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| *Title:* | **Non-SCE1: Improved color gamut scalability** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This proposal tested two improvements based on asymmetric 3D LUT for SHVC color gamut scalability (CGS) proposed in JCTVC-P0063 under SCE1 core experiment test conditions. It can reduce the computation complexities. For usecase 2 test, the proposed scheme reportedly achieves average {Y, U, V} BD rate gain of {-8.3%, -10.0%, -12.9%}, and {6.0%, -6.9%, -10.5%} for AI and RA-2x, respectively.

# Introduction

The bit-depth and color gamut scalability with 3D LUT is investigated in SCE1 [4]. JCTVC-P0128 [2] and JCTVC-P0186 [3] reported CE results with symmetric 3D LUT. JCTVC-P0063 [1] proposed asymmetric 3D LUT to reduce the size of 3D LUT and improve the performance with 3D LUT parameter update at picture level. However, the computation complexity of JCTVC-P0063 [1] is higher because color gamut conversion is applied after upsampling. In this proposal, we made two changes to JCTVC-P0063 to reduce the computation complexity and improve the performance: (1) apply color gamut conversion before upsampling; (2) add luma and chroma phase alignment for luma 3D LUT interpolation.

# Simplified asymmetric 3D LUT

Based on the software of JCTVC-P0063 [1], color gamut conversion with asymmetric 3D LUT is moved before upsampling. For the 8-bit BL and 10-bit EL test case, bit-depth and color gamut are converted with 3D LUT at the same stage, and “O0194\_JOINT\_US\_BITSHIFT” is disabled. This reduces computation complexity since the conversion process is applied on ¼ of the pixels.

For YUV 420 video, luma samples and chroma samples are not fully aligned. Figure 1 shows the default grid of luma and chroma sample locations for YUV420 video. Because 3D LUT is cross color component processing, we added a simple linear filter to align the luma and chroma sample locations.

Specifically, if luma L4, L5, L8, L9 in Figure 1 are to be interpolated with 3D LUT, the input chroma components are derived with simple resampling filters as follows:

C(L4) = (C0\*3 + C2 + 2)>>2

C(L5) = ((C0+C1)\*3 + (C2+C3) + 4)>>3

C(L8) = (C0 + C2\*3 + 2)>>2

C(L9) = ((C0+C1) + (C2+C5)\*3 + 4)>>3

For color gamut conversion of the chroma components, the luma component is derived with 4 nearest points averaging, which is the same as JCTVC-P0063 [1].



Figure . Default phase shift between luma and chroma samples for YUV420 chroma format: squares are luma samples, circles are chroma samples

# Simulation results

The compression performance is measured using BD rate compared with SCE1 anchors, using the SCE1 test conditions [4]. We only reported the performance of use case 2 with two settings listed in Table 1. Table 2 and Table 3 gives the detailed average BD rate reduction for use case 2 compared with SCE1 anchors with two settings, respectively.

Table . The configuration of settings

|  |  |  |
| --- | --- | --- |
| **Setting** | **the place of color gamut conversion** | **chroma alignment filtering** |
| 1 | Before upsampling | Disabled |
| 2 | Before upsampling | Enabled |

As shown in Table 1, compared with SCE1 anchors, the setting 1 achieves average {Y, U, V} BD rate gain of {-7.6%, -9.5%, -12.4%}, and {-5.6%, -6.4%, -10.0%} for AI and RA-2x, respectively. As shown in Table 2, the setting 2 achieves average {Y, U, V} BD rate gain of {-8.3%, -10.0%, -12.9%}, and {-6.0%, -6.9%, -10.5%} for AI and RA-2x, respectively.

