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| *Title:* | **Performance of Combined Skip Slice and Adaptive Filter tools** | | |
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| *Author(s) or Contact(s):* | Yong He, Yuwen He, Xiaoyu Xiu, Yan Ye 9710 Scranton Rd, Suite 250 San Diego, CA 92121, USA  Tomoyuki Yamamoto, Yukinobu Yasugi  1-9-2 Nakase, Mihama-ku, Chiba-shi, Chiba, JAPAN | Tel: Email:  Tel: Email: | +1-858-210-4807 [Yong.He@InterDigital.com](mailto:Yong.He@InterDigital.com)  +81 43 299 8696  [yamamoto.tomoyuki@sharp.co.jp](mailto:yamamoto.tomoyuki@sharp.co.jp) |
| *Source:* | InterDigital Communications, LLC  SHARP Corporation | | |

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# Abstract

In this contribution, the performance of combined tools, skipped slice mode and inter-layer adaptive filter, is presented for SHVC. The skipped slice mode uses up-sampled base layer reconstructed picture directly as the enhancement layer reconstruction to achieve better rate distortion performance. The inter-layer adaptive filter improves the quality of up-sampled base layer reconstruction which further enhances the performance of skipped slice.

# Introduction

Enhancement layer skipped slice mode uses up-sampled base layer reconstructed picture directly as the enhancement layer reconstruction. The skip slice mode can sometimes offer better rate distortion performance. When such is the case, only inter layer processing parameters, used to generate the inter layer reference, need to be sent at picture (or slice) level, and no additional coding of the blocks in the enhancement layer picture is performed, which significantly reduces decoding complexity as well. EL skipped slice (EL-Skip) mode was proposed in InterDigital SHVC CFP response [1] and was assigned to TE-A2 [2] in JCTVC 11th meeting.

In the proposed tool, the encoder uses R-D cost to determine whether to choose the EL Skip mode for the enhancement layer picture. The percentage of EL skipped slices depends on the video content, the correlation between the layers, as well as on the relatively rate allocation between the base and the enhancement layers.

The up-sampled base layer reconstruction quality is one the major factors determining the percentage of EL skipped slices. A number of inter-layer filters were proposed in JCTVC 11th meeting and assigned to TE-B4 for performance evaluation [3]. Among these tools, the TE4-4.4.1, adaptive filter prior to inter-layer prediction from K0032 [4], achieves the outstanding coding performance in all test cases. The TE4-4.4.1 adaptive Filter (AF) is applied to the up-sampled base-layer reconstruction; a 5x5 square shape filter characterized by 13 coefficients is used to each pixel. Filtering can be turned on and off in a unit called AF unit. The AF units are represented by quad-tree structure, of which max depth is equal to 3.

# Simulation results

Table 1 is the EL-Skip simulation results on IntraBL framework, the reference is the Smuc 0.1.1 intraBL.

1. EL-Skip simulation results (vs. Smuc0.1.1 intraBL)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AI HEVC 2x** | | | **AI HEVC 1.5x** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class A | 0.0% | 0.0% | 0.0% |  |  |  |  |  |  |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| **Overall (EL+BL)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| **Overall (EL)** | 0.0% | 0.0% | 0.0% | -0.4% | -0.4% | -0.4% |  |  |  |
| Enc Time[%] | 98.3% | | | 97.1% | | |  |  |  |
| Dec Time[%] | 97.9% | | | 96.2% | | |  |  |  |
| BL Match | Matched | | | Matched | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **RA HEVC 2x** | | | **RA HEVC 1.5x** | | | **RA HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% |  |  |  | 0.0% | 0.0% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (EL+BL)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (EL)** | 0.0% | 0.0% | 0.0% | -0.2% | 0.0% | -0.4% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 99.9% | | | 99.9% | | | 100.7% | | |
| Dec Time[%] | 96.8% | | | 94.7% | | | 99.6% | | |
| BL Match | Matched | | | Matched | | | Matched | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **LD-P HEVC 2x** | | | **LD-P HEVC 1.5x** | | | **LD-P HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% |  |  |  | 0.0% | 0.0% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (EL+BL)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (EL)** | 0.0% | 0.1% | 0.0% | -0.9% | 0.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 98.6% | | | 101.1% | | | 97.4% | | |
| Dec Time[%] | 97.0% | | | 96.1% | | | 98.2% | | |
| BL Match | Matched | | | Matched | | | Matched | | |

Table 2 is the AF simulation results on IntraBL framework, the reference is the Smuc 0.1.1 intraBL results.

