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| --- | --- | --- | --- |
| *Title:* | **Modification of Coding Mode Order for HEVC Screen Content Coding** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

In this contribution, a new coding mode order for inter slice is proposed. First, *pred\_mode\_flag* is coded to distinguish intra or inter mode. If the mode is not inter, *intra\_bc\_flag* will be coded to check whether the mode is intra block copy mode and if the mode is not intra block copy, the *palette\_mode\_flag* will be coded in the end to decide the mode is palette mode or regular intra mode. Under the common test condition, it is reported that average 15.68%, 27.53%, 18.25%, 20.45%, 18.64%, 34.63%, 27.62%, 32.05% bins saving are achieved for 444 and RGB sequences lossy RA, LB, lossless RA, LB, and 420 sequences lossy RA, LB, lossless RA, LB cases, respectively.

# Introduction

Intra and inter modes are two primary modes in the HEVC version 1 [1]. If the slice is inter slice and the current mode is not skip mode, one bin, *pred\_mode\_flag,* is present to distinguish intra and inter CU. Intra block copy (IBC) and palette mode (PM) [2] are two new coding modes adopted for HEVC screen content coding (SCC) extension. Two new syntax, i.e. *intra\_bc\_flag* and *palette\_mode\_flag*, are added to indicate IBC and PM if certain conditions are satisfied [2].

More specifically, if the syntax *intra\_block\_copy\_enabled\_flag* specified at SPS is enabled, a syntax *intra\_bc\_flag* is present for each CU, indicating whether IBC is used or not for the current CU. Similarly, if the *palette\_mode\_enabled\_flag* specified at SPS is enabled, the current mode (CuPredMode) is intra (MODE\_INTRA), ChromaArrayType is 3 and the current mode is not IBC, *palette\_mode\_flag* will be present to indicate whether palette mode will be used for the current CU or not.

# Proposed method

In the current SCC specification [2], if the mode is not skip for inter slice, *intra\_bc\_flag* is coded first. If the mode is not IBC, *pred\_mode\_flag* will be coded then. If the mode is not inter mode, *palette\_mode\_flag* will be coded in the end. IBC, inter mode, palette mode and intra mode need 1, 2, 3 and 3 bins for inter slice, respectively. The coding tree for current HEVC SCM-3.0 is shown in the Figure 1a.

 

Figure 1 a. The coding tree in the SCM-3.0 b. The proposed coding tree

Table 1 shows the percentage of selected mode of CU for SCM3.0 lossy anchor bitstreams excluding skip mode. From this table, it is observed that inter mode is most frequently selected mode for all category of sequences. For camera captured 1080p sequence, around 70% and 90% CU selected inter mode for RA and LB, respectively.

