|  |  |
| --- | --- |
| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  24th Meeting: Geneva, CH, 26 May – 1 June 2016 | Document: JCTVC-X0078r1 |

|  |  |  |  |
| --- | --- | --- | --- |
| *Title:* | **Crosscheck of JCTVC-X0072: On** **closed form HDR 4:2:0 chroma subsampling (AHG13 related)** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Crosscheck | | |
| *Author(s) or Contact(s):* | Taoran Lu, Fangjun Pu, Peng Yin 432 Lakeside Dr,  Sunnyvale, CA 94085, USA | Tel: Email: | +1-408-330-3252 [tlu@dolby.com](mailto:tlu@dolby.com)  [pyin@dolby.com](mailto:pyin@dolby.com) |
| *Source:* | Dolby Laboratories, Inc. | | |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Abstract

This document reports a crosscheck results for proposal JCTVC-X0072 on closed form HDR 4:2:0 chroma subsampling. X0072 evaluated several luma adjustment algorithms (disable, iterative micro-grading, proposed Algorithm1 and proposed Algorithm2) and also studied practical scenario using mismatched upsampling filters. We repeated the experiments and the objective metrics matched with those results provided in JCTVC-X0072. Results indicate that the difference in performance of Algorithm 2 and micro-grading is smaller than the performance drop when the upsampling filter in the “decoder” mismatches the upsampling filter in the “encoder”. For the test dataset, the subjective quality of the Algorithm 2 is indistinguishable to micro-grading with lower complexity.

# Introduction

Luma adjustment was initially introduced to correct the non-constant luminance error of NCL YCbCr introduced in chroma downsampling in the pre-processing stage before encoding. The original iterative micro-grading algorithm used in current Anchor generation process is having very high complexity due to the iterative close loop conversion. JCTVC-X0072 [1] proposed two closed-form solutions to reduce the complexity and tested its effect under various conditions.

The experiments are conducted using v0.11 of HDRTools software [2] and are purely conversion-only tests consisting end to end RGB to YCbCr420 to RGB conversion. Several luma adjustment algorithms are evaluated by setting different values of parameter “ClosedLoopConversion” in HDRTools configuration file:

* Direct: disable luma adjust (ClosedLoopConversion = 0)
* Micro-grading: iterative luma adjust with 10 iterations (ClosedLoopConversion = 5)
* Algorithm1: (ClosedLoopConversion = 16)
* Algorithm2: (ClosedLoopConversion = 17)

The downsampling filter and upsampling filter used in pre-processing are kept same as in Anchor generation process. In post process, an additional test set with mismatched upsampling filters are conducted as well. Table 1 summarizes the parameter settings in the 16 test cases. Note that one difference from this experiment to the Anchor is that the parameters OutputChromaLocationTop, OutputChromaLocationBottom, SourceChromaLocationTop, SourceChromaLocationBottom are set to default value (0) instead of 2 which is used in Anchor.

**Table 1. Parameter setting in Test Cases**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **ct709 match upfilter** | | | | **ct2020 match upfilter** | | | | **ct709 mismatch upfilter** | | | | **ct2020 mismatch upfilter** | | | |
| **Test Case** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** |
| **Pre-process:** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| OutputColorPrimaries | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| ChromaDownsampleFilter | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| ChromaUpsampleFilter | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| ClosedLoopConversion | 0 | 5 | 16 | 17 | 0 | 5 | 16 | 17 | 0 | 5 | 16 | 17 | 0 | 5 | 16 | 17 |
| **Post-process:** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| SourceColorPrimaries | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| ChromaUpsampleFilter | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |

# Simulation results

Table 2 shows the PSNR results for conversion only in different test cases. These results match those provided in JCTVC-X0072 (Table 1-4). It can be observed from the results that Algorithm 2 minimizing the linear luminance closely resembles in performance the luma micro-grading algorithm. The difference between the performance of Algorithm 2 and Micro-grading is smaller than the drop in performance of either of these two algorithms when the upsampling filter in the “decoder” does not match the upsampling filter in the “encoder”. Per-sequence results can be found in the attached excel sheet.