1. AF simulation results (vs. Smuc 0.1.1 intraBL)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AI HEVC 2x** | | | **AI HEVC 1.5x** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class A | -0.3% | -1.0% | -1.0% |  |  |  |  |  |  |
| Class B | -0.4% | -0.5% | -0.5% | -0.7% | -1.0% | -1.1% |  |  |  |
| **Overall (EL+BL)** | -0.4% | -0.7% | -0.7% | -0.7% | -1.0% | -1.1% |  |  |  |
| **Overall (EL)** | -0.7% | -1.5% | -1.4% | -2.7% | -3.7% | -3.4% |  |  |  |
| Enc Time[%] | 111.0% | | | 109.8% | | |  |  |  |
| Dec Time[%] | 162.4% | | | 156.3% | | |  |  |  |
| BL Match | Matched | | | Matched | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **RA HEVC 2x** | | | **RA HEVC 1.5x** | | | **RA HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -0.3% | -0.6% | -0.6% |  |  |  | -4.7% | -2.6% | -2.0% |
| Class B | 0.2% | 0.2% | 0.3% | -0.3% | -0.4% | 0.0% | -1.3% | -0.4% | 0.2% |
| **Overall (EL+BL)** | 0.0% | 0.0% | 0.1% | -0.3% | -0.4% | 0.0% | -2.2% | -1.0% | -0.4% |
| **Overall (EL)** | 0.0% | -0.2% | 0.0% | -1.2% | -1.5% | 0.0% | -4.6% | -2.5% | -1.3% |
| Enc Time[%] | 103.9% | | | 104.0% | | | 103.3% | | |
| Dec Time[%] | 207.3% | | | 194.6% | | | 205.1% | | |
| BL Match | Matched | | | Matched | | | Matched | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **LD-P HEVC 2x** | | | **LD-P HEVC 1.5x** | | | **LD-P HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -0.4% | -0.9% | -0.9% |  |  |  | -6.7% | -3.2% | -3.0% |
| Class B | -0.3% | -0.4% | -0.3% | -0.8% | -1.2% | -0.7% | -2.2% | -1.3% | -0.6% |
| **Overall (EL+BL)** | -0.4% | -0.6% | -0.4% | -0.8% | -1.2% | -0.7% | -3.5% | -1.9% | -1.3% |
| **Overall (EL)** | -0.8% | -1.3% | -1.0% | -2.5% | -3.8% | -2.3% | -6.5% | -4.1% | -3.1% |
| Enc Time[%] | 105.3% | | | 103.8% | | | 105.3% | | |
| Dec Time[%] | 208.0% | | | 196.5% | | | 218.7% | | |
| BL Match | Matched | | | Matched | | | Matched | | |

Table 3 is the combined EL-Skip and AF simulation results on IntraBL framework, the reference is the Smuc 0.1.1 intraBL results.

1. Combined AF and EL-Skip simulation results (vs. Smuc0.1.1 intraBL)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AI HEVC 2x** | | | **AI HEVC 1.5x** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class A | -0.3% | -1.0% | -1.0% |  |  |  |  |  |  |
| Class B | -0.4% | -0.5% | -0.5% | -0.7% | -1.0% | -1.1% |  |  |  |
| **Overall (EL+BL)** | -0.4% | -0.7% | -0.7% | -0.7% | -1.0% | -1.1% |  |  |  |
| **Overall (EL)** | -0.7% | -1.5% | -1.4% | -3.2% | -4.1% | -3.8% |  |  |  |
| Enc Time[%] | 113.0% | | | 108.0% | | |  |  |  |
| Dec Time[%] | 159.6% | | | 149.3% | | |  |  |  |
| BL Match | Matched | | | Matched | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **RA HEVC 2x** | | | **RA HEVC 1.5x** | | | **RA HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -0.3% | -0.6% | -0.6% |  |  |  | -4.7% | -2.6% | -2.0% |
| Class B | 0.2% | 0.2% | 0.3% | -0.3% | -0.4% | -0.1% | -1.3% | -0.4% | 0.2% |
| **Overall (EL+BL)** | 0.0% | 0.0% | 0.1% | -0.3% | -0.4% | -0.1% | -2.2% | -1.0% | -0.4% |
| **Overall (EL)** | -0.1% | -0.2% | -0.1% | -1.4% | -1.6% | -0.4% | -4.6% | -2.5% | -1.3% |
| Enc Time[%] | 105.3% | | | 100.9% | | | 101.6% | | |
| Dec Time[%] | 196.7% | | | 178.6% | | | 180.7% | | |
| BL Match | Matched | | | Matched | | | Matched | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **LD-P HEVC 2x** | | | **LD-P HEVC 1.5x** | | | **LD-P HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -0.4% | -0.9% | -0.9% |  |  |  | -6.7% | -3.2% | -3.0% |
| Class B | -0.3% | -0.4% | -0.3% | -0.8% | -1.2% | -0.7% | -2.2% | -1.3% | -0.6% |
| **Overall (EL+BL)** | -0.4% | -0.5% | -0.4% | -0.8% | -1.2% | -0.7% | -3.5% | -1.9% | -1.3% |
| **Overall (EL)** | -0.8% | -1.3% | -1.0% | -3.3% | -4.2% | -2.6% | -6.5% | -4.1% | -3.1% |
| Enc Time[%] | 111.6% | | | 97.2% | | | 108.0% | | |
| Dec Time[%] | 211.7% | | | 168.3% | | | 195.5% | | |
| BL Match | Matched | | | Matched | | | Matched | | |

