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| *Title:* | **Non-CE2: Unification of IntraBC mode with inter mode** | | |
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| *Purpose:* | Proposal | | |
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# Abstract

This proposal is a combination of two CE2 tests: block vector derivation in CE2 Test 3, and unification of IntraBC with inter mode in CE2 Test 5b. Compared to Test 5b, the IntraBC merge process is separated from the inter merge process based on intra\_bc\_flag. The derived block vectors from Test 3 are added as IntraBC merge candidates. Compared to CE2 anchors, for lossy coding, the proposed scheme reportedly achieves average {Y, U, V} BD rate gain of {-4.5%, -6.0%, -5.8%}, {-5.6%, -7.5%, -7.4%} and {-5.6%, -7.2%, -7.0%} for the category (RGB/YUV, text & graphics with motion, 1080p) for AI, RA and LDB, respectively. And the lossless coding reportedly achieves total bit-rate saving of 2.7%, 4.5% and 4.8% for the category (RGB/YUV, text & graphics with motion, 1080p) for AI, RA and LDB, respectively.

# Introduction

Unification of IntraBC mode with inter mode was proposed in JCTVC-R0100 [2] and JCTVC-R0190 [3], and evaluated in CE2 Test1, Test2 and Test5 [1]. The block vector derivation was proposed in JCTVC-R0165 [4] and evaluated in CE2 Test3 [1]. This proposal proposed to combine those three methods together. The PU signalling is changed to support IntraBC as shown in Figure 1. The modification to current SCC design [5] is highlighted. The intra\_bc\_flag is migrated from CU level to PU level. In intra slice, CU-level inter prediction mode is still needed because IntraBC is unified with inter mode. The BV prediction and BVD entropy coding method are the same as SCC test model [5] (SCM-2.0). Different merge process will be applied for inter and IntraBC depending on intra\_bc\_flag: inter merge process is applied for merge mode with intra\_bc\_flag being equal to 0; IntraBC merge process is applied for merge mode with intra\_bc\_flag being equal to 1. Note that in intra slice, if CU-level inter prediction mode is signaled, then intra\_bc\_flag will not be signaled and will be inferred as 1; in inter slice, if cu\_skip\_flag is set, then intra\_bc\_flag is not signaled and is inferred as 0.



Figure 1. PU signalling for inter CU in inter slice

## Inter merge process

If current inter PU is merge mode and intra\_bc\_flag is equal to 0, then the inter merge process will be applied. The block vectors from neighbors coded using IntraBC mode will not be considered as valid merge candidate in the inter merge process.

## IntraBC merge process

The IntraBC merge candidate list is constructed with valid and unique BVs from the following possible candidates in order.

1. Five spatial BVs from neighboring blocks (C0 to C4) shown in Figure 2;
2. One temporal BV from collocated blocks in temporal reference pictures:

setting1: using collocated reference picture only (C5). This setting is the same as TMVP derivation.

setting2: using the first two reference pictures in each list (C5-C8);

1. After all spatial neighbors are checked in (1) and one temporal candidate is checked in (2), if the candidate list is not full, then the block derivation is applied to fill the remaining entries:

For each BV in the list obtained from (1) and (2), if the corresponding reference block is IntraBC mode and the corresponding derived BV is unique compared to the candidate list and valid for the current PU, then add the derived BV to the merge candidate list.



Figure 2. Spatial neighboring blocks (C0-C4) and temporal blocks (C5, or C5-C8) for IntraBC merge candidate list construction

In simulations, a constraint of local window consisting of one CTU row above and current CTU row is applied for BV derivation: if the block pointed by block vector is outside the local window, then this block vector will be treated as invalid BV and BV derivation will not be applied.

# Simulation results

The compression performance of the proposed method is compared with CE2 anchors, using the CE2 test conditions [1]. We did two tests as listed in Table 1. Table 2 and Table 3 give the average BD rate reduction of test A for lossy and lossless coding, respectively. Table 4 and Table 5 give the average BD rate reduction of test B for lossy and lossless coding, respectively. Test A and B results are provided in the accompanying spreadsheets for further details.

