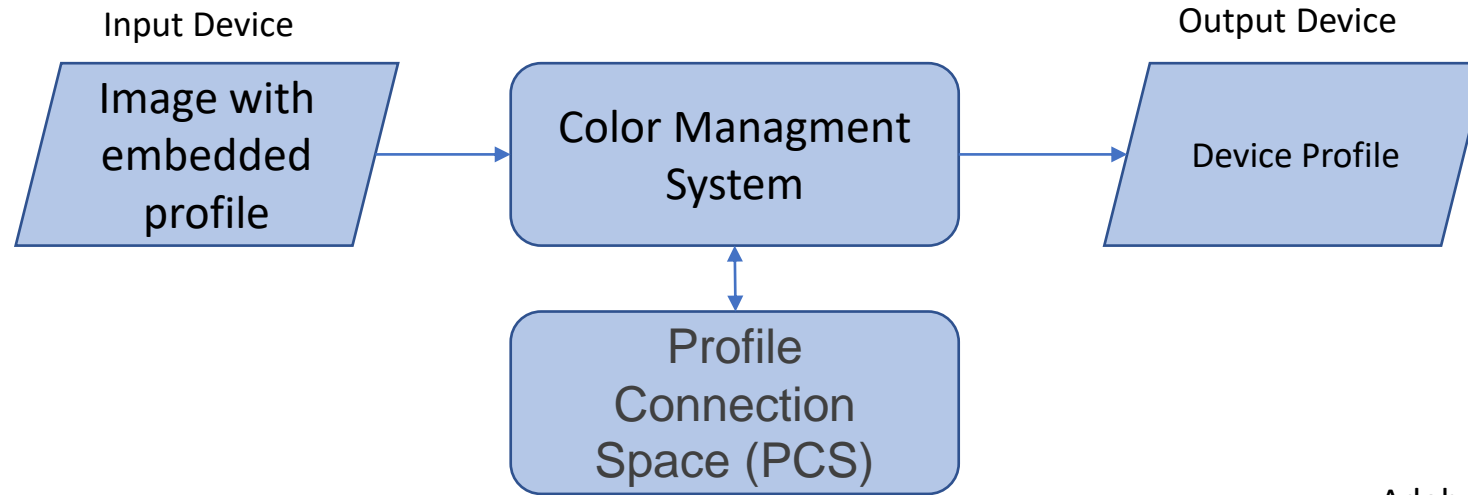
Color Management:



- Device-independent paradigm
- Each input and output device is connected to a reference color space.
 - The Academy Color Encoding System (**ACES**)
 - **ICC profile-based** Color Management System (CMS)