**Table 1. The percentage of selected mode of CU for SCM3.0 lossy anchor bitstreams**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Random Access | total\_cus | intra\_cus | inter\_cus | ibc\_cus | palette\_cus |
| RGB, text & graphics with motion, 1080p | 100.00% | 5.30% | 56.10% | 33.30% | 5.30% |
| RGB, text & graphics with motion, 720p | 100.00% | 33.60% | 39.60% | 22.10% | 4.70% |
| RGB, mixed content, 1440p | 100.00% | 33.60% | 43.30% | 21.80% | 1.30% |
| RGB, mixed content, 1080p | 100.00% | 28.30% | 45.10% | 24.80% | 1.80% |
| RGB, Animation, 720p | 100.00% | 26.50% | 71.80% | 1.40% | 0.30% |
| RGB, camera captured, 1080p | 100.00% | 28.10% | 71.50% | 0.30% | 0.00% |
| YUV, text & graphics with motion, 1080p | 100.00% | 4.90% | 59.20% | 30.00% | 5.90% |
| YUV, text & graphics with motion, 720p | 100.00% | 31.90% | 39.90% | 22.90% | 5.30% |
| YUV, mixed content, 1440p | 100.00% | 33.70% | 40.70% | 23.40% | 2.20% |
| YUV, mixed content, 1080p | 100.00% | 28.90% | 41.00% | 27.50% | 2.50% |
| YUV, Animation, 720p | 100.00% | 32.20% | 64.90% | 2.20% | 0.70% |
| YUV, camera captured, 1080p | 100.00% | 29.60% | 69.70% | 0.60% | 0.00% |
| Average | **100%** | **17.50%** | **54.80%** | **23.80%** | **3.90%** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Low delay B | total\_cus | intra\_cus | inter\_cus | ibc\_cus | palette\_cus |
| RGB, text & graphics with motion, 1080p | 100.00% | 4.60% | 60.60% | 29.70% | 5.10% |
| RGB, text & graphics with motion, 720p | 100.00% | 22.80% | 61.10% | 12.70% | 3.50% |
| RGB, mixed content, 1440p | 100.00% | 19.30% | 67.00% | 13.20% | 0.50% |
| RGB, mixed content, 1080p | 100.00% | 8.30% | 79.60% | 11.60% | 0.60% |
| RGB, Animation, 720p | 100.00% | 8.30% | 91.20% | 0.40% | 0.00% |
| RGB, camera captured, 1080p | 100.00% | 8.00% | 91.90% | 0.10% | 0.00% |
| YUV, text & graphics with motion, 1080p | 100.00% | 3.60% | 67.40% | 23.60% | 5.40% |
| YUV, text & graphics with motion, 720p | 100.00% | 19.90% | 65.20% | 11.80% | 3.10% |
| YUV, mixed content, 1440p | 100.00% | 18.50% | 67.10% | 13.70% | 0.70% |
| YUV, mixed content, 1080p | 100.00% | 8.50% | 78.50% | 12.30% | 0.60% |
| YUV, Animation, 720p | 100.00% | 9.60% | 89.60% | 0.70% | 0.10% |
| YUV, camera captured, 1080p | 100.00% | 6.80% | 93.10% | 0.10% | 0.00% |
| Average | **100%** | **8.70%** | **70.90%** | **17.30%** | **3.20%** |

In this contribution, we proposed to code inter mode first so that number of bins processed can be reduced to save complexity for inter slices. More specially, *pred\_mode\_flag* will be coded first. If the mode is not inter mode, *intra\_bc\_flag* will be coded then. If the mode is not IBC, *palette\_mode\_flag* will be coded in the end. The new coding tree is shown in the Figure 1b and the proposed syntax change is shown in the Table 2.

**Table 2. The proposed syntax change**

|  |  |
| --- | --- |
| coding\_unit( x0, y0, log2CbSize ) { | Descriptor |
| if( transquant\_bypass\_enabled\_flag ) |  |
| **cu\_transquant\_bypass\_flag** | ae(v) |
| if( slice\_type != I ) |  |
| **cu\_skip\_flag**[ x0 ][ y0 ] | ae(v) |
| nCbS = ( 1  <<  log2CbSize ) |  |
| if( cu\_skip\_flag[ x0 ][ y0 ] ) |  |
| prediction\_unit( x0, y0, nCbS, nCbS ) |  |
| else { |  |
| ~~if( intra\_block\_copy\_enabled\_flag )~~ |  |
| **~~intra\_bc\_flag~~**~~[ x0 ][ y0 ]~~ | ~~ae(v)~~ |
| if( slice\_type != I ~~&& !intra\_bc\_flag[ x0 ][ y0 ]~~ ) |  |
| **pred\_mode\_flag** | ae(v) |
| if( intra\_block\_copy\_enabled\_flag && (CuPredMode[ x0 ][ y0 ] = = MODE\_INTRA) ) |  |
| **intra\_bc\_flag**[ x0 ][ y0 ] | ae(v) |
| if( palette\_mode\_enabled\_flag && ChromaArrayType = = 3 &&   CuPredMode[ x0 ][ y0 ] = = MODE\_INTRA && !intra\_bc\_flag[ x0 ][ y0 ] ) |  |
| **palette\_mode\_flag**[ x0 ][ y0 ] | ae(v) |
| …………………… |  |
| …………………… |  |

Note that the red color with strikethrough indicates the removed lines from the current HEVC screen content coding extension specification [2] and the yellow color highlights the changes.

With the proposed change , inter mode, IBC, palette mode and intra mode need 1, 2, 3 and 3 bins for inter slice, respectively. Therefore, the total number of processed bins can be saved. Another benefit of the proposed change is that it harmonizes with HEVC version 1 by presenting *pred\_mode\_flag* first instead of presenting *intra\_bc\_flag* first.

