JCTVC-W0086: Indication of SMPTE 2094-10 metadata in HEVC

DOLBY

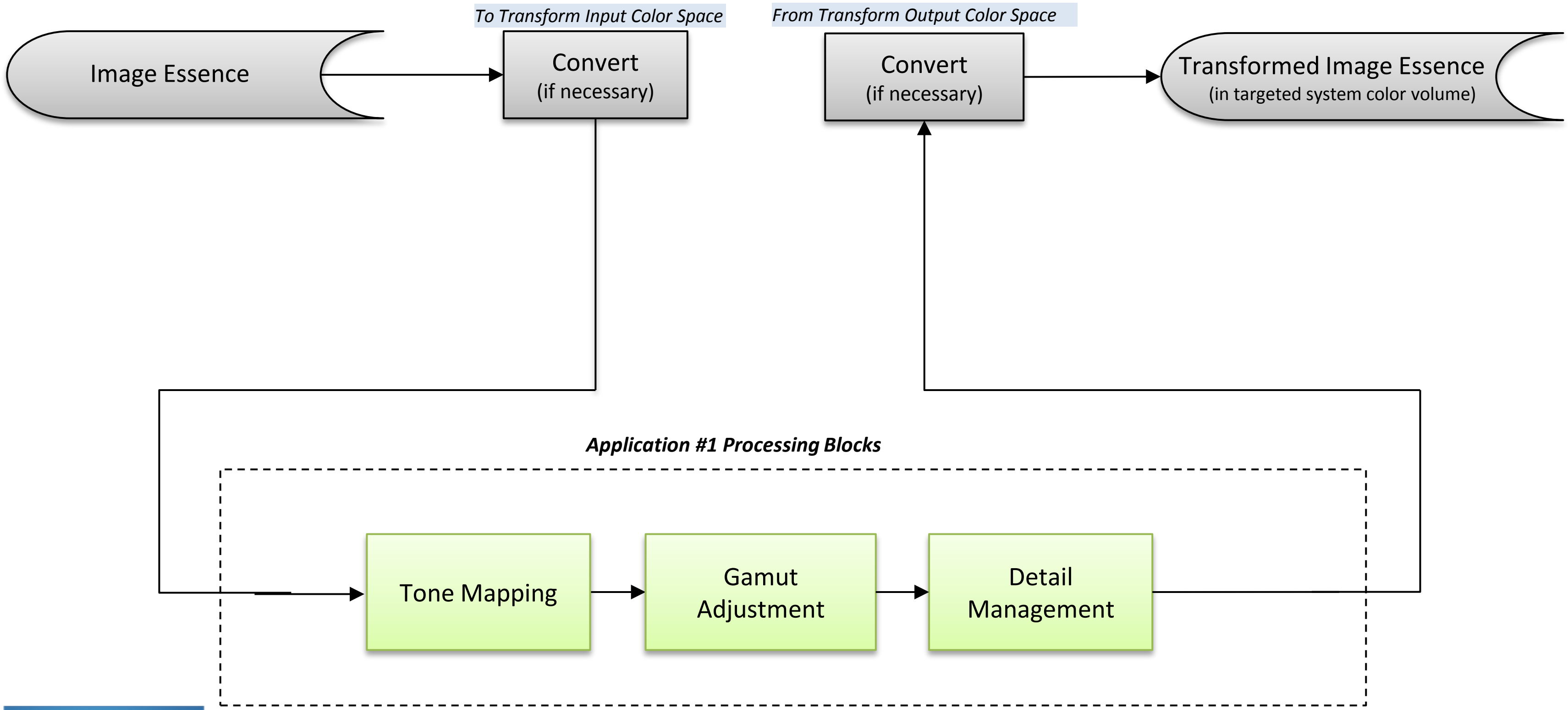
Outline

- Introduction of ST-2094
- Colour volume transform information SEI message for ST-2094-10

SMPTE 2094 Suite

- ST 2094 suite of documents define metadata for use in color volume transforms of content.
  - Intention: transform HDR/WCG source content for presentation on a display having a smaller color volume than source content's mastering display
  - Dynamic metadata: content-dependent and can vary scene-by-scene or frame-by-frame
  - Currently, there are 4 applications in 2094 "family".
- ST 2094-10:
  - Dynamic Metadata for Color Volume Transform - Application #1
  - Based on an adaptive tone mapping curve parameterized by source content characteristics as well as manually set adjustments.

ST-2094-10 Dynamic Metadata Color Volume Transform Model (Annex A: Informative)



ST-2094-10 Dynamic Metadata

- ST-2094-10 defines metadata sets.
- A metadata set shall contain exactly one of each of the following:
  - ApplicationIdentifier (= 1)
  - ApplicationVersion (= 0)
  - TimeInterval
  - ProcessingWindow
  - TargetedSystemDisplay
  - ColorVolumeTransform
    - ImageCharacteristicsLayer
    - ManualAdjustmentLayer (optional)
- The proposed SEI message is one to one mapping from ST-2094-10 metadata to SEI message syntax
  - The informative mapping process (Annex A and B in ST-2094-10) is described in NOTE in semantics to illustrate how to use the syntax.

