HDR problem definition

HDRWG-20-05 Propose an HDR problem definition for HDRWG to address (Wallis, Borg, Revie, Lilley).

Problem statement

Workflows for capture, editing and display of images and graphics have been specified by ICC and ITU. The ICC model is predominantly used for still images (primarily SDR) and the ITU model is predominantly used for moving images (SDR and HDR).

Both workflows provide effective colour management while preserving as much content as possible throughout the workflow with colour conversion being applied at the last step (late binding). There are currently no recommendations for the interchange of content between these two workflows. The main goal as stressed by many is to preserve the creative intent.

This problem has three distinct aspects:

1. the reliable identification of the colour encoding used by the content (enabling content interchange between the two workflows with minimal or no round-tripping loss),
2. the effective processing of ICC-based content in an ITU workflow and
3. the effective processing of ITU-specified content by an ICC workflow.

Assumptions

There are digital cameras that are able to capture high dynamic range (HDR) images and video.

There are displays that are designed to display HDR images and video.

HDR (and SDR) video is colour managed today in cameras, NLEs, phones, and TVs, entirely without ICC profiles, including on many devices where ICC profiles are available.

There is widespread adoption of ICC colour management in computer systems, mobile phones, web browsers and support for ICC Profiles in still image and document formats[1].

There are two basic HDR philosophies loosely described as Hybrid Log Gamma (HLG) and Perceptual Quantisation (PQ) and handling of content encoded using these for broadcast television is well defined in a series of ITU recommendations.

The ITU has developed a set of recommendations for conversion between HLG and PQ and between each of these and the traditional Rec. 709 model. These models (or variations of them) are widely used for the display of video.

The majority (perhaps all) video exchange is based on these ITU recommendations. In some cases, additional metadata is included to provide rendering hints. There are many flavours of HDR rendering metadata; some are for the entire clip (HDR10), some are by frame (Dolby Vision)[2].

Important sources of HDR still images are from HDR video and direct capture from an HDR camera.

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[1] This support is currently limited to support of standard dynamic range (SDR) imaging. The ICC Specification does support a limited form of HDR imaging but that is currently not widely used.

[2] The metadata is intended to be applied only in the final consumption device. Applying the metadata earlier in the editor, especially the frame-specific metadata, can cause frames to be rendered inconsistently, can make editing, color keying, and color grading practically impossible, and can seriously limit the creative intent. A relation to graphics art: Maybe this is similar to not applying OutputIntent while editing a document.

Popular HDR spaces include:

- Video & cinema: ITU-R BT.2100 PQ|HLG, ACES/ACEScg/ACEScct …
- Still images: TBD.

Proprietary HDR workflows: Dolby Vision.

See "The Flavors of HDR video" for more details of HDR video.

ICC known issues

There are some aspects of the ICC model[3] that make support for HDR imaging difficult. It assumes:

- that a source and destination transform can be defined independently of image content,
- that a source transform can be defined independently of the destination device and
- that a destination transform can be defined independently of the source.

There are some secondary issues. It assumes:

- that the display device does not change and that any given display values will produce the same colour.

ITU / ACES known issues

SMPTE HDR report in 2015: https://www.murideo.com/uploads/5/2/9/0/52903137/study_group_on_high-dynamic-range-hdr-ecosystem.pdf

Additional notes from Lars

The big Q: Are we addressing color in the consumption device? Or in the editing device?

Some things I'm missing:

On computers, ICC display profiles are present. In video players, these seem to be used for SDR displays only. So far I haven't seen any HDR display profiles.

Some HDR displays accept HDR encoded pixel data, such as BT.2100 PQ.

Both MacOS and Windows have HDR display buffer color spaces (not using ICC) that use a fixed color space and extended ranges for channel values, for example sRGB with half-float encoding, or BT.2100 PQ. You can't determine the display gamut from this color space info.

We might want to do an inventory of these HDR computer display spaces.

AFAIK HDR videos are rendered on computers without use of ICC profiles.

AFAIK Adobe After Effects is the only product that applies ICC profiles to video sources.

What are the differences between HDR video and HDR stills?

There is of course an intersection such as HDR stills used as background plates in HDR video, and HDR video processed as stills for pixel editing,

But what's outside the intersection? Are there additional aspects that are unique for stills or video? Do we know of HDR stills color spaces that will not be part of video? Etc.

At the end we can tabulate the shortcomings (versus the goals here) of various current color management systems, including ICC, ITU, ACES, ??

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3 There are extensions in iccMAX that are intended to address some of the ICC v4 limitations. While I don't think this approach should be ruled out, it may be difficult to persuade users that this is the right direction as the solution is necessarily complex.