# Experiment Results

Under the common test condition for screen content coding [3], lossy and lossless BDrate results are depicted in Table 3 and Table 4. For further detail, refer to attached excel files.

**Table 3. Lossy results of the proposed method**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p & 720p | 0.02% | 0.01% | 0.01% |
| RGB, mixed content, 1440p & 1080p | 0.00% | 0.02% | -0.03% |
| RGB, Animation, 720p | -0.03% | 0.05% | 0.01% |
| RGB, camera captured, 1080p | -0.06% | -0.03% | -0.01% |
| YUV, text & graphics with motion, 1080p & 720p | 0.01% | -0.01% | -0.01% |
| YUV, mixed content, 1440p & 1080p | -0.01% | 0.04% | 0.04% |
| YUV, Animation, 720p | -0.07% | -0.02% | -0.02% |
| YUV, camera captured, 1080p | -0.06% | -0.01% | -0.12% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |
|  |  |  |  |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p & 720p | 0.03% | 0.03% | 0.06% |
| RGB, mixed content, 1440p & 1080p | 0.03% | 0.04% | -0.01% |
| RGB, Animation, 720p | 0.09% | 0.00% | -0.14% |
| RGB, camera captured, 1080p | -0.01% | -0.06% | -0.03% |
| YUV, text & graphics with motion, 1080p & 720p | 0.09% | 0.07% | -0.04% |
| YUV, mixed content, 1440p & 1080p | -0.03% | -0.19% | -0.04% |
| YUV, Animation, 720p | -0.05% | -0.11% | -0.03% |
| YUV, camera captured, 1080p | -0.09% | 0.17% | 0.07% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| Text & graphics with motion, 720p | -0.02% | -0.01% | -0.04% |
| Mixed content, 480p | -0.04% | -0.04% | -0.02% |
| Animation, 768p | 0.01% | 0.02% | -0.05% |
| Average of all sequences | -0.02% | -0.01% | -0.04% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| Text & graphics with motion, 720p | -0.09% | -0.16% | -1.03% |
| Mixed content, 480p | 0.08% | 0.13% | -0.14% |
| Animation, 768p | 0.00% | -0.06% | 0.05% |
| Average of all sequences | -0.03% | -0.06% | -0.54% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |

**Table 4. Lossless results of the proposed method**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Random Access** | | | |
|  | Bit-rate change (Total) | Bit-rate change (Average) | Bit-rate change (Min) | Bit-rate change (Max) |
|  |
| RGB, text & graphics with motion, 1080p & 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, mixed content, 1440p & 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| 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 & 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, mixed content, 1440p & 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| 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[%] | 100% | | | |
| Dec Time[%] | 100% | | | |
|  |  |  |  |  |
|  |  |  |  |  |
|  | **Low Delay B** | | | |
|  | Bit-rate change (Total) | Bit-rate change (Average) | Bit-rate change (Min) | Bit-rate change (Max) |
|  |
| RGB, text & graphics with motion, 1080p & 720p | 0.0% | 0.0% | -0.1% | 0.0% |
| RGB, mixed content, 1440p & 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| 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 & 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, mixed content, 1440p & 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| 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[%] | 100% | | | |
| Dec Time[%] | 100% | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Random Access** | | | |
|  | Bit-rate change (Total) | Bit-rate change (Average) | Bit-rate change (Min) | Bit-rate change (Max) |
|  |
| Text & graphics with motion, 720p | 0.0% | -0.1% | -0.1% | 0.0% |
| Mixed content, 480p | 0.0% | 0.0% | 0.0% | 0.0% |
| Animation, 768p | 0.0% | 0.0% | 0.0% | 0.0% |
| Average of all sequences | 0.0% | 0.0% | -0.1% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 100% | | | |
|  |  |  |  |  |
|  | **Low Delay B** | | | |
|  | Bit-rate change (Total) | Bit-rate change (Average) | Bit-rate change (Min) | Bit-rate change (Max) |
|  |
| Text & graphics with motion, 720p | 0.0% | 0.1% | 0.0% | 0.1% |
| Mixed content, 480p | 0.0% | 0.0% | 0.0% | 0.0% |
| Animation, 768p | 0.0% | 0.0% | 0.0% | 0.0% |
| Average of all sequences | 0.0% | 0.0% | 0.0% | 0.1% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 100% | | | |

While there is no bit saving, there are lots of bins saving because the proposed method codes the high probability mode first. The table 5 and 6 show the bin saving results for lossy and lossless, respectively.