Colour Volume Transform SEI Message Syntax

colour_volume_transformation_info(payloadSize) {	**Descriptor**
colour_volume_transform_id	ue(v)
colour_volume_transform_cancel_flag	u(1)
if(!colour_volume_transform_cancel_flag) {	
colour_volume_transform_persistence_flag	u(1)
num_metadata_sets_minus1	ue(v)
for (i = 0; i < num_metadata_sets_minus1 + 1; i++) {	
application_identifier[i]	ue(v)
application_version[i]	ue(v)
proc_win_num_id[i]	ue(v)
proc_win_left_offset[i]	ue(v)
proc_win_right_offset[i]	ue(v)
proc_win_top_offset[i]	ue(v)
proc_win_bottom_offset[i]	ue(v)
for(c = 0; c < 3; c++) {	
target_display_primaries_x[i][c]	u(16)
target_display_primaries_y[i][c]	u(16)
}	
target_display_white_point_x[i]	u(16)
target_display_white_point_y[i]	u(16)
max_target_display_luminance[i]	u(32)
min_target_display_luminance[i]	u(32)
min_PQ_maxRGB[i]	u(32)
avg_PQ_maxRGB[i]	u(32)
max_PQ_maxRGB[i]	u(32)
manual_adjustment_flag	u(1)
if (manual_adjustment_flag = = 1) {	
min_PQ_maxRGB_offset[i]	i(32)
avg_PQ_maxRGB_offset[i]	i(32)
max_PQ_maxRGB_offset[i]	i(32)
tone_mapping_offset[i]	i(32)
tone_mapping_gain[i]	u(16)
tone_mapping_gamma[i]	u(16)
chroma_compensation_weight[i]	i(16)
saturation_gain[i]	i(16)
tone_detail_factor[i]	u(16)
}	
}	
}	
}	

ProcessingWindow

TargetSystemDisplay

ImageCharacteristics

ManualAdjustment

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Annex B: Parametric Tone Mapping Method Description (Informative)

Tone Curve Design

- Goals:
  - Perceptually unchanged – maintain contrast
  - Except at toe and shoulder
- Map log to log (or perceptual) linearly
- Controls:
  - Three anchor points
    - Minimum luminance
    - Mid-point / adaptation point
    - Maximum luminance
  - Mid-region slope

Tone Mapping Function (*f*)

$$L_t = \frac{c_1 + c_2 L^n}{1 + c_3 L^n}$$

Conditions:
$$L_{s,\min} \rightarrow L_{t,\min}$$
$$L_{a,s} \rightarrow L_{a,t}$$
$$L_{s,\max} \rightarrow L_{t,\max}$$

Short-hands:
$$(x_1, x_2, x_3) = (L^n_{s,\min}, L^n_{a,s}, L^n_{s,\max})$$
$$(y_1, y_2, y_3) = (L_{t,\min}, L_{a,t}, L_{t,\max})$$

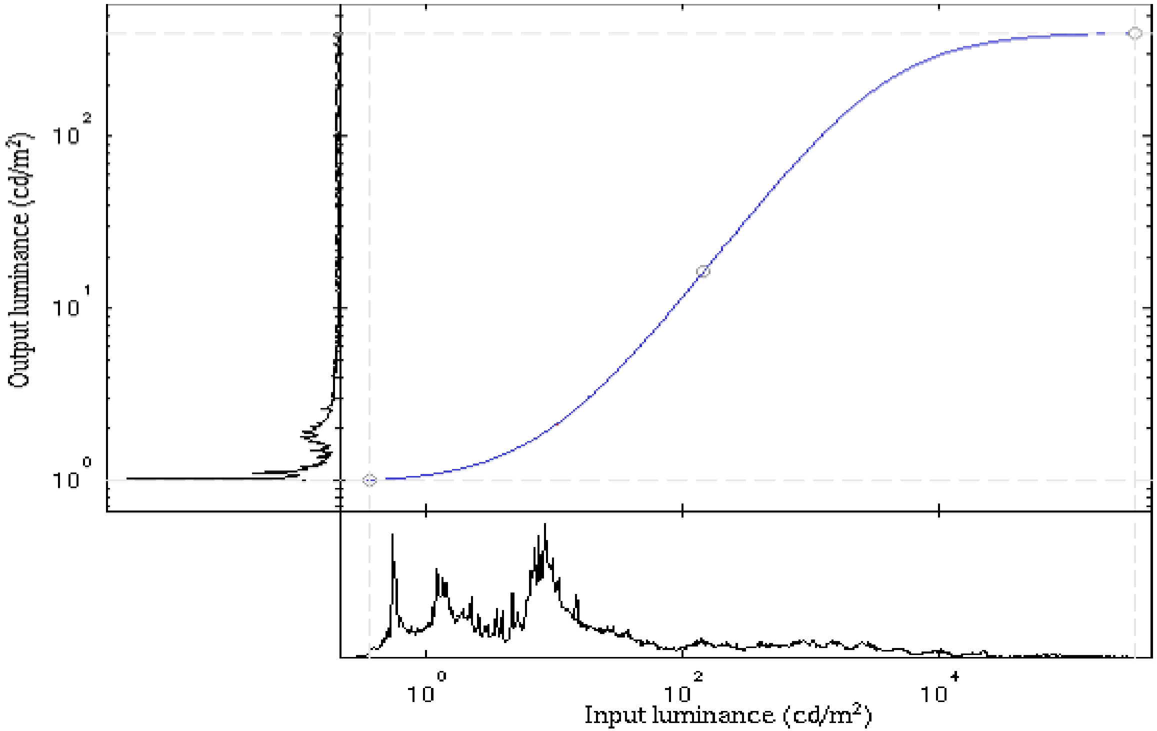
and:
$$L_{a,t} = \sqrt{L_{a,s}\sqrt{L_{t,\min} L_{t,\max}}}$$