Table 2. Average BD rate reduction for setting 1 compared with SCE1 anchors

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **AI HEVC 2x 10-bit base** | | | **AI HEVC 2x 8-bit base** | | |
|  | Y | U | V | Y | U | V |
|  |  |  |  |  |  |  |
| Class A+ | -7.6% | -9.5% | -12.5% | -7.5% | -9.4% | -12.4% |
| **Overall (Test vs Ref)** | -7.6% | -9.5% | -12.5% | -7.5% | -9.4% | -12.4% |
| **Overall (Test vs single layer)** | 9.5% | 11.0% | 3.6% | 12.0% | 12.8% | 4.9% |
| **Overall (Ref vs single layer)** | 18.5% | 22.8% | 18.1% | 21.2% | 24.7% | 19.4% |
| **EL only (Test vs Ref)** | -15.2% | -16.6% | -19.6% | -15.1% | -16.6% | -19.5% |
| **Overall (Test EL+BL vs single EL+BL)** | -28.4% | -27.6% | -33.2% | -26.7% | -26.5% | -32.4% |
| Enc Mem[%] | #DIV/0! | | | #DIV/0! | | |
| BL Match | Matched | | | Matched | | |
|  |  |  |  |  |  |  |
|  | **RA HEVC 2x 10-bit base** | | | **RA HEVC 2x 8-bit base** | | |
|  | Y | U | V | Y | U | V |
|  |  |  |  |  |  |  |
| Class A+ | -5.6% | -6.4% | -10.1% | -5.5% | -6.4% | -9.8% |
| **Overall (Test vs Ref)** | -5.6% | -6.4% | -10.1% | -5.5% | -6.4% | -9.8% |
| **Overall (Test vs single layer)** | 20.2% | 25.2% | 13.9% | 22.1% | 26.8% | 15.3% |
| **Overall (Ref vs single layer)** | 27.5% | 33.7% | 26.9% | 29.2% | 35.2% | 27.9% |
| **EL only (Test vs Ref)** | -10.7% | -11.0% | -14.7% | -10.5% | -10.9% | -14.3% |
| **Overall (Test EL+BL vs single EL+BL)** | -20.0% | -15.9% | -23.9% | -18.9% | -15.2% | -23.2% |
| Enc Mem[%] | #DIV/0! | | | #DIV/0! | | |
| BL Match | Matched | | | Matched | | |

Table 3. Average BD rate reduction for setting 2 compared with SCE1 anchors

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **AI HEVC 2x 10-bit base** | | | **AI HEVC 2x 8-bit base** | | |
|  | Y | U | V | Y | U | V |
|  |  |  |  |  |  |  |
| Class A+ | -8.3% | -10.0% | -13.0% | -8.2% | -10.0% | -12.8% |
| **Overall (Test vs Ref)** | -8.3% | -10.0% | -13.0% | -8.2% | -10.0% | -12.8% |
| **Overall (Test vs single layer)** | 8.6% | 10.3% | 3.0% | 11.2% | 12.1% | 4.3% |
| **Overall (Ref vs single layer)** | 18.5% | 22.8% | 18.1% | 21.2% | 24.7% | 19.4% |
| **EL only (Test vs Ref)** | -16.1% | -17.3% | -20.4% | -16.0% | -17.3% | -20.2% |
| **Overall (Test EL+BL vs single EL+BL)** | -29.0% | -28.0% | -33.6% | -27.3% | -26.9% | -32.8% |
| Enc Mem[%] | #DIV/0! | | | #DIV/0! | | |
| BL Match | Matched | | | Matched | | |
|  |  |  |  |  |  |  |
|  | **RA HEVC 2x 10-bit base** | | | **RA HEVC 2x 8-bit base** | | |
|  | Y | U | V | Y | U | V |
|  |  |  |  |  |  |  |
| Class A+ | -6.1% | -6.9% | -10.7% | -5.9% | -6.9% | -10.4% |
| **Overall (Test vs Ref)** | -6.1% | -6.9% | -10.7% | -5.9% | -6.9% | -10.4% |
| **Overall (Test vs single layer)** | 19.7% | 24.6% | 13.2% | 21.5% | 26.0% | 14.5% |
| **Overall (Ref vs single layer)** | 27.5% | 33.7% | 26.9% | 29.2% | 35.2% | 27.9% |
| **EL only (Test vs Ref)** | -11.3% | -11.6% | -15.4% | -11.1% | -11.6% | -15.1% |
| **Overall (Test EL+BL vs single EL+BL)** | -20.4% | -16.3% | -24.5% | -19.3% | -15.6% | -23.9% |
| Enc Mem[%] | #DIV/0! | | | #DIV/0! | | |
| BL Match | Matched | | | Matched | | |

# Patent rights declaration(s)

**InterDigital Communications, Inc. may have IPR relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**

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