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| *Title:* | **HEVC encoder optimization** | | |
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# Abstract

This proposal proposes two non-normative encoder optimization methods for HEVC encoders: deblocking filter parameter selection, and chroma quantization parameter adjustment. Compared to HEVC HM-16.7 anchor, average luma BD rate saving of the deblocking filter parameter selection method is reported to be 0.2% for AI, 0.4% for RA, 0.3% for LDB, and 0.5% for LDP. Average chroma BD rate saving of the chroma QP offset adjustment method is reported to be 11.6% for RA, 14.2% for LDB, and 13.9% for LDP, with a small loss for the luma component.

These two optimization methods are also applicable to HDR/WCG coding. It is asserted that on SIM2 display, compared to the HDR/WCG anchors, quality improvements can be observed for low to medium bit rates for a range of HDR video content, mainly in the form of more details and fewer blocking artifacts.

# Introduction

Two encoder optimization methods are proposed for HEVC encoding [1] [2]: deblocking filter parameter selection, chroma quantization parameter offset adjustment. We report simulation results for both HEVC test sequences and HDR/WCG test sequences.

## Deblocking filter parameter selection

A fast deblocking parameters searching algorithm is proposed. Two HEVC deblocking filter parameters, β and tc, are adaptively adjusted to optimize picture quality. If the reconstructed picture has low quality because the QP values applied to code the picture are high, then we can increase β and tc to make deblocking filter stronger to remove more blocking artifacts. Otherwise, if the reconstructed picture quality is sufficient, then we can decrease the β and tc values to make deblocking filter weaker. The encoder can select β and tc to minimize the distortion between deblocked picture and original picture. Denote BO and TO as β and tc, respectively.

(BO, TO)Opt = (1)

Where rec is the reconstructed picture before deblocking; orgYCbCr is the original picture; DB(rec, BO, TO) is the deblocked picture generated by deblocking the reconstructed picture rec with BO and TO parameters. The distortion between the two pictures is the weighted sum of individual distortion of each color component. Instead of applying parameter search in a brute force manner for each possible (BO, TO) pair, early termination is applied to accelerate the parameter searching process. If the distortion increases with one parameter BO (or TO), then further search of that parameter will be early terminated.

In order to avoid temporal flickering that may be caused by varying deblocking filter parameters between neighboring pictures, the hierarchical coding structure is considered. For those pictures at the same temporal layer coded with same QP, their deblocking parameters are kept similar.

## Chroma quantization parameter adjustment

In HEVC Main/Main-10 profile, the chroma quantization parameters can be adjusted at the sequence level and at the slice level. The sequence level chroma QP offsets for each chroma component, relative to the luma QP, are signaled at Picture Parameter Set (PPS), which will apply to all slices that refer to this PPS. The QP offsets signaled at PPS will also affect the QP calculation used for chroma deblocking. The slice level chroma QP offsets are signaled in the slice header, and are only applied to that specific slice. The slice QP offsets can provide fine granularity adjustment, but it will not affect the QP calculation for chroma deblocking. The proposed chroma QP adjustment method applies a temporal level based chroma QP adjustment; specifically, more bits are allocated to pictures at lower temporal level than to those at higher temporal level.

The chroma QP offset is derived as follows:

QPc\_offset = QPc\_adj(TL\_Idx)

where QPc\_adj is the temporal layer based chroma QP adjustment, and TL\_Idx is the temporal level index. The QPc\_adj(TL\_Idx) values for Cb and Cr components are shown in Figure 1. It is worth noting that the values in Figure 1 are used for general-purpose HEVC encoding, and are different from those used for HDR/WCG content coding [1].

The chroma QP QPc is calculated as:

QPc = QP + Clip(-12, 12, QPc\_offset)

Where QP is the luma QP.



Figure . The temporal-level based chroma QP adjustment values for two settings

The proposed chroma QP offsets are signalled in the slice header.

# Simulation results for HEVC CTC test sequences

The proposed encoder optimization are integrated to HM-16.7. Three tests are performed for HEVC test sequences with common test condition compared to HM-16.7 anchor.

