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| *Title:* | **Non-CE6a: Using averaged down-sampling reference pixels in LM parameter generation** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

A method of simplifying intra chroma from luma (LM mode) prediction is proposed. The simplification of intra LM mode reduces the number of multiplication operations for calculating parameter alpha and beta by using the averaged down-sampled reference luma and chroma samples. It is reported that 1:2 down-sampling of 16x16 PU has 0.00% change for Y and Cb, 0.02% coding loss for Cr; 1:4 down-sampling of 16x16 PU and 1:2 down-sampling of 8x8 PU has 0.00% change in Y, 0.04% and 0.05% coding loss for Cb and Cr, in all intra high efficiency tests.

# Introduction

For chroma blocks, the current design of High Efficiency Video Coding (HEVC) has a chroma from luma intra prediction mode, which is also referred as LM mode, in addition to the directional modes and the DC mode.

According to the HEVC working draft [1] and the HM-5.0 software, the current design of LM mode uses reconstructed luma samples to predict chroma samples. The values of the prediction are derived as the following ordered steps [1]:

1. Variable k3 and the sample array pY’ are derived as:

k3 = Max( 0, BitDepthC + log2( nS ) – 14 ) (1)

pY’[ x, y ] = ( recSamplesL[ 2x-1, 2y+1 ] +   
2\*recSamplesL[ 2x, 2y+1 ] + recSamplesL[ 2x+1, 2y+1 ] + 2 ) >> 2, with x=0..nS-1, y = -1 (2)

pY’[ x, y ] = ( recSamplesL[ 2x, 2y ] + recSamplesL[ 2x, 2y+1 ] ) >> 1, with x=-1..nS-1, y = 0..nS-1 (3)

1. Variables L, C, LL, LC and k2 are derived as follows:

L =  (4)

C =  (5)

LL =  (6)

LC =  (7)

k2 = log2( (2\*nS) >> k3 ) (8)

1. Variables a, b and k are derived as:

a1 = ( LC << k2 ) – L\*C (9)  
a2 = ( LL << k2 ) – L\*L (10)  
k1 = Max( 0, log2( abs( a2 ) ) – 5 ) – Max( 0, log2( abs( a1 ) ) – 14 ) + 2 (11)  
a1s = a1 >> Max(0, log2( abs( a1 ) ) – 14 ) (12)  
a2s = abs( a2 >> Max(0, log2( abs( a2 ) ) – 5 ) ) (13)  
a3 = a2s < 1 ? 0 : Clip3( -215, 215-1, a1s\*lmDiv + ( 1 << ( k1 – 1 ) ) >> k1 ) (14)

alpha = a3 >> Max( 0, log2( abs( a3 ) ) – 6 ) (15)  
k = 13 – Max( 0, log2( abs( alpha ) ) – 6 ) (16)

beta = ( L – ( ( alpha \* C ) >> k1 ) + ( 1 << ( k2 – 1 ) ) ) >> k2 (17)

where *lmDiv* is specified in a look-up table [1] with the input a2s.

1. The values of the prediction samples predSamples[ x, y ] are derived as:

predSamples[ x, y ] = Clip1C( ( ( pY’[ x, y ] \* alpha ) >> k ) + beta ), with x, y = 0..nS-1 (18)

In equation (4), (5), (6), and (7), reference samples from reconstructed above and left neighboring blocks are used to calculate the parameters (Alpha and Beta) needed for the LM mode intra prediction, L, C, LL, and LC. In the current design of HEVC Test Model, HM v5.0, the calculations in (4), (5), (6), (7), involve *nS* of downsampled reconstructed luma samples and *nS* reconstructed chroma samples, where *nS* is the prediction size, which is equal to the width or height of the current predicted block. As shown in Figure-1, when nS = N, NxN chroma samples are used; 2Nx2N luma samples are downsampled to NxN and used in the calculations.

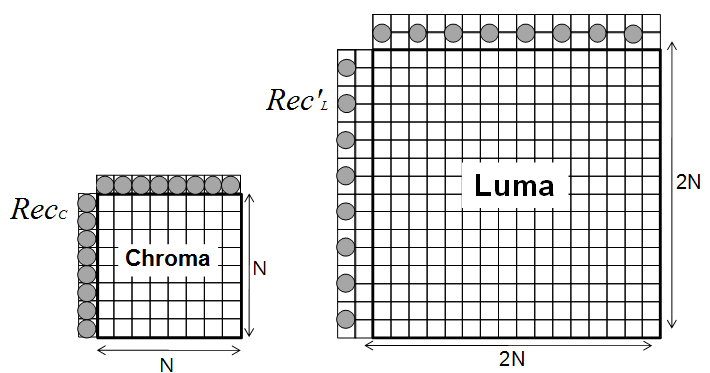


Figure-1 Reference luma and chroma neighboring samples used for LM mode [2]

For each block, the total number of additions in equation (4), (5), (6), (7) is *8\*nS*, and the total number of multiplications is *4\*nS*, respectively.

# Description of proposed simplifications

[3] recommended to use 1:2 down-sampling method to reduce the multiplications in generating alpha and beta. This method provides a method to further reduce the multiplications by using the averaged down-sampling reference luma and chroma samples.