Web Color Management



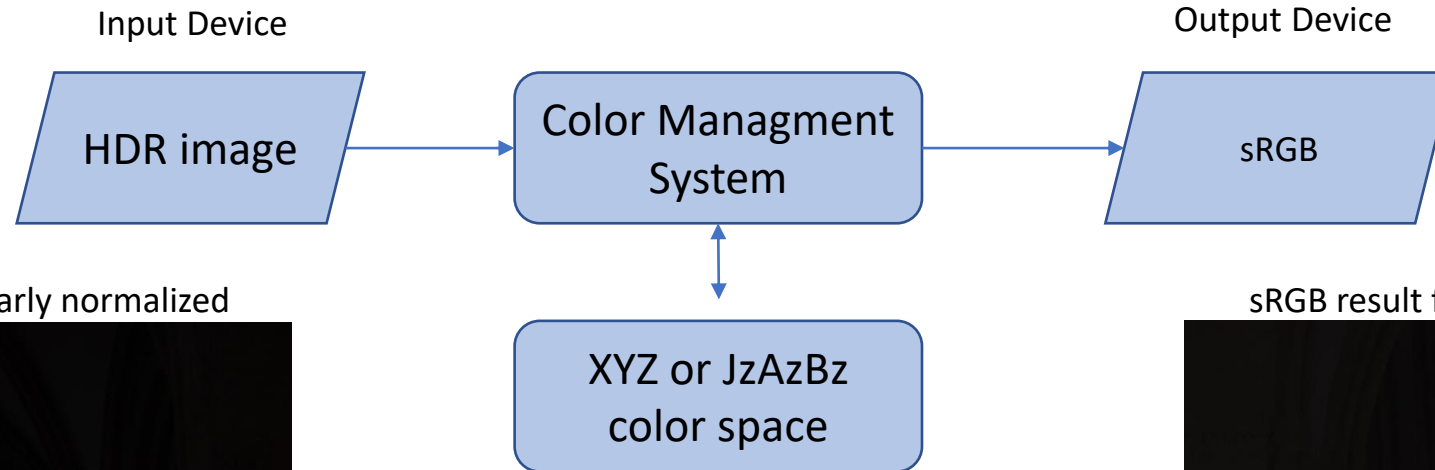
sRGB



Adobe RGB - 1998



HDR Color Management



HDR image in RGBE format, linearly normalized



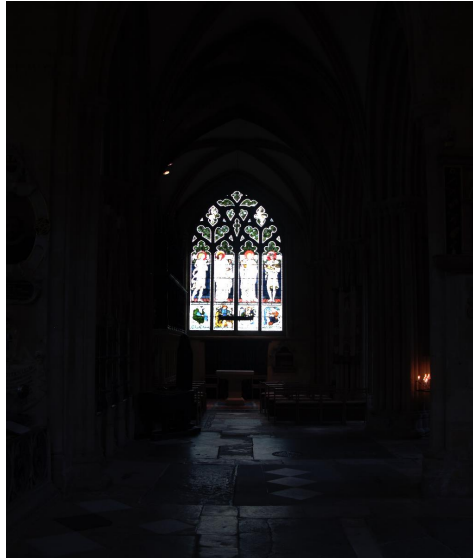
sRGB result following the iCC profile conversion



- HDR formats are not supported on browsers yet.
- The transformation is simulated on MATLAB.
- Additional tone mapping is necessary.

Tone Mapping for HDR Color Management

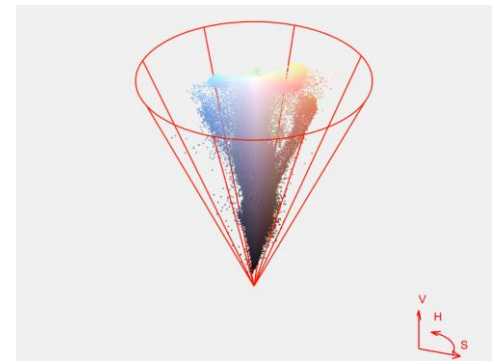
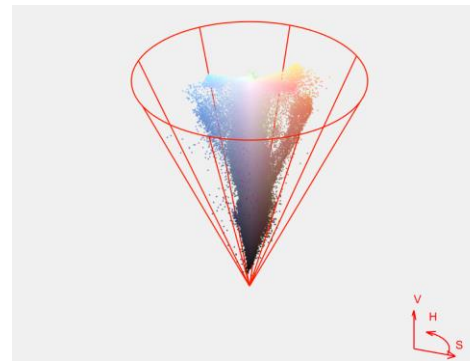
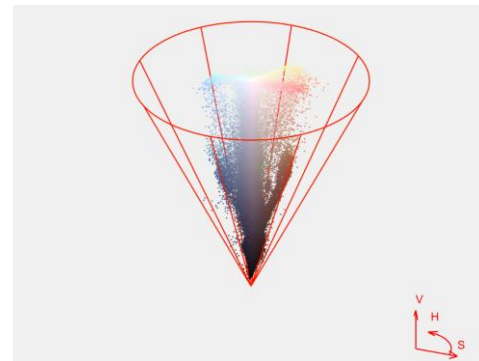
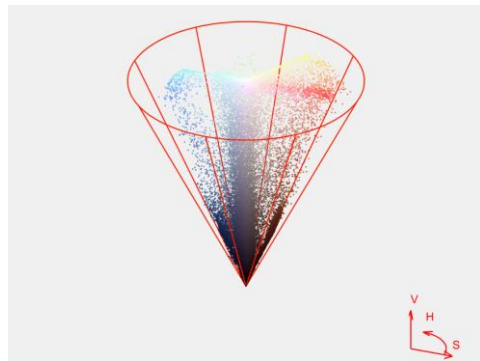
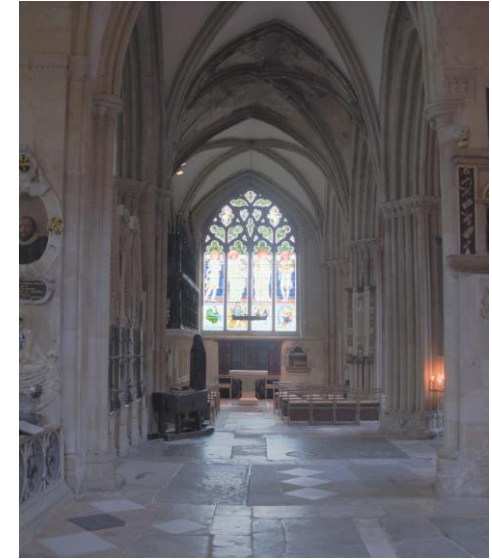
Linear HDR



