JCTVC-G244 (non-CE6a): Luma-based chroma prediction - Model correction

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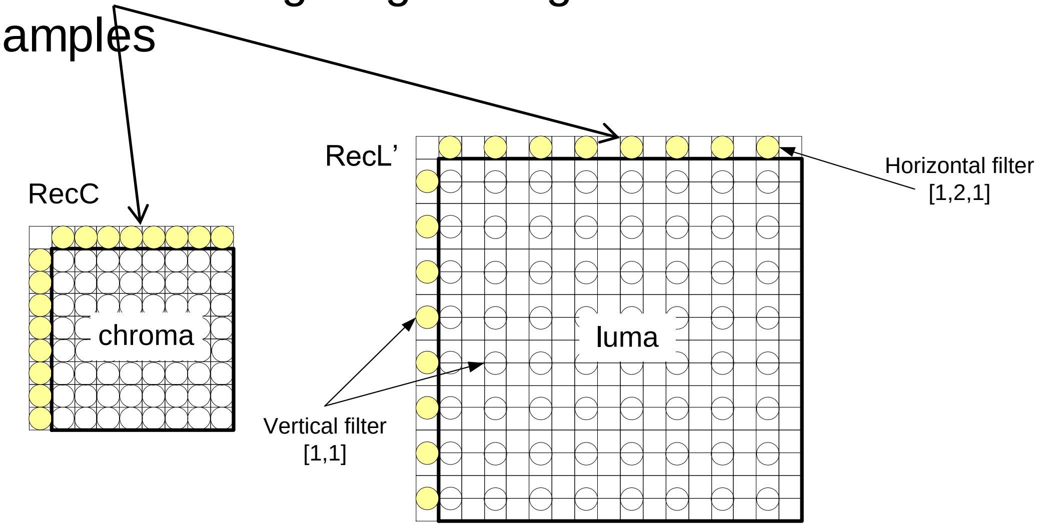
LM chroma prediction mode in the HM

- Chroma derived as follows: $Pred_C[x,y] = \alpha \cdot Rec_L'[x,y] + \beta$
- With: $Rec_L'[x,y] = (Rec_L[2x,2y] + Rec_L[2x,2y+1]) >> 1$
  - Rec_L[.] being the luma samples already reconstructed of the current block
  - The borders use slightly different formulas in HM4.0 but this is unimportant
- α and β are estimated using neighboring reconstructed luma and chroma samples



Use of Least-Mean Squares

- Least-Mean-Square-based method
  - Let Y[i,j] = Chroma[i,j] and X[i,j] =Rec'$_L$[i,j] with i,j on the borders
  - Goal is to find α, β minimizing following equation:

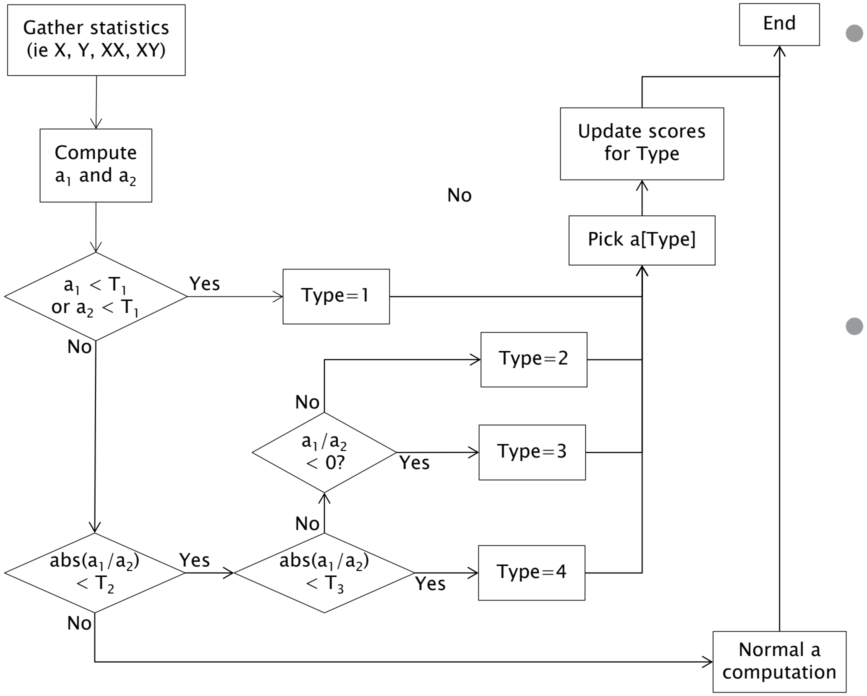
$$(\; [\quad] \qquad [\quad] \quad)$$

  - The α parameter is then computed as (N being the number of pixels):