Table 1. The settings of tests

|  |  |
| --- | --- |
| **Test** | **Maximum number of temporal pictures used for temporal BV derivation in IntraBC merge process** |
| A | 1 (temporal collocated reference picture) |
| B | 4 for RA or 2 for LDB at most (the first two reference pictures for each list) |

As shown in Table 2, for lossy coding, test A achieves average {Y, U, V} BD rate gain of {-5.5%, -6.9%, -6.8%}, {-5.9%, -7.8%, -7.6%} and {-5.8%, -7.4%, -7.1%} for the category (RGB, text & graphics with motion, 1080p) for AI, RA and LDB, respectively. As shown in Table 3, compared with CE2 anchors, for lossless coding, test A achieves total bit-rate saving of 3.2%, 4.7% and 5.1% for the category (RGB, text & graphics with motion, 1080p) for AI, RA and LDB, respectively.

Table 2. Average BD rate reduction for test A lossly coding compared with CE2 anchors

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -5.5% | -6.9% | -6.8% |
| RGB, text & graphics with motion,720p | -3.1% | -4.0% | -3.9% |
| RGB, mixed content, 1440p | -2.7% | -2.9% | -3.1% |
| RGB, mixed content, 1080p | -2.4% | -2.9% | -2.9% |
| RGB, Animation, 720p | -0.2% | -0.2% | -0.2% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -3.5% | -5.0% | -4.9% |
| YUV, text & graphics with motion,720p | -2.8% | -3.5% | -3.8% |
| YUV, mixed content, 1440p | -1.9% | -2.6% | -2.8% |
| YUV, mixed content, 1080p | -2.0% | -3.3% | -3.3% |
| YUV, Animation, 720p | -0.4% | -0.5% | -0.6% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 118% | | |
| Dec Time[%] | 96% | | |
|  |  |  |  |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -5.9% | -7.8% | -7.6% |
| RGB, text & graphics with motion,720p | -2.3% | -3.6% | -3.6% |
| RGB, mixed content, 1440p | -2.0% | -2.9% | -3.1% |
| RGB, mixed content, 1080p | -2.0% | -3.2% | -3.3% |
| RGB, Animation, 720p | 0.0% | -0.2% | -0.2% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -5.3% | -7.1% | -7.2% |
| YUV, text & graphics with motion,720p | -1.8% | -3.3% | -3.4% |
| YUV, mixed content, 1440p | -1.6% | -3.1% | -3.0% |
| YUV, mixed content, 1080p | -1.8% | -4.5% | -4.4% |
| YUV, Animation, 720p | -0.1% | -0.7% | -0.6% |
| YUV, camera captured, 1080p | 0.0% | 0.1% | 0.0% |
| Enc Time[%] | 101% | | |
| Dec Time[%] | 89% | | |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -5.8% | -7.4% | -7.1% |
| RGB, text & graphics with motion,720p | -1.5% | -2.7% | -2.9% |
| RGB, mixed content, 1440p | -1.6% | -2.4% | -2.6% |
| RGB, mixed content, 1080p | -1.8% | -3.1% | -3.4% |
| RGB, Animation, 720p | 0.0% | -0.1% | 0.0% |
| RGB, camera captured, 1080p | 0.1% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -5.5% | -7.1% | -6.9% |
| YUV, text & graphics with motion,720p | -1.6% | -2.5% | -3.3% |
| YUV, mixed content, 1440p | -1.5% | -3.0% | -3.0% |
| YUV, mixed content, 1080p | -1.5% | -4.8% | -6.3% |
| YUV, Animation, 720p | 0.1% | -0.5% | 0.1% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.2% |
| Enc Time[%] | 98% | | |
| Dec Time[%] | 91% | | |

Table 3. Average BD rate reduction for test A lossless coding compared with CE2 anchors

