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| *Title:* | **Non-SCE1: De-noising of inter-layer reference** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution presents test results for de-noising of inter-layer reference frame for color-gamut scalability. De-noising is achieved by filtering “zero-phase” positions by 2D separable FIR consistent with SHVC re-sampling filter. Two variants are tested: non-switchable and picture based on/off de-noising of inter-layer reference. Under SCE1 test conditions algorithm shows in average 1.5% (×1) and 0.3% (×2) BD-rate gain for non-switchable version and 1.6% (×1) and 0.6% (×2) BD-rate gain for non-switchable version. It is demonstrated that gain is additive with performance improvement provided by other tools for color-gamut scalability in SCE1 and non SCE1 contributions.

# Introduction

De-noising filter for inter-layer reference frame was proposed in several variations: non-switchable, Picture based on/off or PU-based on/off [1], [2] and studied SCEs. For example, this is known that this tool doesn’t increase the worst case memory access. De-noising effect is achieved by filtering integer pel positions during inter-layer reference frame creation. The highest gain from this tool was shown in SNR test: 1,3% (non-switchable), 1,5% (Picture based on/off) and 1,9% (PU based on/off) average BD-rate gain. If both bit-depth, resolution and color-gamut are the same for enhancement and base layers then no inter-layer processing is needed (SNR test for non CGS content). But in SCE1 [3] color-gamut scalability is studied and even layers have the same spatial re-solution inter-layer processing is required due to difference in bit-depth or color gamut.

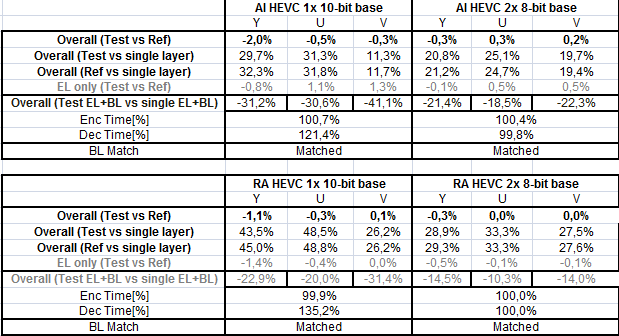
This contribution presents test results for the simplest (non-switchable) implementation of de-noising [1] and picture based switchable de-noising filter [2]. Filter coefficient are the same with [1] and [2]. So this tool is well known and was extensively studied during SHVC development. New tests were performed using SCE1 test conditions (different color gamut for base and enhancement layers and all-intra ×1 tests were not studied before).

# Experimental results

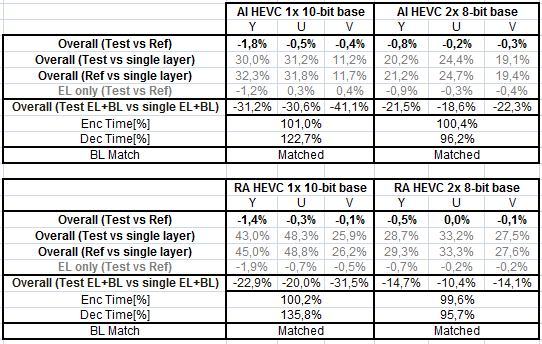
Tests were performed using 2 layers with different color-gamut (BT709 for base layer and BT2020 for enhancement layer) according to SCE1 description [1]. Results are summarized in Table 1. Gain shown by de-noising of inter-layer reference frame in RA×1 test is consistent with performance demonstrated for non CGS content [1]. For all-intra (AI×1) configuration tool is tested for the first time and gain is twice higher than in RA×1 test.

For test content with the same color-gamut at base and enhancement layers de-noising of reference frame show good performance is resolutions of base and enhancement layers are the same. But for CGS content tool appears to be useful even for spatial scalability test: 0,3% (non-switchable version) – 0,6% (picture based on/off). For ×1 ratio average gain is 1,5% (non-switchable version) – 1,6% (picture based on/off).