Gamma 1/2.2



Reinhard et al. Global TMO Reinhard et al. Local TMO





(A) iCAM06 [5]



(C) Kim [18]



(E) Reinhard [6]



(G) IPT



(I) Power low



(B) Reinhard [22]



(D) CIELab



(F) hdr-CIELab [159]



(H) hdr-IPT [159]



(J) New model

Sample TMO results of HDR color appearance models and TMOs.

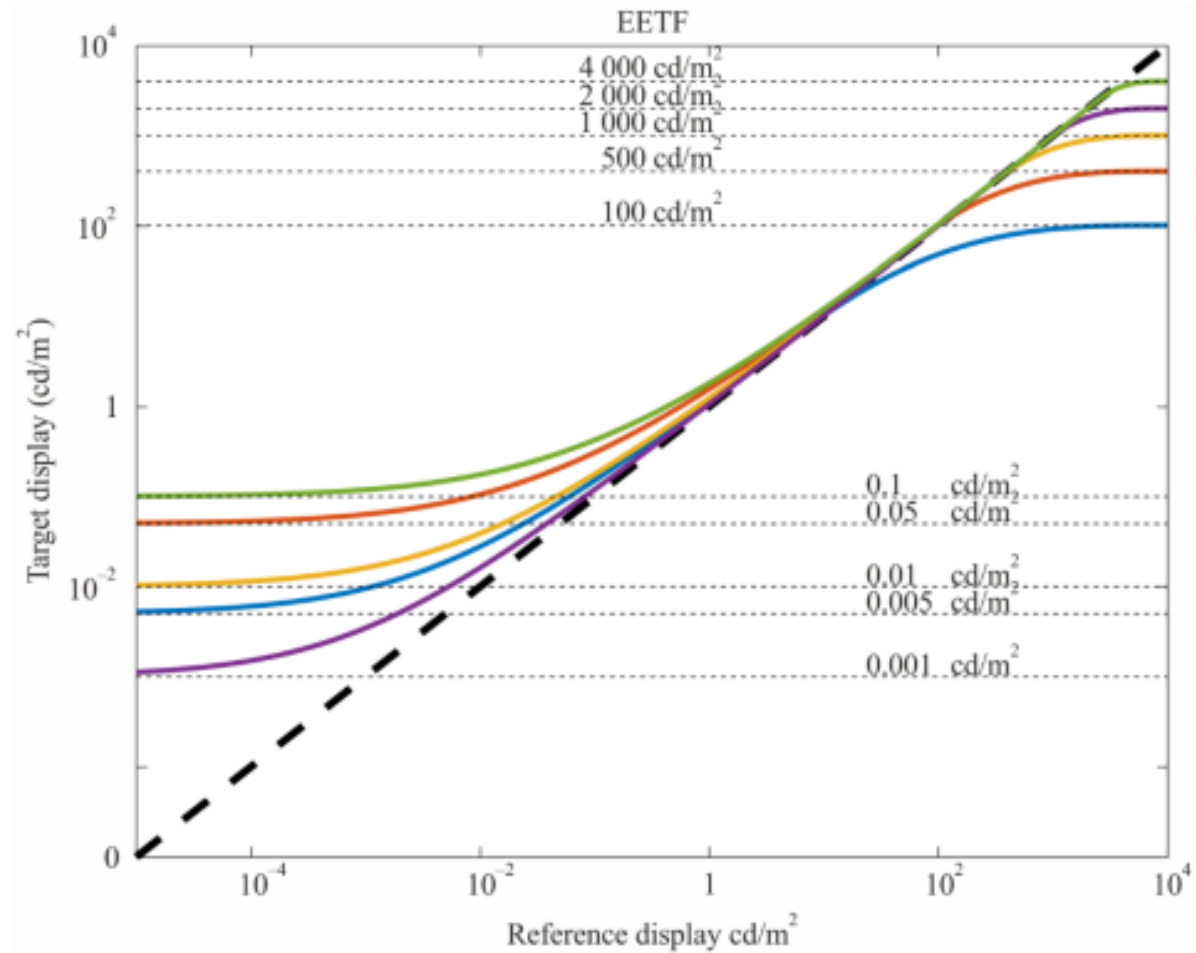
Rep. ITU-R BT.2390-8

Example tone mapping curves to various display black levels and display white levels, given in ITU-R BT. 2390-8.

