Tone expression in television applications

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Background

- Everybody talks about high dynamic range (HDR).
- But, there's a lot of disagreement as to what that actually is.
- Members in ITU-R has been trying to define dynamic range by using bit-depth, OETF/EOTF, scene/screen luminance, peak brightness, average brightness, black level,,
- But, there's no agreed definition yet.

- In this presentation: some perspectives are given from television application point of view.
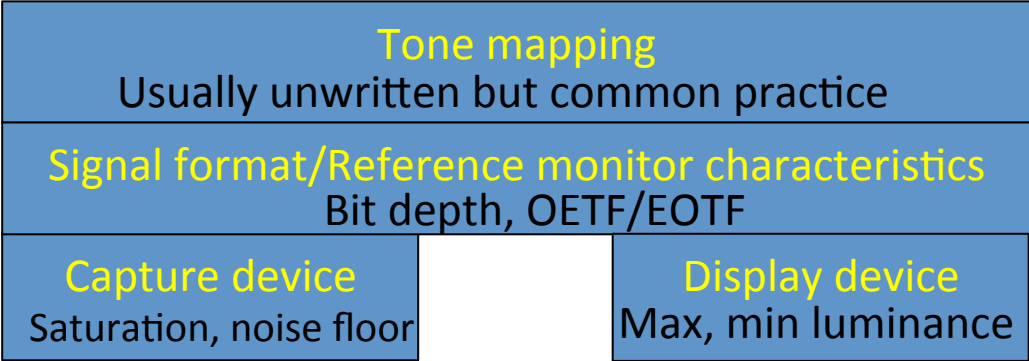
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HPA Tech Retreat

Tone reproduction to be improved in current TV applications

1. Loss of detail in high-light portion due to level compression

2. Decrease in color saturation in high luminance portion

3. Difficulty in the reproduction of differently illuminated scenes, e.g., sun-lit and sun-shade

4. Tone jump (banding) in dark scene (8 bit delivery)

5. Loss of detail in dark portion at end-user in bright-surrounding viewing environment

Items 1 to 3 will be discussed.

Which part we are talking about?
- dynamic range hierarchy in TV -

Tone mapping
Usually unwritten but common practice

Signal format/Reference monitor characteristics
Bit depth, OETF/EOTF

Capture device
Saturation, noise floor

Display device
Max, min luminance

Operational practice (OP)

System standard (SS)

Device performance (DP)

Scene-referred

Display-referred

Log display luminance

Log scene luminance
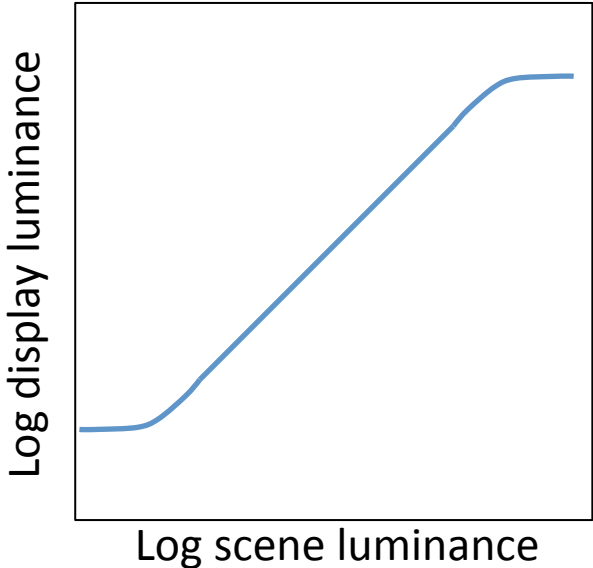
Proposed general requirements for television broadcast applications

- Significant improvement in user visual experience in terms of tone reproduction

- Reasonable cost

- Acceptable change from current practice at production and presentation ends

- Satisfactory compatibility with current practices

Problem-solution matrix

Solution	Tier	1: clip in high-light	2: drop in color saturation	3: differently illuminated scenes
A: Higher brightness display	DP	**	-	*
B: Deeper bit depth	SS	*	-	*
C: More efficient quantization	SS	*	-	*
D: Increased "head room"	OP	***	***	**
E: Improved tone mapping	OP	**	**	***

DP: Display performance
SS: System standard
OP: Operational practice

*** : required
** : applicable
* : may be helpful
- : not related

A: Higher brightness display
D: Increased "head room"

- Combination of D & A seems major approach.

- Display technologies already provide several hundred cd/m^2, and much more is possible.

- Major change in production practice
  - Will mastering on a higher brightness monitor automatically make HDR programs easily exchangeable?
    Or do we need standardized operational practice?
  - Can HDR master be automatically tone-mapped for current/legacy displays?

- Major change in end-users' practice
  - How to adjust the display for various viewing environments?
    - Current practice: CONTRAST and BRIGHTNESS knobs controlled by user
  - Are there any point of view other than "wow-factor"?
    - Comfortableness, burden on eyes

- How much head room? and How to implement are the real issues.

B: Deeper bit depth
C: More efficient quantization

- Secondary issue that may be derived from solution D: Increased "head room".

- Solution B: Deeper bit depth
  - Small change from current practice
  - Rec. BT.2020 already specifies 12 bit.

- Solution C: More efficient quantization
  - Large change from current practice is not desirable.
    - Processing and monitoring with encoded signals in program production and post-production
  - Quality and cost should be studied in the delivery with compression technology.

E: improved tone mapping

- We want to extend scene dynamic range.

- Increase display maximum luminance as well?

- "HDR" for still picture application is to compress the dynamic range into conventional displays.
    - Space-variant approach, e.g., Retinex
    - Similar approach is applicable to television application?
    - Technical feasibility not yet proven.
    - Difference between still and motion media?
    - Difference between reflective and self-emitting display?

HDR in still picture applications

iPhone HDR off

iPhone HDR on

Conclusion

- Tone reproduction to be improved in current TV applications

- Main objective is to enlarge reproducible scene range.
  - Q1: Display's physical luminance range as well?

- Increase in "head room" is Major solution
  - Q2: to what extent?
  - Q3: how to implement?

- Q4: What do you think about improved tone-mapping as an alternative approach?

- We must find a solution that fits the requirements.

Thank you!

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Appendix