$$\frac{}{} \qquad \frac{[\quad]\;[\quad]}{[\quad]\;[\quad]} \qquad \frac{}{}$$

- Sources of inaccuracies:
  - Elements XY, XX, X and Y may have their resolution reduced so that computations fit in 32 bits arithmetic
  - The X[i,j] and Y[i,j] signals have been subject to lossy coding
  - The X[i,j] and Y[i,j] signals are not stationary

Proposed solution: detection



- First cause of error is quantization: check whether the a_1 or a_2 values are within a quantization noise threshold (type 1)
  - Current formula: 2×QP<<(g_uiBitIncrement+iCountShift-2)
- Next cause of error is non-stationarity:
  - Check the potentially resulting alpha value with 3 subcases: near 0 range (type 4), within a positive range (type 2), within negative range (type 3)
  - Current ranges:
    - Type 4: [-1,1]/(1>>6)
    - Type 3: [-5,0]/(1>>5)
    - Type 2:]0,5]/(1>>5)

Proposed solution: correction

- Corrective action
  - If nothing detected (type 0), use normal LM mode
  - Otherwise, set α to a predetermined value, from a table of 16 elements, depending on the type, and compute β as usual
- Information sent by the encoder:
  - Indices of the predetermined alpha values within the tables in the bitstream
  - Thresholds
- Finding the predetermined values at the encoder
  - Evaluate each of the 16 elements during analysis and select the best for next frame

Results

- In HM4.0 + alpha bits bugfix

	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V
Class A	0.0%	-14.1%	-16.8%	-0.1%	-14.2%	-16.0%
Class B	0.0%	-1.8%	-1.0%	0.0%	-2.0%	-1.0%
Class C	-0.1%	-1.3%	-1.7%	-0.1%	-1.6%	-1.5%
Class D	-0.1%	-1.4%	-1.4%	-0.1%	-1.5%	-1.5%
Class E	0.0%	-2.6%	-1.6%	-0.1%	-2.9%	-1.7%
Overall	0.0%	-4.2%	-4.5%	-0.1%	-4.4%	-4.3%
	0.0%	-4.1%	-4.4%	-0.1%	-4.3%	-4.2%
Enc Time[%]	100.4%			100.5%		
Dec Time[%]	100.2%			100.7%		

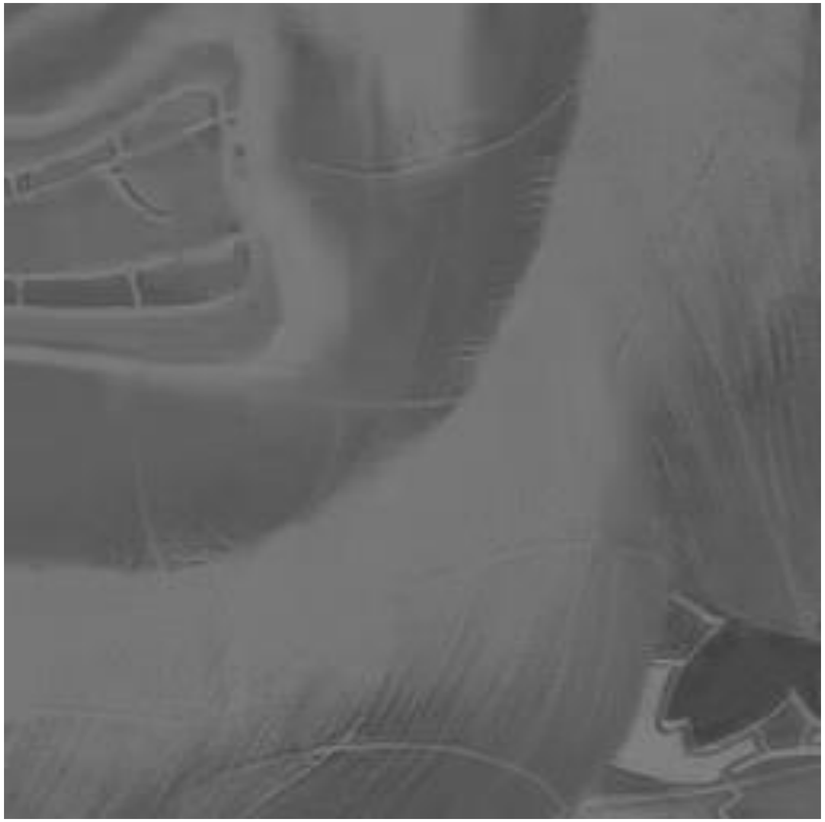
Cross-checked by P.Bordes and P.Salmon from Technicolor in G270