**Table 5. Bins result for Lossy Coding**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Random Access | Original | Proposal | Original - Proposal | Bin Saving |
| RGB, text & graphics with motion, 1080p | 24106136 | 20998973 | 3107163 | 12.89% |
| RGB, text & graphics with motion, 720p | 7598734 | 6979992 | 618742 | 8.14% |
| RGB, mixed content, 1440p | 7111035 | 6395080 | 715955 | 10.07% |
| RGB, mixed content, 1080p | 3072908 | 2768623 | 304285 | 9.90% |
| RGB, Animation, 720p | 4269213 | 2937158 | 1332055 | 31.20% |
| RGB, camera captured, 1080p | 7141102 | 4917214 | 2223888 | 31.14% |
| YUV, text & graphics with motion, 1080p | 21864843 | 18351232 | 3513611 | 16.07% |
| YUV, text & graphics with motion, 720p | 6301562 | 5798572 | 502990 | 7.98% |
| YUV, mixed content, 1440p | 5401903 | 4958185 | 443718 | 8.21% |
| YUV, mixed content, 1080p | 2416983 | 2256455 | 160528 | 6.64% |
| YUV, Animation, 720p | 2810129 | 2045192 | 764937 | 27.22% |
| YUV, camera captured, 1080p | 5258403 | 3678365 | 1580038 | 30.05% |
| **All** | **97352951** | **82085041** | **15267910** | **15.68%** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Low Delay B | Original | Proposal | Original - Proposal | Bin Saving |
| RGB, text & graphics with motion, 1080p | 24993187 | 20697569 | 4295618 | 17.19% |
| RGB, text & graphics with motion, 720p | 6674103 | 5160797 | 1513306 | 22.67% |
| RGB, mixed content, 1440p | 6428422 | 4754890 | 1673532 | 26.03% |
| RGB, mixed content, 1080p | 2479005 | 1625155 | 853850 | 34.44% |
| RGB, Animation, 720p | 4469992 | 2524366 | 1945626 | 43.53% |
| RGB, camera captured, 1080p | 9349243 | 5234565 | 4114678 | 44.01% |
| YUV, text & graphics with motion, 1080p | 22543922 | 17233577 | 5310345 | 23.56% |
| YUV, text & graphics with motion, 720p | 5344879 | 3990875 | 1354004 | 25.33% |
| YUV, mixed content, 1440p | 4550287 | 3367189 | 1183098 | 26.00% |
| YUV, mixed content, 1080p | 1760500 | 1169769 | 590731 | 33.55% |
| YUV, Animation, 720p | 2668894 | 1534411 | 1134483 | 42.51% |
| YUV, camera captured, 1080p | 6692504 | 3693744 | 2998760 | 44.81% |
| **All** | **97954938** | **70986907** | **26968031** | **27.53%** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Random Access | Original | Proposal | Original-Proposal | Bin Saving |
| RGB, text & graphics with motion, 1080p | 2134502 | 2192698 | -58196 | -2.73% |
| YUV, Animation, 720p | 1394663 | 982907 | 411756 | 29.52% |
| YUV, camera captured, 1080p | 2865368 | 2027209 | 838159 | 29.25% |
| All | **6394533** | **5202814** | **1191719** | **18.64%** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Low Delay B | Original | Proposal | Original-Proposal | Bin Saving |
| RGB, text & graphics with motion, 1080p | 1616970 | 1218935 | 398035 | 24.62% |
| YUV, Animation, 720p | 1601690 | 970679 | 631011 | 39.40% |
| YUV, camera captured, 1080p | 3004045 | 1877988 | 1126057 | 37.48% |
| All | **6222705** | **4067602** | **2155103** | **34.63%** |

