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Exploring Workflows for Real-Time HDR-SDR Conversion

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.

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India Fleuchaus & Justus Mai

From Brilliance to Balance:

Exploring Workflows for Real-Time HDR-SDR conversion

India Fleuchaus, Justus Mai, Romy Walcher, Lasse Bickelmann, Justin Janßen, Kevin Felkel, Dr. Jan Fröhlich



About Us



Structure

Introduction

Related Work

Methods

Results

Conclusion

Why does anyone need HDR-SDR conversion?

What's the current state of HDR-SDR conversion?

How did we analyze our data?

How do different tone mapping approaches compare?

How does a ideal tone mapper look like?



About Our Paper

- Open project in second semester for research on a self-chosen topic 'HDR use in live broadcast'
 - Creation Reference HDR PQ data set with displayed linear light >1000 cd/m²
 Exploration HDR SDR live & postproduction tone mapping approaches





Inspired by Harald Brendel (ARRI), Timo Kunkel





HDR Systems Hybrid-Log Gamma (HLG) Perceptu

Perceptual Quantization (PQ)

Color Volume

Displayed Linear Light System

Color Space

Displayed Linear Light Reference Display

Color Space Reference Display SMPTE ST 2084 / ITU-R BT.2020

0 - 10.000 cd/m² ITU-R BT.2100

ITU-R BT.2020

0.005 - 1.000 cd/m² ITU-R BT. 2100

> SMPTE ST 2113 DCI-P3



SDR System



Color Volume

Displayed Linear Light System ITU-R BT.709

0 - 100 cd/m² ITU-R BT.709

Color Space

ITU-R BT.709

- For distribution, both HDR and SDR are important (compatibility with all end devices)
- Dual master production is too expensive / complex → simultaneous real-time tone mapping is the solution
- Common issues of tone mapping: color shifts, clipping, low-contrast appearance affecting the creative intent



HDR video levels





HDR PQ Data set: Technical documentation

Color Volume

Displayed Linear Light SMPTE ST 2084 / ITU-R BT.2020

< 4.000 cd/m²

Color Space

Recording in



ITU-R BT.2020

ARRI Log C V3 / AWG V3

Converted via LUT provided by ARRI





Related Work

- considerable amount of literature to be found on various tone mappers
- focus on tone mappers that are already being used in the industry

Tone Mapping Comparison	
Static Tone Mapping	Dynamic Tone Mapping
TV-Show Mapping Example	Dolby Vision
Subjectively Adjusted Hardware Tone Mapping	Reinhard-Devlin Tone Mapper
NBCU PQ to SDR LUT	
SMPTE ST 2065 - ACEScct 1.3	
ITU-R BT.2446 Method A	
ITU-R BT.2446 Method C	

 The AJA FS-HDR was available as a hardware device. ACES and Dolby Vision were applied in DaVinci Resolve. The remaining tone mappers were implemented and applied in Python.



Methods

- How to analyze tone mappers without their specific information on tone mapping functions and gamut mapping?
- Development of a specific test pattern with luminance and color gradients in Python
- Calculation of the difference between the original HDR pattern and the mapped SDR equivalent
- Derivation of the individual mapping characteristics from the examined tone mappers regarding luminance and gamut



J. Froehlich, "Proposal for a standard 3D-LUT format based on PNG-files," presented at the CINEC 2008 International Film Technology Exhibition, Munich, Bavaria, Sep. 2008.



ITU-R BT.2446 - Method A / Method C









TV-Show Mapping Example / Subjectively Adjusted Hardware Tone Mapping







4000 cd/m²

0.8

1.0



ACEScct 1.3 / NBCU PQ-SDR LUT









Dynamic mappings: Dolby Vision / Reinhard Devlin







BT.2446 Method A

BT.2246 Method C

NBCU-LUT

Reinhard-Devlin

ACEScct 1.3



NBCU-LUT









BT.2446 Method A

BT.2246 Method C

NBCU-LUT

Reinhard-Devlin

Dolby Vision

ACEScct 1.3

Reinhard-Devlin









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BT.2446 Method A

BT.2246 Method C

NBCU-LUT

Reinhard-Devlin

Dolby Vision



Subjectively Adjusted Hardware Tone Mapping









BT.2446 Method A

BT.2246 Method C

NBCU-LUT

Reinhard-Devlin

Subjectively Adjusted Hardware Tone Mapping





























TV-Show Mapping Example

NBCU-LUT

BT.2446 Method A







TV-Show Mapping Example LUT Transformation



NBCU LUT Transformation



ITU-R BT.2446 Method A LUT Transformation





Outlook: Customizable tone mapper

- Potential parameters
 - Highlight compression (colloquially known as knee)
 - Contrast
 - Lowlight compression
- Tone mapping information could be embedded in the meta data of files or via SDI as ancillary data
- Goal: Create uniform workflow that works across as many productions and departments as possible (including lighting designers, image engineers or colorists)







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Thank you for your time! We are happy to answer your questions now.

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