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| *Title:* | **Luma/Chroma QP Adaptation for Hybrid Log-Gamma Sequences Encoding** | | |
| *Status:* | Input document to JVET | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution presents a study of luma/chroma QP adaptation for hybrid log-gamma sequences encoding. For PQ content, both luma QP adaptation and chroma QP offset is meaningful to improve the subjective quality. Similar approach is applied to the HLG content to study the subjective quality influence. Based on the subjective evaluation, luma QP adaptation provide negligible improvement while chroma QP offset provides significant improvement at the ultra-low bitrate range.

# Problem statements

The new HDR contents with hybrid log-gamma (HLG) transfer function is proposed in the past meetings [1]. The rate point candidates are also proposed in this meeting. Encoding configuration and QP adaptation is not yet studied well.

The HDR/WCG data by HLG which is ready for compression will exhibit slightly different characteristics than both typical, standard dynamic range (SDR) data and HDR date by Perceptual Quantizer (PQ) transfer function. This means that it may be possible to increase perceptual/subjective quality if the encoder is configured in a slightly different manner compared to when compressing SDR data or PQ data. This contribution presents two such differences in data characteristics and proposes how an encoder may be configured to better exploit these differences.

In this contribution, technical report [2] for PQ HDR/WCG encoding are considered for HLG content.

# Proposed configuration

## Luma-dependent adaptive quantization

The purpose is to try and match a similar level of distortion to a particular, gray level, luminance value x when either the power law transfer function of Rec. ITU-R BT.709 or that of HLG transfer function are used, in combination with 10 bit quantization as well as a codec’s quantization level. More specifically, it is highly desirable to determine the QP value QPHLG to be used with a PQ encoded value x, that would result in the same or similar distortion, or equivalently the same or similar quantization behavior Quant( ), if that same value was encoded using the Rec. ITU-R BT.709 transfer function and a known QP value QP709­. That is:

The linear characteristics of the transformations employed on residual data in codecs such as AVC and HEVC enable the consideration of these formulations even after such transformations are performed. However, these also limit the consideration of such an optimization at a block level. Based on the characteristics of the Rec. ITU-R BT.709 and HLG transfer function and the above formula, an approximate relationship between QPPQ and QP709 can be computed as:

In this contributions, we assume that 100 nits in the scene luminance is corresponding to the code word 940 in BT.709 and 502 in HLG transfer function. Since the transfer curve of BT.709 and HLG is the same in the dark areas where is less than 100 nits, shifting bits is not required. On the other hand, the transfer curves are different in the bright areas where is larger than 100nits. Firstly, we simply convert the signal, which is proportional to scene linear light and scaled by camera exposure, normalized to the range [0:12], into 10 bit integer representation by the transfer curve of BT.709. In the remaining part, we borrow the procedure of “luma quantization noise” [3]. We approximate the code words by code words, which model is given as:

Let us consider the effect of a small perturbation of a luma value on the Y709 representation. It can be modelled in closed form by taking the derivative of the above model. This is expressed as:

The amplification factor appeared in the above equation can be re-expressed as quantization step size. Using the definition of a QP step in HEVC, we can express this as:

We note that this relationship may be further simplified by observing that the curve is generally linear for larger luma values. Fitting a linear line to these values, we see get the following model:

Since the constant value can be ignored in the QPs’ relation, dQP is decreased at every 72 in code word of 10 bit integer representation for HLG.

This relationship is depicted in Table 1 with intL replacing the value of x. More specifically, in a particular implementation, intL is computed by obtaining the average luma value of a 64×64 CTU block, Laverage, and then rounding this quantity, i.e. intL= Round(Laverage). Based on this relationship, for every CTU, the QP will be adjusted according to its brightness by this dQP value.

Table 1 Look-up table of the dQP value from the average of the luma value.

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| **luma intL range** | **dQP** |
| intL < 525 | 0 |
| 525 ≤ intL < 597 | −1 |
| 597 ≤ intL < 669 | −2 |
| 669 ≤ intL < 741 | −3 |
| 741 ≤ intL < 813 | −4 |
| 813 ≤ intL < 885 | −5 |
| intL ≥ 885 | −6 |

Finally, HM configuration is shown as follows.