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **All Intra** | | | |
|  | Bit-rate saving (Total) | Bit-rate saving (Average) | Bit-rate saving (Min) | Bit-rate saving (Max) |
|  |
| RGB, text & graphics with motion, 1080p | 3.2% | 3.2% | 2.8% | 3.5% |
| RGB, text & graphics with motion,720p | 0.7% | 0.8% | 0.2% | 1.2% |
| RGB, mixed content, 1440p | 2.0% | 1.7% | 0.4% | 3.0% |
| RGB, mixed content, 1080p | 1.7% | 1.7% | 1.7% | 1.7% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 2.2% | 2.1% | 1.5% | 2.6% |
| YUV, text & graphics with motion,720p | 0.6% | 0.6% | 0.2% | 0.9% |
| YUV, mixed content, 1440p | 1.9% | 1.7% | 0.5% | 2.9% |
| YUV, mixed content, 1080p | 1.4% | 1.4% | 1.4% | 1.4% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 117% | | | |
| Dec Time[%] | 102% | | | |
|  |  |  |  |  |
|  | **Random Access** | | | |
|  | Bit-rate saving (Total) | Bit-rate saving (Average) | Bit-rate saving (Min) | Bit-rate saving (Max) |
|  |
| RGB, text & graphics with motion, 1080p | 4.7% | 4.1% | 2.9% | 5.0% |
| RGB, text & graphics with motion,720p | 0.4% | 0.5% | 0.3% | 1.0% |
| RGB, mixed content, 1440p | 0.4% | 0.4% | 0.1% | 0.8% |
| RGB, mixed content, 1080p | 0.4% | 0.4% | 0.4% | 0.4% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 4.4% | 3.5% | 2.0% | 4.8% |
| YUV, text & graphics with motion,720p | 0.3% | 0.5% | 0.3% | 0.9% |
| YUV, mixed content, 1440p | 0.4% | 0.4% | 0.1% | 0.8% |
| YUV, mixed content, 1080p | 0.4% | 0.4% | 0.4% | 0.4% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 105% | | | |
| Dec Time[%] | 98% | | | |
|  |  |  |  |  |
|  | **Low Delay B** | | | |
|  | Bit-rate saving (Total) | Bit-rate saving (Average) | Bit-rate saving (Min) | Bit-rate saving (Max) |
|  |
| RGB, text & graphics with motion, 1080p | 5.1% | 4.2% | 2.5% | 5.5% |
| RGB, text & graphics with motion,720p | 0.3% | 0.4% | 0.2% | 0.8% |
| RGB, mixed content, 1440p | 0.2% | 0.2% | 0.0% | 0.5% |
| RGB, mixed content, 1080p | 0.2% | 0.2% | 0.2% | 0.2% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 4.5% | 3.8% | 1.9% | 5.0% |
| YUV, text & graphics with motion,720p | 0.2% | 0.4% | 0.2% | 0.9% |
| YUV, mixed content, 1440p | 0.2% | 0.2% | 0.0% | 0.4% |
| YUV, mixed content, 1080p | 0.2% | 0.2% | 0.2% | 0.2% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 106% | | | |
| Dec Time[%] | 103% | | | |

Table 4. Average BD rate reduction for test B lossly coding compared with CE2 anchors

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -5.5% | -6.9% | -6.8% |
| RGB, text & graphics with motion,720p | -3.1% | -4.0% | -3.9% |
| RGB, mixed content, 1440p | -2.7% | -2.9% | -3.1% |
| RGB, mixed content, 1080p | -2.4% | -2.9% | -2.9% |
| RGB, Animation, 720p | -0.2% | -0.2% | -0.2% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -3.5% | -5.0% | -4.9% |
| YUV, text & graphics with motion,720p | -2.8% | -3.5% | -3.8% |
| YUV, mixed content, 1440p | -1.9% | -2.6% | -2.8% |
| YUV, mixed content, 1080p | -2.0% | -3.3% | -3.3% |
| YUV, Animation, 720p | -0.4% | -0.5% | -0.6% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 118% | | |
| Dec Time[%] | 97% | | |
|  |  |  |  |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -6.2% | -8.1% | -7.9% |
| RGB, text & graphics with motion,720p | -2.3% | -3.7% | -3.7% |
| RGB, mixed content, 1440p | -2.0% | -2.9% | -3.2% |
| RGB, mixed content, 1080p | -2.0% | -3.2% | -3.4% |
| RGB, Animation, 720p | 0.0% | -0.2% | -0.2% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -5.6% | -7.5% | -7.5% |
| YUV, text & graphics with motion,720p | -1.8% | -3.4% | -3.5% |
| YUV, mixed content, 1440p | -1.7% | -3.2% | -3.0% |
| YUV, mixed content, 1080p | -1.8% | -4.5% | -4.4% |
| YUV, Animation, 720p | -0.1% | -0.7% | -0.6% |
| YUV, camera captured, 1080p | 0.0% | 0.1% | 0.0% |
| Enc Time[%] | 106% | | |
| Dec Time[%] | 94% | | |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -6.2% | -7.8% | -7.6% |
| RGB, text & graphics with motion,720p | -1.5% | -2.8% | -3.0% |
| RGB, mixed content, 1440p | -1.6% | -2.3% | -2.6% |
| RGB, mixed content, 1080p | -1.7% | -3.2% | -3.4% |
| RGB, Animation, 720p | 0.1% | -0.1% | 0.0% |
| RGB, camera captured, 1080p | 0.1% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -5.9% | -7.5% | -7.3% |
| YUV, text & graphics with motion,720p | -1.7% | -2.6% | -3.3% |
| YUV, mixed content, 1440p | -1.5% | -2.9% | -2.8% |
| YUV, mixed content, 1080p | -1.6% | -4.8% | -6.3% |
| YUV, Animation, 720p | 0.0% | -0.6% | 0.1% |
| YUV, camera captured, 1080p | 0.0% | 0.1% | 0.3% |
| Enc Time[%] | 105% | | |
| Dec Time[%] | 96% | | |

