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| |  |  | | --- | --- | | **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  16th Meeting: San Jose, CA, 9 Jan. – 17 Jan. 2014 | Document: JCTVC-Oxxxx | | Document: JCTVC-P0161 |  |

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| *Title:* | **Non-RCE4: Simplification of major color based palette prediction** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | Guoxin Jin, Ankur Saxena, Chanyul Park and Felix Fernandes | Email: Tel: | [guoxin.jin@sta.samsung.com](mailto:guoxin.jin@sta.samsung.com),  [asaxena@sta.samsung.com](mailto:asaxena@sta.samsung.com),  [cy1205.park@samsung.com](mailto:cy1205.park@samsung.com)  [ffernandes@sta.samsung.com](mailto:ffernandes@sta.samsung.com)  1-972-761-7761 |
| *Source:* | Samsung Electronics, Co., Ltd. | | |

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# Abstract

Major-color-based coding, a palette prediction coding scheme was proposed in JCTVC-O0182. It was shown that major-color-based coding can provide significant compression gains for screen content sequences. In JCTVC-P0108, a simple palette prediction technique, which tries to re-use the palettes from above or left CUs, was also introduced. In this contribution, the effectiveness of such palette prediction schemes is studied, and various simplifications of using only left CU palette; or none of left and top palettes as prediction are proposed. Simulation results shows that marginal 0.1% average bit-rate gain loss on disabling the prediction from the above CU palette, but the codec need no longer store the above CU palette data, which can be huge, especially for higher resolution sequences.

# Introduction

Major-color-based coding proposed in JCTVC-O0182, JCTVC-P0108 [1,2], and currently being tested in RCE 4[3] achieves significant compression gain on HM12.0+Rext5.1 software base for screen content, as screen content is likely to have similar regions locally. There are various techniques considered in Major-color-based coding, such as Escape color, color index prediction, and joint index coding. One of the techniques is palette prediction from left or above CUs.

Specifically, in the palette prediction scheme in [1], the palettes of above and left CU can be re-used if there is a color in the aligned palette location which is same as the color in the current CU palette. Let the palettes of left CU be denoted as PL = { pL(0), pL(1), pL(2), ..., pL(K)}; and the palette of current CU as

P = { p(0), p(1), p(2), ..., p(M)}. Note that K and M may differ. Then p(i) will re-use pL(i) if and only if p(i) = pL(i). As a result prediction is be signaled as in Table 1.

**Table 1: Signalling of Palette Prediction in JCTVC-P0108**

|  |  |
| --- | --- |
| Mode | Bits |
| No Aligned colors are same in left and above CUs | 0+bitDepth |
| Aligned color predicted from left CU | 10 |
| Aligned color predicted from above CU | 11 |

# Scheme A: Disabling prediction from left and top CU’s

We first disable the prediction from left, and above CU’s. Thus, no signaling is required, and the palette is coded as shown in Table 2.

**Table 2: Disabling prediction from left and above in JCTVC-P0108**

|  |  |
| --- | --- |
| Mode | Bits |
| Any color irrespective of alignment | bitDepth |

The coding gains are summarized in Table 3 and 4. The Anchor is HM12.1+RExt5.1+ JCTVC-P0108 There is about a 0.3% to 0.5% gain loss if the prediction is disabled from both left and above CU’s. Detailed results are in attached excel files in the folder.

**Table 3: Lossless: Anchors is HM12.1+RExt5.1+JCTVC-P0108. Proposed technique disables prediction from top and left CU’s**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average bit-rate increase | | |
|  | **AI** | **RA** | **LB** |
| Class F | 0.0% | 0.1% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% |
| RGB 4:4:4 SC | 0.7% | 0.6% | 0.6% |
| RGB 4:4:4 Animation | 0.0% | 0.0% | 0.0% |
| YCbCr 4:4:4 SC | 0.4% | 0.3% | 0.3% |
| YCbCr 4:4:4 Animation | 0.0% | 0.0% | 0.0% |
| RangeExt | 0.0% | 0.0% | 0.0% |
| RGB 4:4:4 SC (Optional) | 3.4% | 3.4% | 1.0% |
| YCbCr 4:4:4 SC (Optional) | 1.7% | 1.9% | 1.8% |
| Enc Time[%] | 100% | 100% | 100% |
| Dec Time[%] | 100% | 101% | 100% |
|  |  |  |  |
| Number of differences from anchor | 34 | 34 | 34 |
| Total differences | 102 |  |  |

