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| *Title:* | **Improvement of cross-component prediction** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

SCM1.0 (and HM-14.0+RExt-7.0) contains a cross-component prediction (CCP) process. This document proposes modifying the CCP process by adding an offset block to the reconstructed luma (or first component) residual block. This offset block is the difference between the luma prediction block after intra boundary filtering is applied and the same block before intra boundary filtering is applied. The intra boundary filtering is not modified. Simulations results for making this modification to SCM1.0 are provided. For all intra test lossy conditions, BD-rate improvements for GBR components for mixed content 1440p are -1.7%, -1.6%, and -1.7% respectively.

# Introduction

In SCM1.0 (and HM-14.0+RExt-7.0), a cross-component prediction (CCP) process is used to predict chroma (or 2nd and 3rd components) prediction residuals from the luma (or 1st component) prediction residual. For luma (1st component) prediction blocks, a boundary filtering process is applied for blocks that use the DC, horizontal or vertical intra prediction mode. This boundary filtering process is not applied to chroma components. Therefore, CCP uses a luma residual block generated using a boundary filtering process to predict a chroma residual block generated without using a boundary-filtering process. This document proposes modifying the CCP process to compensate for the changes made to the luma residual block by the intra boundary filtering process. The intra boundary filtering is not modified.

## Intra boundary filtering

In SCM1.0 (and HM-14.0+RExt-7.0), when a luma block is predicted using DC, horizontal or vertical prediction mode, the boundary pixels of the prediction block may be modified according to an intra boundary filtering process. For an NxN luma block, the DC, horizontal and vertical prediction process consists of two steps:

* Step 1: Form the initial prediction value  for the current block, with x, y = 0..N−1. For DC mode,  is equal to the average of the reference pixels. For horizontal mode, , where are the reference pixels to the left of the current block. For vertical mode, , where are the reference pixels above the current block.
* Step 2: Form the final prediction value  by applying the intra boundary filtering process to when the filtering process is enabled, or by setting when the filtering process is disabled.

## Cross component prediction

In SCM1.0 (and HM-14.0+RExt-7.0), when a chroma block is intra-coded using DM mode, i.e. intra\_chroma\_pred\_mode[ xCb ][ yCb ]==4, a cross component prediction process may be applied. At the decoder, the chroma residual block is reconstructed as follows:

, (1)

where

denotes the chroma CCP residual block;

denotes the reconstructed luma residual block;

denotes the reconstructed chroma residual block, and

α is a scaling parameter that calculated by the encoder and is signaled in the bit-stream.

# Proposed method

# This document proposes modifying the cross-component prediction process by adding an offset block to the reconstructed luma residual block as follows:

, (2)

where

. (3)

is set to 0 when *x* ≠ 0 and *y* ≠ 0, i.e. only the left and top boundaries can be nonzero. When intra boundary filtering is not applied, all elements of are set to 0. No changes are made to the intra boundary filtering process.

# Simulation results

The proposed method is integrated on the reference software SCM-1.0 and is tested using the common conditions for screen content coding tests from JCTVC-Q1015 [1]. Full simulation results and the associated spreadsheets will be provided in a revised document.