The proposed simplification method has two variations,

1. Down sampling the number of both above and left reference samples used in (4), (5), (6), (7) to 4, if nS > 4.

As shown in Figure-2, both luma and chroma neighboring samples are downsampled to 4x4

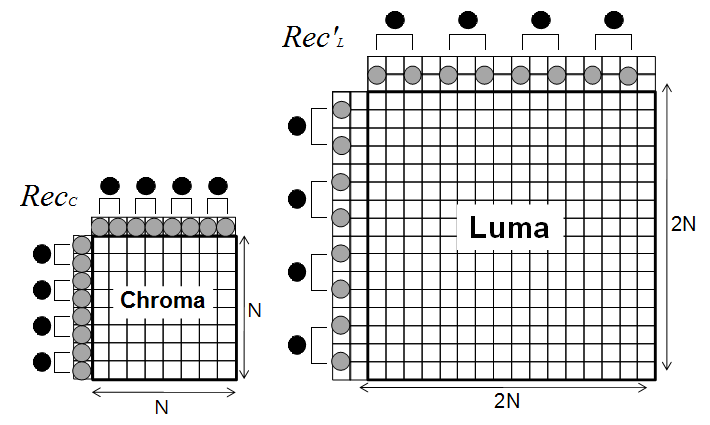


Figure 2. Down sampled and averaged luma and chroma neighboring reference samples to 4, dark dots denote the averaged samples used in calculation

1. Down sampling the number of both above and left reference samples used in (4), (5), (6), (7) to 8, if nS > 8. It’s similar to down sampling to 4x4, but only applied when the prediction size is greater than 8.

Thus, the reduction of related additions and multiplications will be,

1. Down sampling to 4 case: 75% for blocks with size 16x16, 50% for blocks with size 8x8, and no reduction for blocks with size 4x4;
2. Down sampling to 8 case: 50% for blocks with size 16x16, and no reduction for blocks with size 8x8 and 4x4;

In addition to the down sampling of the reference samples, in each down sampling interval, get the average of left samples *avgLL* for luma, *avgLC* for chroma, the average of above samples, *avgAL* for luma, *avgAC* for chroma, and use the averaged sample values for *alpha* and *beta* calculations. Let g denotes the size of down-sampling interval, we have,









1) For down sampling to 4x4 case, equations (4), (5), (6), and (7) may be changed to,

L =  (19)

C =  (20)

LL =  (21)

LC =  (22)

Where, k3’ = Max( 0, BitDepthC + 2 – 14 ).

2) For down sampling to 8x8 case, for chroma blocks with size greater than 4x4, equations (4), (5), (6), and (7) may be changed to,

L =  (23)

C =  (24)

LL =  (25)

LC =  (26)

Where, k3’ = Max( 0, BitDepthC + 3 – 14 ).

The averaging processes involves only Adding and Shifting operations, no extra multiplication operations needed.

The number of reconstructed luma pixels in the current prediction unit used in the LM prediction remains the same.

# Simulation results

Simulations are conducted following the common HM test conditions [4]. Since intra LM mode is disabled in low complexity configuration, only All Intra HE simulations were performed.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A (8bit) | 0.00% | 0.00% | 0.05% |
| Class B | -0.01% | 0.00% | 0.05% |
| Class C | 0.00% | 0.00% | 0.02% |
| Class D | 0.00% | 0.04% | -0.01% |
| Class E | 0.00% | -0.04% | -0.01% |
| **Overall** | 0.00% | 0.00% | 0.02% |
|  | 0.00% | 0.01% | 0.02% |
| Class F | 0.00% | -0.11% | -0.05% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 102% | | |

Table-1 Neighbouring reference sample reduction to 8x8 for LM mode

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A (8bit) | 0.02% | 0.05% | 0.15% |
| Class B | 0.00% | 0.06% | 0.13% |
| Class C | 0.00% | -0.01% | 0.03% |
| Class D | 0.00% | 0.08% | 0.02% |
| Class E | 0.00% | 0.00% | -0.06% |
| **Overall** | 0.00% | 0.04% | 0.05% |
|  | 0.00% | 0.04% | 0.06% |
| Class F | -0.01% | 0.00% | 0.07% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 103% | | |

Table-2 Neighbouring reference sample reduction to 4x4 for LM mode

# Conclusion

As observed in the simulation result, the simplification of LM mode intra prediction has no impact on BD-rate while reducing computational complexity. It is proposed to consider adopt the simplification of 1:4 averaged down-sampling of 16x16 PU and 1:2 averaged down-sampling of 8x8 PU.

# Reference

[1] Benjamin Bross, et. Al, “WD5: Working Draft 5 of High-Efficiency Video Coding”, ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G1103

[2] Jianle Chen, et. Al, “Complexity reduction of chroma intra LM prediction mode”, ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-F494

[3] Madhukar Budagavi, et. Al, ”CE6.a: Sub-sampling portion of neighboring pixels in calculation of LM parameters”, ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G129

[4] Frank Bossen, “Common HM test conditions and software reference configurations”, ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G1200

# Patent rights declaration(s)

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