Hue Shift and saturation change are expected to be noticeable with such global compression of image dynamic ranges.

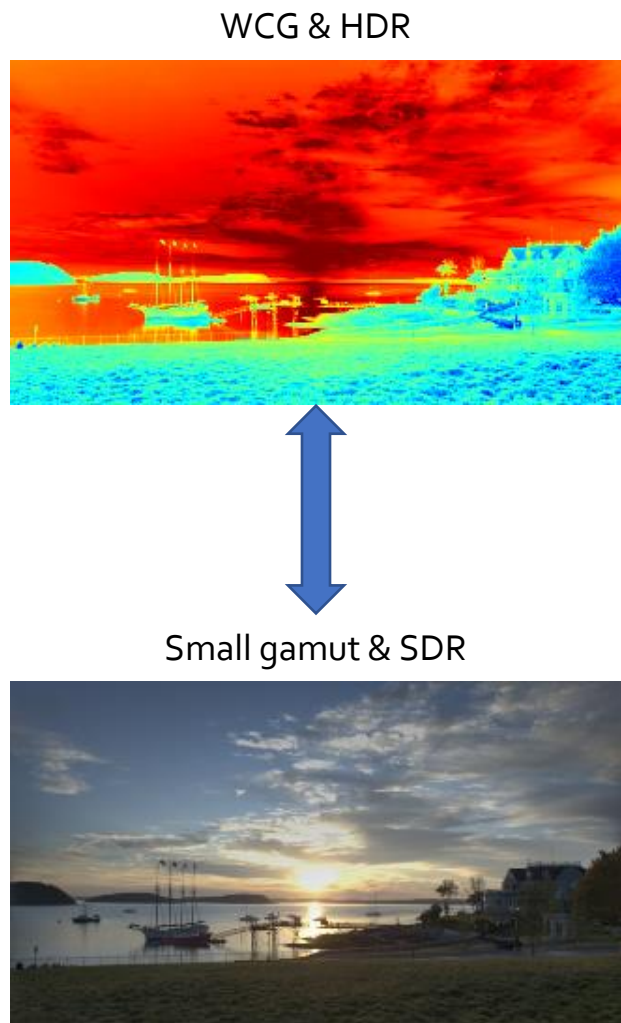
The acceptability of such changes among the end users or how much they affect the artistic intents of the content creators also incur another question.