Test1: deblocking filter parameter selection;

Test2: chroma QP adjustment;

Setting1: -1, -1, 0, 1, 2

Setting2; -1, 0, 1, 2, 3

For setting2, chroma QP adjustment is set to -1 at one second period for LDB and LDP coding;

Test3:

Combined test with chroma QP adjustment setting1

Combined test with chroma QP adjustment setting2

The simulation results for Test1, Test2 and Test3 compared to HM-16.7 anchor are listed in Table 1, Table 2, Table 3, Table 4 and Table 5, respectively.

Table . Test1 compared to HM-16.7 anchor

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra Main** | | |
|  | Y | U | V |
| Class A | -0.3% | -0.1% | -0.1% |
| Class B | -0.2% | -0.3% | -0.2% |
| Class C | -0.1% | -0.2% | -0.2% |
| Class D | -0.1% | -0.2% | -0.1% |
| Class E | 0.0% | 0.0% | 0.0% |
| **Overall** | -0.2% | -0.2% | -0.1% |
|  | -0.2% | -0.2% | -0.1% |
| Class F | -0.1% | -0.3% | -0.4% |
| Enc Time[%] | 106% | | |
| Dec Time[%] | 105% | | |
|  |  |  |  |
|  | **Random Access Main** | | |
|  | Y | U | V |
| Class A | -0.5% | -0.3% | -0.2% |
| Class B | -0.4% | -0.5% | -0.5% |
| Class C | -0.4% | -0.5% | -0.5% |
| Class D | -0.2% | -0.4% | -0.3% |
| Class E |  |  |  |
| **Overall** | -0.4% | -0.4% | -0.4% |
|  | -0.4% | -0.4% | -0.4% |
| Class F | -0.2% | -0.5% | -0.5% |
| Enc Time[%] | 102% | | |
| Dec Time[%] | 103% | | |
|  |  |  |  |
|  | **Low delay B Main** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | -0.4% | 0.0% | -0.3% |
| Class C | -0.2% | 0.0% | -0.3% |
| Class D | -0.3% | 0.5% | -0.1% |
| Class E | -0.2% | -0.2% | 0.0% |
| **Overall** | -0.3% | 0.1% | -0.2% |
|  | -0.3% | 0.0% | -0.2% |
| Class F | 0.0% | -0.1% | -0.3% |
| Enc Time[%] | 102% | | |
| Dec Time[%] | 101% | | |
|  |  |  |  |
|  | **Low delay P Main** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | -0.8% | -0.3% | -0.3% |
| Class C | -0.5% | -0.1% | -0.2% |
| Class D | -0.3% | -0.3% | 0.2% |
| Class E | -0.4% | -0.6% | -0.1% |
| **Overall** | -0.5% | -0.3% | -0.1% |
|  | -0.5% | -0.2% | -0.1% |
| Class F | -0.2% | -0.4% | -0.5% |
| Enc Time[%] | 102% | | |
| Dec Time[%] | 101% | | |

Table . Test2 Setting1 compared to HM-16.7 anchor

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Random Access Main** | | |
|  | Y | U | V |
| Class A | 0.8% | -14.4% | -14.9% |
| Class B | 1.0% | -13.1% | -13.0% |
| Class C | 0.7% | -9.1% | -8.4% |
| Class D | 0.7% | -10.1% | -9.1% |
| Class E |  |  |  |
| **Overall** | 0.8% | -11.8% | -11.4% |
|  | 0.8% | -11.4% | -11.0% |
| Class F | 0.9% | -6.6% | -5.8% |
| Enc Time[%] | 101% | | |
| Dec Time[%] | 102% | | |
|  |  |  |  |
|  | **Low delay B Main** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | 1.1% | -16.1% | -16.0% |
| Class C | 1.0% | -11.2% | -10.7% |
| Class D | 0.8% | -12.9% | -12.3% |
| Class E | 0.7% | -16.2% | -15.7% |
| **Overall** | 0.9% | -14.1% | -13.7% |
|  | 0.9% | -13.9% | -13.4% |
| Class F | 1.1% | -9.0% | -8.6% |
| Enc Time[%] | 101% | | |
| Dec Time[%] | 99% | | |
|  |  |  |  |
|  | **Low delay P Main** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | 1.1% | -16.1% | -16.2% |
| Class C | 0.9% | -11.6% | -10.9% |
| Class D | 0.9% | -12.9% | -12.2% |
| Class E | 0.5% | -17.4% | -17.0% |
| **Overall** | 0.9% | -14.4% | -14.0% |
|  | 0.9% | -14.2% | -13.7% |
| Class F | 1.2% | -8.5% | -8.4% |
| Enc Time[%] | 101% | | |
| Dec Time[%] | 101% | | |