System Solve:

$$\begin{pmatrix} c_1 \\ c_2 \\ c_3 \end{pmatrix} = \frac{1}{\alpha} \begin{pmatrix} x_2 x_3 (y_2 - y_3) & x_1 x_3 (y_3 - y_1) & x_1 x_2 (y_1 - y_2) \\ x_3 y_3 - x_2 y_2 & x_1 y_1 - x_3 y_3 & x_2 y_2 - x_1 y_1 \\ x_3 - x_2 & x_1 - x_3 & x_2 - x_1 \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix}$$

with: $\alpha = x_3 y_3 (x_1 - x_2) + x_2 y_2 (x_3 - x_1) + x_1 y_1 (x_2 - x_3)$

Example Curve



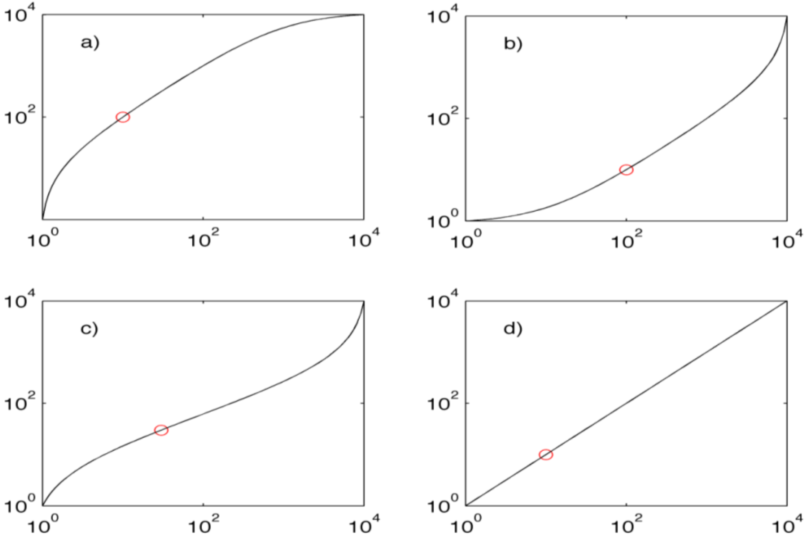
Variants

brightening

darkening

expansion

pass-through



estimated adaptation points
(axes are arbitrarily chosen)

Application

- Linear RGB Space (e.g. PQ use ST 2084)
  - input = (max + Δ_{max}, average + $\Delta_{average}$, min + Δ_{min})

$$R \rightarrow R_{tm} = f(R, S')$$
$$G \rightarrow G_{tm} = f(G, S')$$
$$B \rightarrow B_{tm} = f(B, S')$$

parameter set *S'* = (*c1, c2, c3, n=1*)

- Adjustments (optional)
  - Input = (offset, gain, gamma) for RGB channels (C_i)

$$C_{i,a} = \left(C_{i,tm} \times gain + offset\right)^{gamma}$$

  - *offset* in range [-0.5, 0.5]
  - *gain* in range [0.5, 1.5]
  - *gamma* in range [0.5, 1.5]

Application (Continue)

- Chroma-Saturation (optional)
  - Affected by Saturation Gain (*s*), Chroma Weight Offset (*c*)

$$C_{i,out} = C_{i,a} \times \left(\left((1+c) \times \frac{C_{i,a}}{Y} \right)^{s} \right)$$

  - *s* in range [-0.5, 0.5], Saturates (De-saturates) with *s* > 0.0 (< 0.0)
  - *c* in range [-0.5, 0.5], compensate from *s*
- Conversion to target space in RGB
  - Mastering display (ST 2086)
  - Targeted System Specification
- Detail Management (optional)
  - Affected by Tone-Detail Weight in range [0, 1]