Table 4 is the combined EL-Skip and AF simulation results on IntraBL framework, the reference is the HM8.1 simulcast results.

1. Combined AF and EL-Skip simulation results (vs. HM8.1 simulcast)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AI HEVC 2x** | | | **AI HEVC 1.5x** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class A | -27.2% | -27.7% | -28.5% |  |  |  |  |  |  |
| Class B | -21.3% | -21.6% | -21.3% | -33.0% | -33.5% | -33.5% |  |  |  |
| **Overall (EL+BL)** | -23.0% | -23.4% | -23.4% | -33.0% | -33.5% | -33.5% |  |  |  |
| **Overall (EL)** | -35.1% | -35.8% | -36.0% | -58.8% | -59.1% | -59.3% |  |  |  |
| Enc Time[%] | 127.0% | | | 120.4% | | |  |  |  |
| Dec Time[%] | 172.2% | | | 161.8% | | |  |  |  |
| BL Match | Matched | | | Matched | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **RA HEVC 2x** | | | **RA HEVC 1.5x** | | | **RA HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -18.7% | -8.2% | -9.6% |  |  |  | -24.9% | -14.1% | -13.4% |
| Class B | -15.4% | -9.0% | -7.6% | -26.2% | -20.5% | -18.8% | -20.4% | -11.4% | -7.9% |
| **Overall (EL+BL)** | -16.3% | -8.8% | -8.2% | -26.2% | -20.5% | -18.8% | -21.7% | -12.1% | -9.5% |
| **Overall (EL)** | -25.2% | -13.5% | -12.8% | -47.2% | -38.3% | -35.4% | -34.3% | -20.4% | -16.5% |
| Enc Time[%] | 119.1% | | | 115.9% | | | 113.1% | | |
| Dec Time[%] | 300.0% | | | 282.0% | | | 205.9% | | |
| BL Match | Matched | | | Matched | | | Matched | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **LD-P HEVC 2x** | | | **LD-P HEVC 1.5x** | | | **LD-P HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -13.9% | -2.4% | -3.6% |  |  |  | -19.3% | -10.2% | -9.1% |
| Class B | -12.0% | -7.2% | -5.2% | -22.2% | -17.6% | -15.7% | -14.6% | -6.5% | -2.4% |
| **Overall (EL+BL)** | -12.5% | -5.8% | -4.7% | -22.2% | -17.6% | -15.7% | -16.0% | -7.5% | -4.3% |
| **Overall (EL)** | -20.0% | -9.1% | -7.6% | -41.1% | -33.5% | -30.2% | -25.6% | -14.3% | -9.5% |
| Enc Time[%] | 117.2% | | | 111.6% | | | 109.1% | | |
| Dec Time[%] | 314.5% | | | 284.3% | | | 211.7% | | |
| BL Match | Matched | | | Matched | | | Matched | | |

Table 5 shows additional gain achieved by EL-Skip based on AF approach. Comparing to AF only simulation results, the skipped slice further improves overall (EL) luma gain by 0.4% on AI 1.5x case, 0.1% on RA 1.5x case and 0.7% on LD-P 1.5x case. The coding time is not accurate here because 2 sets of data were running on different clusters.