## Lossly results

Encode and decode time ratios may vary due to differences in computing platforms.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -0.6% | -0.6% | -0.6% |
| RGB, text & graphics with motion,720p | -1.1% | -1.0% | -1.0% |
| RGB, mixed content, 1440p | -1.7% | -1.6% | -1.7% |
| RGB, mixed content, 1080p | -1.6% | -1.6% | -1.6% |
| RGB, Animation, 720p | -0.7% | -0.7% | -0.6% |
| RGB, camera captured, 1080p | -1.1% | -0.9% | -1.2% |
| YUV, text & graphics with motion, 1080p | -0.1% | -0.2% | -0.1% |
| YUV, text & graphics with motion,720p | -0.1% | -0.2% | -0.3% |
| YUV, mixed content, 1440p | -0.1% | -0.3% | -0.1% |
| YUV, mixed content, 1080p | -0.2% | -0.5% | -0.2% |
| YUV, Animation, 720p | -0.1% | -0.3% | -0.1% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | -0.3% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 128% | | |
|  |  |  |  |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -0.2% | -0.2% | -0.2% |
| RGB, text & graphics with motion,720p | -0.9% | -0.7% | -0.8% |
| RGB, mixed content, 1440p | -1.0% | -0.8% | -0.8% |
| RGB, mixed content, 1080p | -1.1% | -1.0% | -1.0% |
| RGB, Animation, 720p | -0.5% | -0.5% | -0.4% |
| RGB, camera captured, 1080p | -0.4% | -0.3% | -0.5% |
| YUV, text & graphics with motion, 1080p | 0.0% | 0.0% | -0.1% |
| YUV, text & graphics with motion,720p | -0.1% | -0.1% | -0.1% |
| YUV, mixed content, 1440p | -0.1% | -0.3% | -0.3% |
| YUV, mixed content, 1080p | -0.1% | -0.3% | -0.1% |
| YUV, Animation, 720p | 0.0% | -0.3% | 0.1% |
| YUV, camera captured, 1080p | 0.0% | -0.1% | 0.0% |
| Enc Time[%] | 101% | | |
| Dec Time[%] | 82% | | |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -0.1% | -0.1% | 0.0% |
| RGB, text & graphics with motion,720p | -0.5% | -0.6% | -0.4% |
| RGB, mixed content, 1440p | -0.4% | -0.7% | -0.4% |
| RGB, mixed content, 1080p | -0.3% | -0.3% | -0.2% |
| RGB, Animation, 720p | -0.1% | -0.1% | 0.0% |
| RGB, camera captured, 1080p | -0.1% | -0.1% | -0.1% |
| YUV, text & graphics with motion, 1080p | -0.1% | -0.1% | 0.0% |
| YUV, text & graphics with motion,720p | -0.2% | 0.2% | -0.2% |
| YUV, mixed content, 1440p | 0.0% | -0.3% | -0.1% |
| YUV, mixed content, 1080p | 0.1% | -1.2% | 0.8% |
| YUV, Animation, 720p | 0.0% | -0.3% | -0.4% |
| YUV, camera captured, 1080p | 0.0% | -0.1% | 0.0% |
| Enc Time[%] | 101% | | |
| Dec Time[%] | 82% | | |

## Lossless results

Encode and decode time ratios may vary due to differences in computing platforms.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **All Intra** | | | |
|  | Bit-rate saving (Total) | Bit-rate saving (Average) | Bit-rate saving (Min) | Bit-rate saving (Max) |
|  |
| RGB, text & graphics with motion, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, text & graphics with motion,720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.1% |
| RGB, mixed content, 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 | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion,720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, mixed content, 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[%] | 103% | | | |
| Dec Time[%] | 111% | | | |
|  |  |  |  |  |
|  | **Random Access** | | | |
|  | Bit-rate saving (Total) | Bit-rate saving (Average) | Bit-rate saving (Min) | Bit-rate saving (Max) |
|  |
| RGB, text & graphics with motion, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, text & graphics with motion,720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, mixed content, 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 | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion,720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, mixed content, 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[%] | 101% | | | |
| Dec Time[%] | 115% | | | |
|  |  |  |  |  |
|  |  |  |  |  |
|  | **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 | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, text & graphics with motion,720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, mixed content, 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 | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion,720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, mixed content, 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[%] | 101% | | | |
| Dec Time[%] | 115% | | | |

# Conclusions

This document proposes modifying the CCP process by adding an offset block to the reconstructed luma (or first component) residual block. This offset block is the difference between the luma prediction block after intra boundary filtering is applied and the same block before intra boundary filtering is applied. The intra boundary filtering is not modified. Simulations results for making this modification to SCM1.0 are provided. For all intra test lossy conditions, BD-rate improvements for GBR components for mixed content 1440p are -1.7%, -1.6%, and -1.7% respectively.

# Patent rights declaration(s)

**Mitsubishi Electric Research Laboratories 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).**

# References

1. H. Yu, R. Cohen, K. Rapaka, J. Xu, “Common conditions for screen content coding tests,” Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-Q1015, 17th Meeting: Valencia, ES, 27 March – 4 April, 2014.