Table 2. PSNR for conversion results of Y’CbCr in different test cases

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **tPSNR-X** | **tPSNR-Y** | **tPSNR-Z** | **tPSNR-XYZ** | **tOSNR-XYZ** | **DE100** | **MD100** | **PSNRL100** |
| BT.709 in BT.709 container | matched upsampling filter | direct | 50.96 | 55.04 | 47.97 | 50.30 | 50.29 | 39.28 | 22.59 | 45.48 |
| micro-grading | 56.51 | 69.78 | 47.64 | 51.83 | 51.35 | 39.76 | 22.65 | 49.63 |
| algorithm1 | 59.37 | 54.02 | 46.79 | 50.55 | 50.64 | 39.90 | 22.47 | 44.13 |
| algorithm2 | 56.50 | 67.02 | 47.61 | 51.78 | 51.33 | 39.76 | 22.59 | 49.29 |
| mismatched upsampling filter | direct | 51.17 | 55.24 | 48.09 | 50.45 | 50.34 | 39.27 | 22.38 | 45.49 |
| micro-grading | 55.87 | 64.56 | 47.72 | 51.77 | 51.18 | 39.68 | 22.42 | 48.33 |
| algorithm1 | 56.80 | 53.36 | 46.81 | 50.33 | 50.25 | 39.71 | 22.24 | 43.78 |
| algorithm2 | 55.86 | 63.38 | 47.68 | 51.72 | 51.16 | 39.68 | 22.37 | 48.13 |
| BT.2020 container | matched upsampling filter | direct | 52.65 | 62.76 | 45.52 | 49.41 | 48.27 | 38.11 | 22.67 | 48.36 |
| micro-grading | 54.33 | 69.66 | 45.22 | 49.45 | 48.39 | 38.20 | 22.68 | 50.27 |
| algorithm1 | 56.59 | 54.72 | 46.05 | 49.77 | 49.07 | 38.27 | 22.64 | 44.95 |
| algorithm2 | 54.36 | 68.46 | 45.22 | 49.45 | 48.39 | 38.20 | 22.66 | 50.03 |
| mismatched upsampling filter | direct | 52.82 | 62.95 | 45.66 | 49.55 | 48.34 | 38.12 | 22.69 | 48.39 |
| micro-grading | 54.37 | 68.43 | 45.36 | 49.57 | 48.44 | 38.21 | 22.69 | 49.90 |
| algorithm1 | 55.78 | 54.50 | 46.11 | 49.78 | 48.90 | 38.25 | 22.66 | 44.84 |
| algorithm2 | 54.40 | 67.32 | 45.36 | 49.57 | 48.44 | 38.21 | 22.68 | 49.68 |

We also observed the complexity difference between the tested algorithms. All the conversions are conducted on the same testing platform (Xeon-E5-2643v2@3.5GHz, RAM=128GB CentOS system). Measured by the conversion speed in frames per second (fps), Table 3 shows the complexity comparison. It is observed that enabling close loop conversion with iterative micro-grading takes about 8x (eight times) time compared to not using it; while using the proposed closed-form algorithms 1 and 2, the conversion speed is about 3x (three times) to the iterative micro-grading.

Table . Pre-processing conversion speed comparison

|  |  |  |
| --- | --- | --- |
|  | **pre-processing conversion speed (fps)** | **complexity** |
| direct | 0.77 | low |
| micro-grading | 0.10 | high |
| algorithm1 | 0.28 | medium |
| algorithm2 | 0.28 | medium |

# Subjective quality comparisons

We performed subjective viewing of the Market clip on HDR display.

For test cases in BT.2020 container, the subjective quality of all test algorithms (disabling luma adjust, micro-grading, algorithm1, algorithm2) are indistinguishable.

For test cases in BT. 709 container, luma adjust algorithms (micro-grading, algorithm1, algorithm2) show advantage than disabling luma adjustment. The performances of the iterative micro-grading and proposed Algorithm 2 are indistinguishable. When mismatched upsampling filters are used for closed loop luma adjustment, some subjective artifacts are observed (example is shown in Figure 1), indicating that the difference in performance of Algorithm 2 and micro-grading is smaller than the performance drop when the upsampling filter in the “decoder” mismatches the upsampling filter in the “encoder”.



Figure Market in BT.709 container: comparison of the test cases

# References

1. Andrey Norkin, “On closed form HDR 4:2:0 chroma subsampling (AHG13 related)”, JCTVC-X0072, May. 2016, Geneva, CH.
2. HDRTools software package (Apple). Alexis M. Tourapis.