1. Combined AF and EL-Skip simulation results (vs. Smuc 0.1.1 intraBL AF)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AI HEVC 2x** | | | **AI HEVC 1.5x** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class A | 0.0% | 0.0% | 0.0% |  |  |  |  |  |  |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| **Overall (EL+BL)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| **Overall (EL)** | 0.0% | 0.0% | 0.0% | -0.4% | -0.4% | -0.4% |  |  |  |
| Enc Time[%] | 116.6% | | | 115.9% | | |  |  |  |
| Dec Time[%] | 119.3% | | | 117.7% | | |  |  |  |
| BL Match | Matched | | | Matched | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **RA HEVC 2x** | | | **RA HEVC 1.5x** | | | **RA HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% |  |  |  | 0.0% | 0.0% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (EL+BL)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (EL)** | 0.0% | 0.0% | 0.0% | -0.1% | 0.0% | -0.3% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 113.0% | | | 108.2% | | | 109.2% | | |
| Dec Time[%] | 120.9% | | | 116.1% | | | 120.6% | | |
| BL Match | Matched | | | Matched | | | Matched | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **LD-P HEVC 2x** | | | **LD-P HEVC 1.5x** | | | **LD-P HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% |  |  |  | 0.0% | 0.0% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (EL+BL)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (EL)** | 0.0% | 0.1% | 0.0% | -0.7% | 0.4% | 0.1% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 118.1% | | | 107.7% | | | 114.2% | | |
| Dec Time[%] | 124.8% | | | 114.0% | | | 125.7% | | |
| BL Match | Matched | | | Matched | | | Matched | | |

Table 6 shows the number of skipped slice increment by combining AF and EL-Skip. It can be concluded that the EL-Skip performance and processing complexity, both from the percentage of skipped slice and the overall BD performance, can be further improved by the sophisticated inter-layer filtering with enhancd up-sampled base layer reconstruction quality.

1. Number of skipped slice comparison on LD-P test case

|  |  |  |
| --- | --- | --- |
| LowDelay\_P | # Skipped Slice | |
| EL-Skip only | AF + EL-Skip |
| Kimono1-1.5x QP 26/28 | 13 (5.41%) | 16 (6.67%) |
| Kimono1-1.5x QP 26/30 | 85 (35.42%) | 91 (37.91%) |
| Kimono1-1.5x QP 30/32 | 38 (15.83%) | 54 (22.5%) |
| Kimono1-1.5x QP 30/34 | 236 (98.33%) | 240 (100%) |
| BasketballDrive-1.5x QP 30/34 | 19 (3.8%) | 23 (4.6%) |

Table 7 also shows the decoding time reduced by implementing EL-Skip. The decoding time is measured on a standalone 64-bit machine with Intel i7 CPU, [Q740@1.73GHz](mailto:Q740@1.73GHz), 6GB RAM. For lowerDelay\_P Kimono 1.5X with QP 30/34, the decoding time with EL-skip is approximately 74% of the decoding time without EL-skip.

1. Decoding time comparison on LD-P test case

|  |  |  |  |
| --- | --- | --- | --- |
| LowDelay\_P | Decoding time (sec.) | | percentage |
| AF | AF + EL-Skip |
| Kimono1-1.5x QP 26/28 | 93.813 | 91.245 | 97.2626% |
| Kimono1-1.5x QP 26/30 | 96.162 | 85.825 | 89.2504% |
| Kimono1-1.5x QP 30/32 | 91.483 | 85.473 | 93.4305% |
| Kimono1-1.5x QP 30/34 | 94.147 | 69.093 | 73.3884% |
| BasketballDrive-1.5x QP 30/34 | 195.115 | 192.51 | 98.6649% |

# Patent rights declaration(s)

**InterDigital Communications, LLC 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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# References

1. J. Dong, Y. He, Y. He, G. McClellan, E. Ryu, X. Xiu, Y. Ye, Description of scalable video coding technology proposal by InterDigital Communications. Document no JCTVC-K0034. Oct. 2012.
2. L. Wei, Y. He, D. Kwon, J. Zan, H. Lakshman, J. Kang, Description of Tool Experiment A2: Inter-layer Texture Prediction Signaling in SHVC, Document no JCTVC-K1102, Oct. 2012.
3. Jianle Chen, Andrew Segall, Elena Alshina, Shan Liu, Jie Dong, Joonyoung Park, Description of Tool Experiment B4: Inter-layer filtering, Document no JCTVC-K1104, Oct. 2012
4. Tomoyuki Yamamoto, Yukinobu Yasugi, Hisao Kumai, Maki Takahashi, Description of scalable video coding technology proposal by SHARP (proposal 2), Document no JCTVC-K0032, Oct. 2012