Table 3. Test2 Setting2 compared to HM-16.7 anchor

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Random Access Main** | | |
|  | Y | U | V |
| Class A | 0.1% | -3.4% | -4.3% |
| Class B | 0.1% | -4.4% | -5.2% |
| Class C | -0.3% | -1.5% | -1.0% |
| Class D | -0.1% | -2.8% | -1.9% |
| Class E |  |  |  |
| **Overall** | -0.1% | -3.1% | -3.2% |
|  | -0.1% | -2.8% | -2.7% |
| Class F | 0.2% | -3.5% | -2.6% |
| Enc Time[%] | 101% | | |
| Dec Time[%] | 101% | | |
|  |  |  |  |
|  | **Low delay B Main** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | 0.0% | -1.7% | -2.3% |
| Class C | -0.3% | 0.1% | 0.7% |
| Class D | -0.2% | -0.7% | -0.3% |
| Class E | 0.1% | -8.5% | -7.5% |
| **Overall** | -0.1% | -2.3% | -2.0% |
|  | -0.1% | -2.0% | -1.7% |
| Class F | 0.2% | -1.9% | -1.9% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 98% | | |
|  |  |  |  |
|  | **Low delay P Main** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | -0.1% | -1.3% | -2.2% |
| Class C | -0.3% | 0.3% | 0.9% |
| Class D | -0.2% | -0.2% | 0.7% |
| Class E | 0.1% | -9.0% | -8.6% |
| **Overall** | -0.1% | -2.1% | -1.9% |
|  | -0.1% | -1.8% | -1.6% |
| Class F | 0.0% | -2.2% | -1.3% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |

Table . Test3 with setting 1 compared to HM-16.7 anchor

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Random Access Main** | | |
|  | Y | U | V |
| Class A | 0.3% | -14.5% | -15.2% |
| Class B | 0.6% | -13.6% | -13.5% |
| Class C | 0.3% | -9.7% | -8.8% |
| Class D | 0.5% | -10.6% | -9.5% |
| Class E |  |  |  |
| **Overall** | 0.4% | -12.2% | -11.9% |
|  | 0.4% | -11.9% | -11.5% |
| Class F | 0.7% | -7.3% | -6.6% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |
|  |  |  |  |
|  | **Low delay B Main** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | 0.7% | -16.1% | -16.0% |
| Class C | 0.8% | -11.6% | -10.9% |
| Class D | 0.6% | -12.7% | -12.3% |
| Class E | 0.5% | -16.3% | -15.6% |
| **Overall** | 0.7% | -14.2% | -13.7% |
|  | 0.7% | -13.9% | -13.5% |
| Class F | 1.1% | -9.1% | -8.7% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |
|  |  |  |  |
|  | **Low delay P Main** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | 0.2% | -16.3% | -16.5% |
| Class C | 0.4% | -12.0% | -11.2% |
| Class D | 0.5% | -13.1% | -12.6% |
| Class E | 0.2% | -17.3% | -17.0% |
| **Overall** | 0.4% | -14.6% | -14.3% |
|  | 0.4% | -14.4% | -14.0% |
| Class F | 1.0% | -9.1% | -8.7% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |

Table 5. Test3 with setting 2 compared to HM-16.7 anchor

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Random Access Main** | | |
|  | Y | U | V |
| Class A | -0.5% | -3.5% | -4.5% |
| Class B | -0.3% | -5.0% | -5.8% |
| Class C | -0.6% | -2.2% | -1.5% |
| Class D | -0.4% | -3.3% | -2.4% |
| Class E |  |  |  |
| **Overall** | -0.4% | -3.6% | -3.7% |
|  | -0.4% | -3.2% | -3.2% |
| Class F | 0.0% | -4.1% | -3.3% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 101% | | |
|  |  |  |  |
|  | **Low delay B Main** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | -0.4% | -1.7% | -2.4% |
| Class C | -0.5% | 0.1% | 0.5% |
| Class D | -0.4% | -0.5% | 0.0% |
| Class E | -0.1% | -8.3% | -6.9% |
| **Overall** | -0.4% | -2.2% | -1.9% |
|  | -0.4% | -1.9% | -1.6% |
| Class F | 0.1% | -2.2% | -2.1% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 98% | | |
|  |  |  |  |
|  | **Low delay P Main** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | -0.9% | -1.5% | -2.2% |
| Class C | -0.7% | 0.0% | 0.6% |
| Class D | -0.5% | -0.7% | 0.9% |
| Class E | -0.4% | -8.8% | -7.9% |
| **Overall** | -0.7% | -2.3% | -1.8% |
|  | -0.7% | -2.1% | -1.5% |
| Class F | 0.0% | -2.1% | -1.2% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |

# Simulation results for HDR/WCG test sequences

We integrated the two encoder optimization methods: deblocking filter parameter selection and chroma quantization parameter (QP) adjustment based on HDR/WCG anchor V3.0 released on Nov. 21, 2015. Whereas the deblocking filter parameter selection method is the same for general-purpose encoding and for HDR/WCG coding, the chroma QP adjustment method for HDR/WCG content coding is slightly different, given the HDR/WCG anchor already contains sequence level chroma QP adjustment. Detailed information about the latter and how it is integrated into the HDR/WCG anchor can be found in [1].

Two tests were performed for HDR/WCG coding:

Test1: deblocking filter parameter selection + chroma QP offset adjustment;

Test2: deblocking filter parameter selection only.

Table 6 and Table 7 list the results of Test1 and Test2 compared to CE1 anchor V3.0, respectively. Subjective viewing was conducted by the proponents on SIM2 display. For Test1 compared to CE1 anchor V3.0, quality improvement in terms of more details and fewer blocking artifacts was observed for the following sequences:

* In real-time playback mode: SunRise, WarmNight, BalloonFestival, BikeSparklers, and ShowGirl
* In toggle mode: Market.

For Test2 compared to CE1 anchor V3.0, quality improvement was observed for the following sequences: WarmNight, BikeSparklers, and ShowGirl. The quality improvement is generally more visible at lower bitrates.