**Table 4: Lossy: Anchors is HM12.1+RExt5.1+JCTVC-P0108. Proposed technique disables prediction from top and left CU’s**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main-tier** | | | **All Intra High-tier** | | | **All Intra Super-High-tier** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class F | 0.1% | 0.2% | 0.2% | 0.1% | 0.1% | 0.2% | 0.1% | 0.1% | 0.1% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB 4:4:4 SC | 0.8% | 0.8% | 0.9% | 0.9% | 0.8% | 0.9% | 0.9% | 0.8% | 0.8% |
| RGB 4:4:4 Animation | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YCbCr 4:4:4 SC | 0.4% | 0.5% | 0.4% | 0.5% | 0.5% | 0.5% | 0.6% | 0.5% | 0.5% |
| YCbCr 4:4:4 Animation | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| RangeExt | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB 4:4:4 SC (Optional) | 3.6% | 3.5% | 3.4% | 3.7% | 3.6% | 3.6% | 3.9% | 3.8% | 3.8% |
| YCbCr 4:4:4 SC (Optional) | 1.5% | 1.6% | 1.5% | 1.9% | 1.8% | 1.6% | 2.2% | 1.9% | 1.9% |
| Enc Time[%] | 100% | | | 100% | | | 100% | | |
| Dec Time[%] | 101% | | | 101% | | | 100% | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main-tier** | | | **Random Access High-tier** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class F | 0.1% | 0.0% | 0.2% | 0.1% | 0.0% | 0.1% |  |  |  |
| Class B | 0.0% | -0.1% | 0.2% | 0.0% | 0.0% | 0.0% |  |  |  |
| RGB 4:4:4 SC | 0.8% | 0.8% | 0.8% | 0.9% | 0.9% | 0.8% |  |  |  |
| RGB 4:4:4 Animation | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% |  |  |  |
| YCbCr 4:4:4 SC | 0.2% | 0.2% | 0.3% | 0.4% | 0.4% | 0.4% |  |  |  |
| YCbCr 4:4:4 Animation | 0.0% | -0.1% | -0.1% | 0.0% | -0.1% | -0.1% |  |  |  |
| RangeExt | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| RGB 4:4:4 SC (Optional) | 3.2% | 3.1% | 3.0% | 3.5% | 3.3% | 3.3% |  |  |  |
| YCbCr 4:4:4 SC (Optional) | 1.5% | 1.4% | 1.3% | 1.7% | 1.6% | 1.5% |  |  |  |
| Enc Time[%] | 100% | | | 100% | | |  |  |  |
| Dec Time[%] | 100% | | | 100% | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main-tier** | | | **Low delay B High-tier** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class F | -0.1% | 0.0% | -0.2% | 0.0% | -0.1% | -0.3% |  |  |  |
| Class B | 0.0% | 0.3% | -0.1% | 0.0% | 0.2% | 0.0% |  |  |  |
| RGB 4:4:4 SC | 0.5% | 0.5% | 0.6% | 0.6% | 0.6% | 0.6% |  |  |  |
| RGB 4:4:4 Animation | 0.0% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% |  |  |  |
| YCbCr 4:4:4 SC | 0.2% | 0.3% | 0.3% | 0.3% | 0.3% | 0.3% |  |  |  |
| YCbCr 4:4:4 Animation | -0.1% | -0.2% | -0.2% | 0.0% | -0.1% | -0.1% |  |  |  |
| RangeExt | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.1% |  |  |  |
| RGB 4:4:4 SC (Optional) | 3.6% | 3.4% | 3.4% | 4.2% | 3.9% | 3.8% |  |  |  |
| YCbCr 4:4:4 SC (Optional) | 0.5% | 0.0% | 0.4% | 1.2% | 0.7% | 0.9% |  |  |  |
| Enc Time[%] | 100% | | | 100% | | |  |  |  |
| Dec Time[%] | 100% | | | 99% | | |  |  |  |

# Scheme B: Disabling prediction from top CU only

Buffering left and above CU palettes will require a lot of memory. Here, we just allow storage of palette from left CU only, and this leads to a marginal 0.1% loss, as compared to JCTVC-P0108. The signaling is simplified as in Table 5. The summaries of coding gains as compared to HM12.0+RExt5.1+JCTVC-P0108 are shown in Table 6 and 7 respectively. Detailed results are in attached excel files in the folder.