LumaLevelToDeltaQPMode : 1

LumaLevelToDeltaQPMappingLuma : 0,0,0,0,525,597,669,741,813,885

It is noted that the LumaLevelToDeltaQPMappingDQP setting is reused from default value settings; from 3 to −6.

## Chroma QP offset

Chroma QP offset settings for HLG content are studied based on the technical report [2].

It is assumed that the colour primaries of the mastering display/capture device are known. Based on this knowledge a model is used to assign QP offsets for Cb and Cr based on the luma QP and a factor based on the capture and representation colour primaries. The model in the TR is expressed as:

where ccb = 1 and ccr = 1 since the capture colour primaries are the same as the representation colour primaries.

and . These values are equaled to that for development of the TR. The latest TR utilize while the studies were conducted by using in historical reason. We also use the historical values. The above model is then not reasonable for low QP settings.

Finally, HM configuration is shown as follows.

WCGPPSEnable : 1

WCGPPSChromaQpScale : -0.46 # Linear chroma QP offset mapping (scale)

WCGPPSChromaQpOffset : 9.26 # Linear chroma QP offset mapping (offset)

WCGPPSCbQpScale : 1.00 # Scale factor depending on capture and representation color space (with BT.2020 container use 1.14 for BT.709 material and 1.04 for P3 material)

WCGPPSCrQpScale : 1.00 # Scale factor depending on capture and representation color space (with BT.2020 container use 1.79 for BT.709 material and 1.39 for P3 material)

# Simulation results

The base coding configuration is follow the rate point candidates which means qpif settings are set the same parameter. To clarify the effectiveness, the configuration except the proposed part is same but obtained bitrate is different due to the QP control.

Subjective evaluation of 2nd lowest bitrates for each content are conducted. Summary is described in Table 2. L and C indicates luma and chroma adaptation in the table.

Table 3 Comments by subjective evaluation

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| Title | Thumbnail | Brief description |
| HLG-1 | HLG1_thumb | Moving crane (Slightly panning)  L: No effectiveness is confirmed.  C: Fake color is dramatically reduced. |
| HLG-2 | HLG2_thumb | Drift ice from moving ship (Track up)  L: No effectiveness is confirmed due no highlight area.  C: Fake color like green is reduced on the edge of ices. |
| HLG-3 | HLG3_thumb | Trees and river from a boat (Track up)  L: Small reduction of blockiness on cloud.  C: No effectiveness is confirmed due to low chrominance. |
| HLG-4 | HLG4_thumb | Waterfall and mountains(Fixed)  L: Small reduction of blockiness on top-right cloud.  C: Fake color on spay is reduced but not perfect. |
| HLG-5 | HLG5_thumb | Waterfall (Fixed)  L: No effectiveness is confirmed.  C: Fake color on spay is reduced but not perfect. |
| HLG-6 | HLG6_thumb | Branches with highlight (Slightly panning)  L&C: No effectiveness is confirmed due to high subjective quality. |
| HLG-7 | HLG7_thumb | Sunset beach (Fixed)  L&C: No effectiveness is confirmed. |

# Conclusion

In this contribution, we proposed encoder configuration for HLG content. Similar to the configuration for PQ content, both luma-dependent adaptive quantization and chroma QP offset are studied. Subjective evaluation presents luma QP adaptation provide negligible improvement while chroma QP offset provides significant improvement at the ultra-low bitrate range.

# References

1. Shunsuke Iwamura and Atsuro Ichigawa “New HDR 4K test sequences with Hybrid Log-Gamma transfer characteristics”, JVET-E0086, Geneva, CH, 12–20 January 2017.
2. Jonatan Samuelsson, Chad Fogg, Andrey Norkin, Andrew Segall, Jacob Ström, Gary Sullivan, Pankaj Topiwala, and Alexis Tourapis, “Conversion and Coding Practices for HDR/WCG Y′CbCr 4:2:0 Video with PQ Transfer Characteristics (Draft 4)”, JCTVC-Z1017, Geneva, CH, 12–20 January 2017.
3. Jie Zhao, Seung-Hwan Kim, Andrew Segall, and Kiran Misra, “Performance investigation of high dynamic range and wide color gamut video coding techniques”, ISO/IEC JTC1/SC29/WG11 MPEG2015/M37439, Geneva, Switzerland, October 2015.

# Patent rights declaration(s)

**KDDI Corporation does not have any current or pending patent rights relating to the technology described in this contribution.**