Table 5. Average BD rate reduction for test B lossless coding compared with CE2 anchors

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **All Intra** | | | |
|  | Bit-rate saving (Total) | Bit-rate saving (Average) | Bit-rate saving (Min) | Bit-rate saving (Max) |
|  |
| RGB, text & graphics with motion, 1080p | 3.2% | 3.2% | 2.8% | 3.5% |
| RGB, text & graphics with motion,720p | 0.7% | 0.8% | 0.2% | 1.2% |
| RGB, mixed content, 1440p | 2.0% | 1.7% | 0.4% | 3.0% |
| RGB, mixed content, 1080p | 1.7% | 1.7% | 1.7% | 1.7% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 2.2% | 2.1% | 1.5% | 2.6% |
| YUV, text & graphics with motion,720p | 0.6% | 0.6% | 0.2% | 0.9% |
| YUV, mixed content, 1440p | 1.9% | 1.7% | 0.5% | 2.9% |
| YUV, mixed content, 1080p | 1.4% | 1.4% | 1.4% | 1.4% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 117% | | | |
| Dec Time[%] | 101% | | | |
|  |  |  |  |  |
|  | **Random Access** | | | |
|  | Bit-rate saving (Total) | Bit-rate saving (Average) | Bit-rate saving (Min) | Bit-rate saving (Max) |
|  |
| RGB, text & graphics with motion, 1080p | 5.0% | 4.3% | 3.0% | 5.3% |
| RGB, text & graphics with motion,720p | 0.4% | 0.5% | 0.3% | 1.1% |
| RGB, mixed content, 1440p | 0.4% | 0.4% | 0.1% | 0.8% |
| RGB, mixed content, 1080p | 0.4% | 0.4% | 0.4% | 0.4% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 4.6% | 3.7% | 2.1% | 5.1% |
| YUV, text & graphics with motion,720p | 0.3% | 0.5% | 0.3% | 0.9% |
| YUV, mixed content, 1440p | 0.4% | 0.4% | 0.1% | 0.8% |
| YUV, mixed content, 1080p | 0.4% | 0.4% | 0.4% | 0.4% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 106% | | | |
| Dec Time[%] | 98% | | | |
|  |  |  |  |  |
|  |  |  |  |  |
|  | **Low Delay B** | | | |
|  | Bit-rate saving (Total) | Bit-rate saving (Average) | Bit-rate saving (Min) | Bit-rate saving (Max) |
|  |
| RGB, text & graphics with motion, 1080p | 5.4% | 4.4% | 2.6% | 5.8% |
| RGB, text & graphics with motion,720p | 0.3% | 0.4% | 0.2% | 0.8% |
| RGB, mixed content, 1440p | 0.2% | 0.3% | 0.0% | 0.5% |
| RGB, mixed content, 1080p | 0.2% | 0.2% | 0.2% | 0.2% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 4.9% | 4.0% | 2.0% | 5.3% |
| YUV, text & graphics with motion,720p | 0.3% | 0.4% | 0.2% | 0.9% |
| YUV, mixed content, 1440p | 0.2% | 0.2% | 0.0% | 0.4% |
| YUV, mixed content, 1080p | 0.2% | 0.2% | 0.2% | 0.2% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 105% | | | |
| Dec Time[%] | 101% | | | |

# 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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