**Table 5: Simplification of Bit Allocation of Palette Prediction without prediction from above**

|  |  |
| --- | --- |
| Mode | Bits |
| No Aligned colors are same in left CU | 0+bitDepth |
| Aligned color predicted from left CU | 1 |

**Table 6: Lossy: Anchor is HM12.1+RExt5.1+JCTVC-P0108. Proposed technique disables prediction from top CU**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average bit-rate increase | | |
|  | **AI** | **RA** | **LB** |
| Class F | 0.0% | 0.1% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% |
| RGB 4:4:4 SC | 0.1% | 0.0% | 0.2% |
| RGB 4:4:4 Animation | 0.0% | 0.0% | 0.0% |
| YCbCr 4:4:4 SC | 0.1% | 0.1% | 0.0% |
| YCbCr 4:4:4 Animation | 0.0% | 0.0% | 0.0% |
| RangeExt | 0.0% | 0.0% | 0.0% |
| RGB 4:4:4 SC (Optional) | 0.3% | 0.2% | 0.1% |
| YCbCr 4:4:4 SC (Optional) | 0.3% | 0.8% | 2.1% |
| Enc Time[%] | 100% | 100% | 100% |
| Dec Time[%] | 100% | 100% | 100% |
|  |  |  |  |
| Number of differences from anchor | 31 | 30 | 28 |
| Total differences | 89 |  |  |

**Table 7: Lossy: Anchor is HM12.1+RExt5.1+JCTVC-P0108. Proposed technique disables prediction from top CU**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main-tier** | | | **All Intra High-tier** | | | **All Intra Super-High-tier** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class F | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 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% |
| RGB 4:4:4 SC | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| RGB 4:4:4 Animation | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YCbCr 4:4:4 SC | 0.0% | 0.0% | 0.1% | 0.1% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% |
| YCbCr 4:4:4 Animation | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| RangeExt | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB 4:4:4 SC (Optional) | 0.3% | 0.2% | 0.2% | 0.3% | 0.3% | 0.3% | 0.3% | 0.3% | 0.3% |
| YCbCr 4:4:4 SC (Optional) | 0.3% | 0.2% | 0.2% | 0.3% | 0.3% | 0.2% | 0.4% | 0.4% | 0.3% |
| Enc Time[%] | 100% | | | 100% | | | 100% | | |
| Dec Time[%] | 100% | | | 100% | | | 100% | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main-tier** | | | **Random Access High-tier** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class F | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.1% |  |  |  |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| RGB 4:4:4 SC | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |  |  |  |
| RGB 4:4:4 Animation | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| YCbCr 4:4:4 SC | 0.0% | 0.0% | 0.1% | 0.2% | 0.1% | 0.2% |  |  |  |
| YCbCr 4:4:4 Animation | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| RangeExt | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| RGB 4:4:4 SC (Optional) | 0.1% | 0.2% | 0.2% | 0.2% | 0.1% | 0.2% |  |  |  |
| YCbCr 4:4:4 SC (Optional) | 0.5% | 0.3% | 0.4% | 0.4% | 0.2% | 0.3% |  |  |  |
| Enc Time[%] | 100% | | | 100% | | |  |  |  |
| Dec Time[%] | 102% | | | 102% | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main-tier** | | | **Low delay B High-tier** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class F | -0.1% | -0.2% | -0.1% | 0.0% | -0.1% | -0.2% |  |  |  |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| RGB 4:4:4 SC | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.2% |  |  |  |
| RGB 4:4:4 Animation | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| YCbCr 4:4:4 SC | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |  |  |  |
| YCbCr 4:4:4 Animation | 0.0% | 0.0% | -0.1% | 0.0% | -0.1% | -0.1% |  |  |  |
| RangeExt | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| RGB 4:4:4 SC (Optional) | 0.4% | 0.4% | 0.4% | 0.3% | 0.2% | 0.2% |  |  |  |
| YCbCr 4:4:4 SC (Optional) | -0.1% | -0.6% | -0.3% | 0.3% | -0.2% | 0.1% |  |  |  |
| Enc Time[%] | 100% | | | 100% | | |  |  |  |
| Dec Time[%] | 101% | | | 100% | | |  |  |  |

# Conclusion

The proposed simplification of palette prediction on top of JCTVC-P0108 by disabling prediction from above CU reduces 0.1 % gain for SC YUV 444 coding. But it can reduce the memory requirement for buffering the palette from above CU. We therefore recommend adopting this proposal in the Committee Draft of HEVC range extensions if major color based palette prediction scheme is adopted from RCE 4 [3].

# References

1. X. Guo et. al, “AHG8: Major-color-based screen content coding”, JCTVC-O0182, Geneva, Switzerland, October 2013.
2. X. Guo et. al, “RCE4: Test1. Major-color-based screen content coding”, JCTVC-P0108, San Jose, USA, Jan 2014.
3. L. Guo, X. Guo and A. Saxena, “HEVC Range Extensions Core Experiment 4 (RCE 4): Palette coding for screen content”, JCTVC-O1124, Geneva, Switzerland, October 2013.

# Patent rights declaration(s)

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