Table . Test1 compared to CE1 anchor V3.0

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | X |  | Y | Z | XYZ | tOSNR-XYZ | DE100 | PSNRL100 |
| class A | FireEaterClip4000r1 | 1.1% |  | -0.8% | 9.3% | 2.6% | 5.3% | 6.0% | -0.3% |
|  | Market3Clip4000r2 | -1.0% |  | -1.2% | 2.7% | 0.3% | 0.9% | 11.6% | -1.5% |
|  | SunRise | -1.1% |  | -1.1% | 2.5% | 0.3% | 1.6% | 7.4% | -0.9% |
| class B | BikeSparklers cut 1 | -3.0% |  | -3.5% | 6.6% | 0.0% | 0.3% | 8.4% | -3.3% |
|  | BikeSparklers cut 2 | -2.7% |  | -3.6% | 8.3% | 0.2% | 0.9% | 11.0% | -3.3% |
|  | GarageExit | -1.7% |  | -2.5% | 7.0% | 1.2% | 2.3% | 12.8% | -2.3% |
| class C | ShowGirl2Teaser | -0.9% |  | -1.3% | 4.7% | 0.8% | 3.1% | 9.3% | -1.1% |
| class D | StEM\_MagicHour cut 1 | -0.8% |  | -1.2% | 4.9% | 1.8% | 2.1% | 5.1% | -1.1% |
|  | StEM\_MagicHour cut 2 | -1.3% |  | -2.1% | 5.4% | 1.6% | 2.4% | 10.0% | -1.8% |
|  | StEM\_MagicHour cut 3 | -0.7% |  | -1.8% | 6.2% | 2.4% | 3.0% | 9.5% | -1.6% |
|  | StEM\_WarmNight cut 1 | -0.6% |  | -1.1% | 4.1% | 1.2% | 1.7% | 6.1% | -1.0% |
|  | StEM\_WarmNight cut 2 | -0.6% |  | -1.1% | 5.0% | 1.7% | 2.1% | 3.7% | -1.1% |
| class G | BalloonFestival | -1.0% |  | -2.1% | 6.0% | 1.6% | 3.2% | 11.7% | -2.1% |
| class H | EBU\_04\_Start | -1.7% |  | -2.5% | 4.3% | 0.6% | 1.7% | 17.5% | -2.3% |
|  | EBU\_06\_Hurdles | -2.4% |  | -3.2% | 4.4% | 0.0% | 0.6% | 11.7% | -3.1% |
|  | **Overall** | -1.2% |  | -1.9% | 5.4% | 1.1% | 2.1% | 9.5% | -1.8% |

Table . Test2 compared to CE1 anchor V3.0

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | X | Y | Z | XYZ | tOSNR-XYZ | DE100 | PSNRL100 |
| class A | FireEaterClip4000r1 | -0.1% | -0.2% | -0.5% | -0.2% | -0.2% | 0.0% | -0.2% |
|  | Market3Clip4000r2 | -0.4% | -0.4% | -0.5% | -0.4% | -0.6% | 0.1% | -0.6% |
|  | SunRise | -0.7% | -0.7% | -0.3% | -0.5% | -0.4% | 1.6% | -0.6% |
| class B | BikeSparklers cut 1 | -0.7% | -0.7% | -0.7% | -0.7% | -0.5% | -0.5% | -0.4% |
|  | BikeSparklers cut 2 | -0.6% | -0.7% | -1.1% | -0.8% | -0.6% | -0.4% | -0.4% |
|  | GarageExit | -0.3% | -0.2% | -0.5% | -0.3% | -0.2% | -0.2% | -0.1% |
| class C | ShowGirl2Teaser | -0.3% | -0.2% | -0.9% | -0.5% | 0.0% | -0.1% | -0.2% |
| class D | StEM\_MagicHour cut 1 | -0.3% | -0.2% | 0.0% | -0.2% | -0.1% | 0.1% | -0.1% |
|  | StEM\_MagicHour cut 2 | -0.9% | -0.8% | -0.5% | -0.7% | -0.6% | -0.5% | -0.6% |
|  | StEM\_MagicHour cut 3 | -0.6% | -0.6% | 0.3% | -0.1% | 0.1% | 0.0% | -0.3% |
|  | StEM\_WarmNight cut 1 | -0.4% | -0.4% | -0.2% | -0.3% | -0.3% | 0.0% | -0.2% |
|  | StEM\_WarmNight cut 2 | 0.0% | -0.1% | 0.3% | 0.1% | 0.1% | 0.4% | 0.0% |
| class G | BalloonFestival | -0.3% | -0.4% | -0.3% | -0.3% | -0.3% | -0.3% | -0.2% |
| class H | EBU\_04\_Start | -0.6% | -0.4% | -0.5% | -0.5% | -0.3% | -0.5% | -0.2% |
|  | EBU\_06\_Hurdles | -0.5% | -0.4% | -0.3% | -0.4% | -0.4% | -0.2% | -0.4% |
|  | **Overall** | -0.5% | -0.4% | -0.4% | -0.4% | -0.3% | 0.0% | -0.3% |

# 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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