FIGURE 20
Example EETFs of various target displays

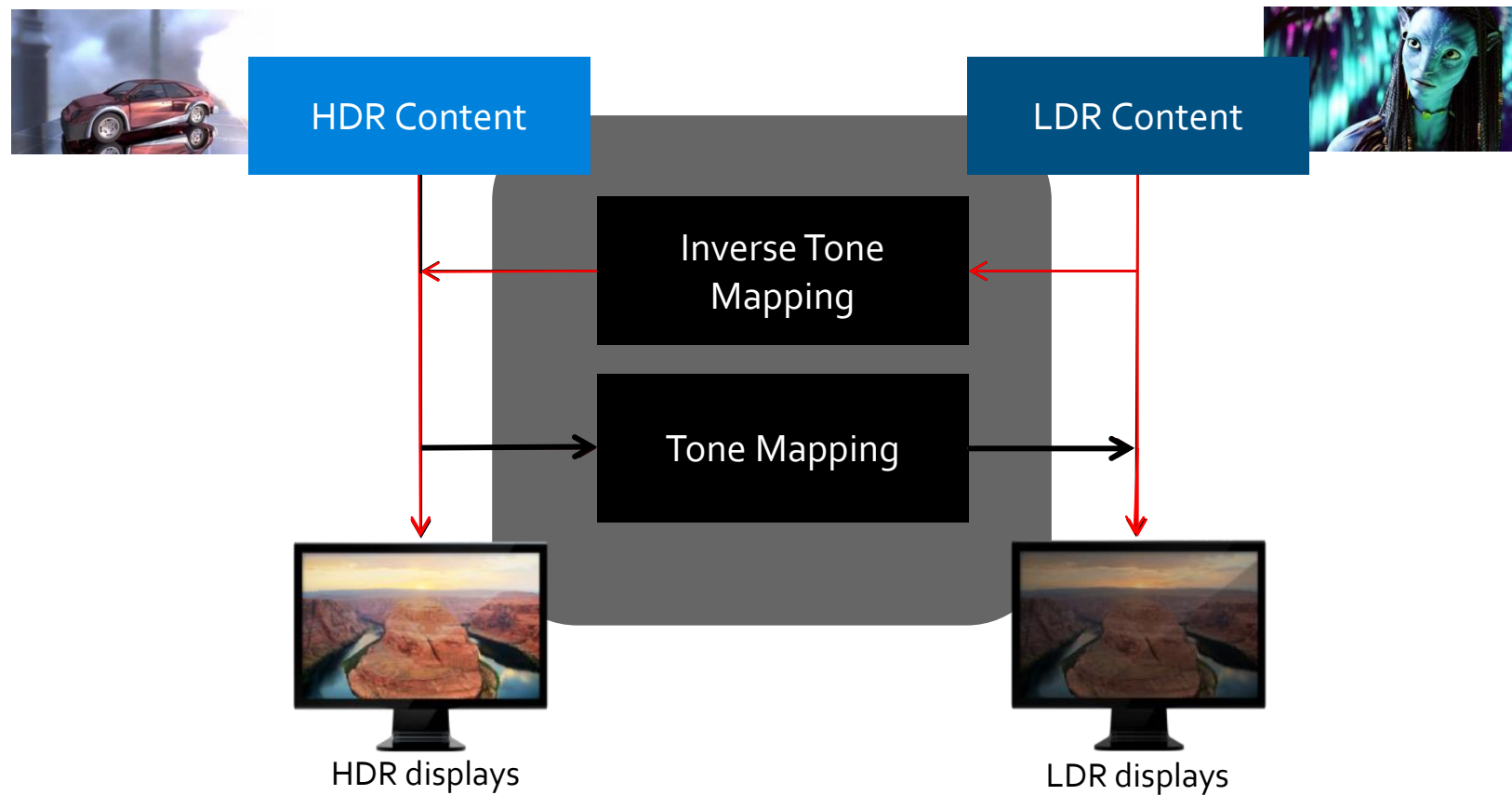


Report BT.2390-20

Current Content production and Devices



High dynamic range imaging: device interoperability



Reverse Tone Mapping



(A) HDR

(C) Kim [18]

(E) Akyuz [13]

(G) IPT

(I) Power low



(B) LDR

(D) CIELab

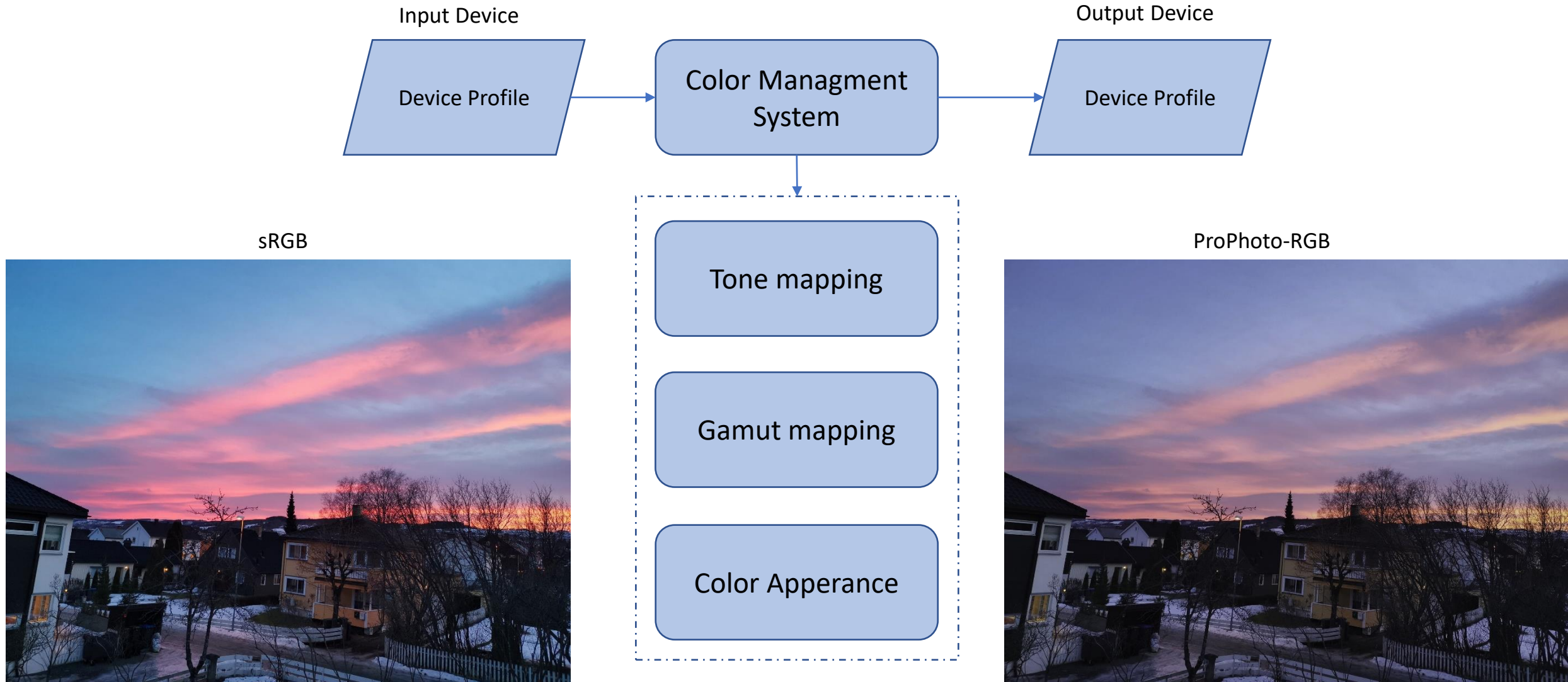
(F) hdr-CIELab [159]