**Table 6. Bins result for Lossless Coding**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Random Access | Original | Proposal | Original-Proposal | Bin Saving |
| RGB, text & graphics with motion, 1080p | 8999706 | 9485190 | -485484 | -5.39% |
| RGB, text & graphics with motion, 720p | 7013766 | 5600866 | 1412900 | 20.14% |
| RGB, mixed content, 1440p | 6233654 | 4748514 | 1485140 | 23.82% |
| RGB, mixed content, 1080p | 4031803 | 2828932 | 1202871 | 29.83% |
| RGB, Animation, 720p | 5049743 | 2869737 | 2180006 | 43.17% |
| RGB, camera captured, 1080p | 14429893 | 11844049 | 2585844 | 17.92% |
| YUV, text & graphics with motion, 1080p | 9208515 | 9885558 | -677043 | -7.35% |
| YUV, text & graphics with motion, 720p | 7290053 | 5644612 | 1645441 | 22.57% |
| YUV, mixed content, 1440p | 6591273 | 4999912 | 1591361 | 24.14% |
| YUV, mixed content, 1080p | 4185589 | 2930629 | 1254960 | 29.98% |
| YUV, Animation, 720p | 6043889 | 3392496 | 2651393 | 43.87% |
| YUV, camera captured, 1080p | 23033816 | 19246404 | 3787412 | 16.44% |
| All | 102111700 | 83476899 | 18634801 | 18.25% |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Low Delay B | Original | Proposal | Original-Proposal | Bin Saving |
| RGB, text & graphics with motion, 1080p | 9064254 | 9871678 | -807424 | -8.91% |
| RGB, text & graphics with motion, 720p | 6248988 | 4723251 | 1525737 | 24.42% |
| RGB, mixed content, 1440p | 4695912 | 3519260 | 1176652 | 25.06% |
| RGB, mixed content, 1080p | 3380669 | 2116990 | 1263679 | 37.38% |
| RGB, Animation, 720p | 5134808 | 2725993 | 2408815 | 46.91% |
| RGB, camera captured, 1080p | 15728978 | 12078838 | 3650140 | 23.21% |
| YUV, text & graphics with motion, 1080p | 9115850 | 9771909 | -656059 | -7.20% |
| YUV, text & graphics with motion, 720p | 6596581 | 4803703 | 1792878 | 27.18% |
| YUV, mixed content, 1440p | 5081828 | 3764677 | 1317151 | 25.92% |
| YUV, mixed content, 1080p | 3442441 | 2161660 | 1280781 | 37.21% |
| YUV, Animation, 720p | 5679169 | 3018015 | 2661154 | 46.86% |
| YUV, camera captured, 1080p | 23871297 | 19436650 | 4434647 | 18.58% |
| All | 98040775 | 77992624 | 20048151 | 20.45% |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Random Access | Original | Proposal | Original-Proposal | Bin Saving |
| Text & graphics with motion, 720p | 1772134 | 1441361 | 330773 | 18.67% |
| Mixed content, 480p | 2735320 | 1727300 | 1008020 | 36.85% |
| Animation, 768p | 7293341 | 5372982 | 1920359 | 26.33% |
| All | **11800795** | **8541643** | **3259152** | **27.62%** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Low Delay B | Original | Proposal | Original-Proposal | Bin Saving |
| Text & graphics with motion, 720p | 1515506 | 1062670 | 452836 | 29.88% |
| Mixed content, 480p | 2830993 | 1672077 | 1158916 | 40.94% |
| Animation, 768p | 7309533 | 5185909 | 2123624 | 29.05% |
| All | **11656032** | **7920656** | **3735376** | **32.05%** |

# Conclusion

A new mode coding order is proposed in this contribution to reduce the number of processed bins. The simulation results show that the average 15.68%, 27.53%, 18.25%, 20.45%, 18.64%, 34.63%, 27.62%, 32.05% bins saving are achieved for 444 and RGB sequences lossy RA, LB, lossless RA, LB, and 420 sequences lossy RA, LB, lossless RA, LB cases, respectively.

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1. [B. Bross](mailto:benjamin.bross@hhi.fraunhofer.de), [W.-J. Han](mailto:wjhan.han@samsung.com), [J.-R. Ohm](mailto:ohm@ient.rwth-aachen.de), [G. J. Sullivan](mailto:garysull@microsoft.com), Ye-Kui Wang, [T. Wiegand](mailto:thomas.wiegand@hhi.fraunhofer.de), “High Efficiency Video Coding (HEVC) text specification draft 10 (for FDIS & Last Call),” Document of Joint Collaborative Team on Video Coding, JCTVC-L1003\_v34, 12th Meeting: Geneva, CH, 14–23 Jan. 2013.
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# Patent rights declaration(s)

**Arris Inc. may have current or pending patent rights 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).**