**Table 1.** Brief summary of test results for non-switchable de-noising filter of inter-layer reference picture.



**Table 2.** Brief summary of test results for picture based switchable de-noising filter of inter-layer reference picture.



Increment of decoding time in ×1 tests comes due to picture based inter-layer processing implementation in the reference s/w. As it was proved in demonstrated SCE rounds with proper implementation w/o redundant inter-layer processing this tool should not critically increase decoding time even in×1 test.

# Interaction with other tools for color-gamut scalability

Proposed tool was tested if integrated on top of 2 proposals improving performance of SHVC for color gamut scalability:

* JCTVC-Q0056 [4] proposes encoder modification for weighted prediction based color-gamut scalability (which is SCE1 anchor)
* JCTVC-Q0048 [5] proposes cross-color inter-layer filter with asymmetric 3D LUT for color-gamut scalability

Performance of listed tools and proposed de-noising of inter-layer reference on top is summarized in Table 3.

Table 3. Summary of performance tests on top of other tools for color-gamut scalability.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| test | description | AI×1 | RA×1 | AI×2 | RA×2 |
| Only de-noising | | | | | |
| DNF | Non-switchable de-noising filter | -2,0% | -1,1% | -0,3% | -0,3% |
| DNF\_Pic | Picture based-switchable DNF | -1,8% | -1,4% | -0,8% | -0,5% |
| Encoder modification for weighted prediction based color-gamut scalability + | | | | | |
| iWP | Improved weighted prediction [4] | -1,6% | -2,1% | -1,2% | -1,1% |
| iWP +DNF | Non-switchable de-noising filter on top of [4] | -3,8% | -3,5% | -1,5% | -1,4% |
| iWP +DNF\_Pic | Picture based-switchable DNF on top of [4] | -3,3% | -3,7% | -1,9% | -1,6% |
| Cross-color inter-layer filter with asymmetric 3D LUT + (Sps\_Pps\_period = 0 ) | | | | | |
| 3D LUT | asymmetric 3D LUT [5] | -9,8% | -10,1% | -8,1% | -5,9% |
| 3D LUT +DNF | Non-switchable de-noising filter on top of [4] | -12,0% | -11,3% | -8,4% | -6,2% |
| 3D LUT +DNF\_Pic | Picture based-switchable DNF on top of [4] | -12,0% | -11,5% | -8,9% | -6,4% |
| Cross-color inter-layer filter with asymmetric 3D LUT +(Sps\_Pps\_period = 1 ) | | | | | |
| 3D LUT | asymmetric 3D LUT [5] | -9,9% | -10,4% | -8,1% | -6,0% |
| 3D LUT +DNF | Non-switchable de-noising filter on top of [4] | -12,1% | -11,7% | -8,4% | -6,3% |
| 3D LUT +DNF\_Pic | Picture based-switchable DNF on top of [4] | -12,2% | -11,9% | -8,9% | -6,5% |

Results from Table 3 confirm that proposed tool doesn’t conflict with other tools improving color gamut scalability: gain is additive sometimes even synergy is observed.

# Additional features

Bit-depth conversion is merged with re-sampling process in current SHVC draft. If spatial resolutions are the same between layers then reference s/w has the bug which was fixed by [6]. Proposed de-noising of inter-layer reference frame operates on a same way as re-sampling filter and so bit-depth conversation is merged with inter-layer filtering (so proposed solution also solves the problem reported in [6]).

# Conclusion

De-noising of reference frame by filtering of “zero-phase” positions appears to be useful in term of performance improvement for both ×1 and ×2 cases if color-gamut is different between layers. Under SCE1 test conditions algorithm shows 1.5% (×1) and 0.3% (×2) BD-rate gain for non-switchable version and 1.6% (×1) and 0.6% (×2) BD-rate gain for non-switchable version. It is demonstrated that gain is additive with performance improvement provided by other tools for color-gamut scalability in SCE1 and non SCE1 contributions.

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# Patent rights declaration(s)

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