(H) hdr-IPT [159]

(J) New model

Sample rTMO results of 8 color appearance models. All the images for the rTMO results, except the LDR input image, are tone mapped using iCAM06 tone mapping operator for visualization purpose.

Color Management for Good Color Fidelity



Summary

Current browser color management solutions works well with tagged contents in sRGB color gamut.

HDR and WCG support with more adaptive tone mapping solutions is required.

Computationally efficient and color appearance preserving tone mapping operators could be interesting.

SDR images to HDR conversion needs more color corrections than just expanding the luminance ranges.

Perceptual color spaces with good luminance and chrominance channel separation/independence could solve most hue and saturation related color fidelity problems.

References

- Recommendation ITU-R BT.601-5, Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide Screen 16:9 Aspect Ratios.
- Recommendation ITU-R BT.709-5. Parameter values for the HDTV standards for production and international programme exchange.
- Rec. ITU-R BT.2020-2 (10/2015). "Parameter values for ultra-high definition television systems for production and international programme exchange." International Telecommunication Union; Broadcasting service (television). <https://www.itu.int/rec/R-REC-BT.2020>.
- Rec. ITU-R BT.2100-2 (07/2018). "Image parameter values for dynamic range television for use in production and international programme exchange." International Telecommunication Union; Broadcasting service (television). <https://www.itu.int/rec/R-REC-BT.2100>.
- Rec. ITU-R BT.2390-7 (07/2019). "High dynamic range television for production and international programme exchange." International Telecommunication Union; Broadcasting service (television). <https://www.itu.int/pub/R-REP-BT.2390>.
- Stokes, Michael, Matthew Anderson, Srinivasan Chandrasekar, and Ricardo Motta, "A Standard Default Color Space for the Internet - sRGB." November 5, 1996.
- Berns, Roy S. Principles of Color Technology, 3rd ed. New York: John Wiley & Sons, 2000.
- WHAT ARE THE ADVANTAGES OF USING ACES FOR COLOR CORRECTION?, November 19, 2015, <https://www.oscars.org/aces/what-are-advantages-using-aces-color-correction>
- iccMAX: <http://www.color.org/iccmax/index.xalter>
- Fábio Pili, Web browser color management guide, <https://cameratico.com/guides/web-browser-color-management-guide/>
- Erik Reinhard, Greg Ward, Sumanta Pattanaik, and Paul Debevec. 2005. High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting (The Morgan Kaufmann Series in Computer Graphics). Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.
- Mekides Assefa Abebe, PhD thesis, <http://nuxeo.edel.univ-poitiers.fr/nuxeo/site/esupversions/3383e212-0d4e-44e0-a1bf-0cbf904ea6d4>