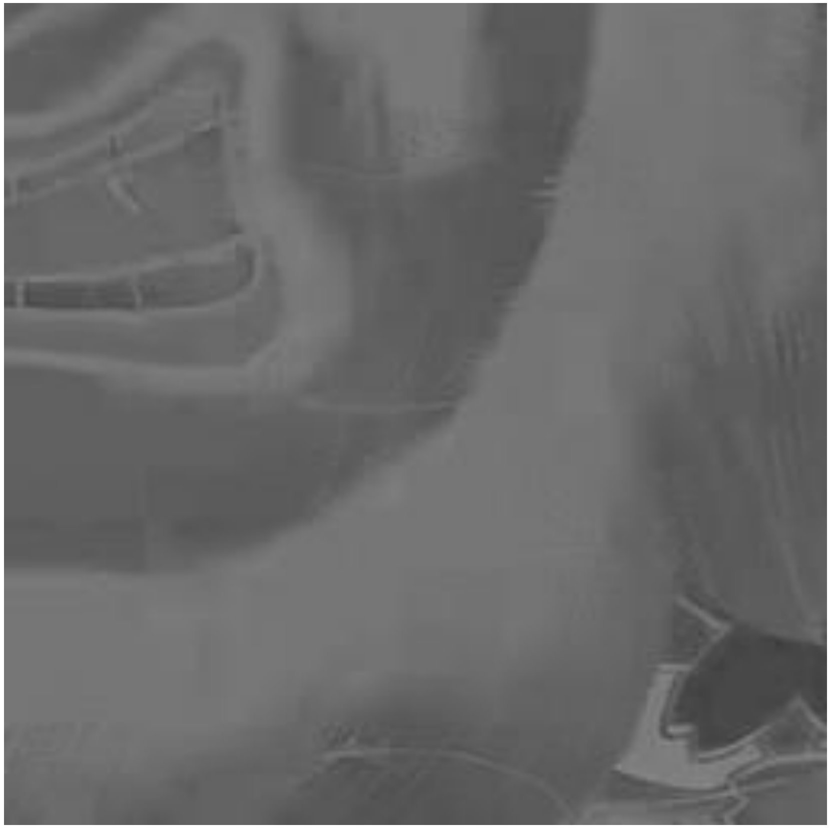
- Number of bits for alpha hardly matter now, as for 9 bits (informative, not cross-checked):

	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V
Class A	0.0%	-14.1%	-16.9%	-0.1%	-14.3%	-16.0%
Class B	0.0%	-1.8%	-1.0%	0.0%	-2.0%	-1.0%
Class C	-0.1%	-1.4%	-1.7%	-0.1%	-1.7%	-1.5%
Class D	-0.1%	-1.4%	-1.4%	-0.1%	-1.5%	-1.5%
Class E	0.0%	-2.7%	-1.7%	-0.1%	-2.9%	-1.7%
Overall	0.0%	-4.2%	-4.5%	-0.1%	-4.4%	-4.3%
	0.0%	-4.2%	-4.4%	-0.1%	-4.3%	-4.2%
Enc Time[%]	100.2%			100.7%		
Dec Time[%]	99.9%			101.8%		

Visual inspection

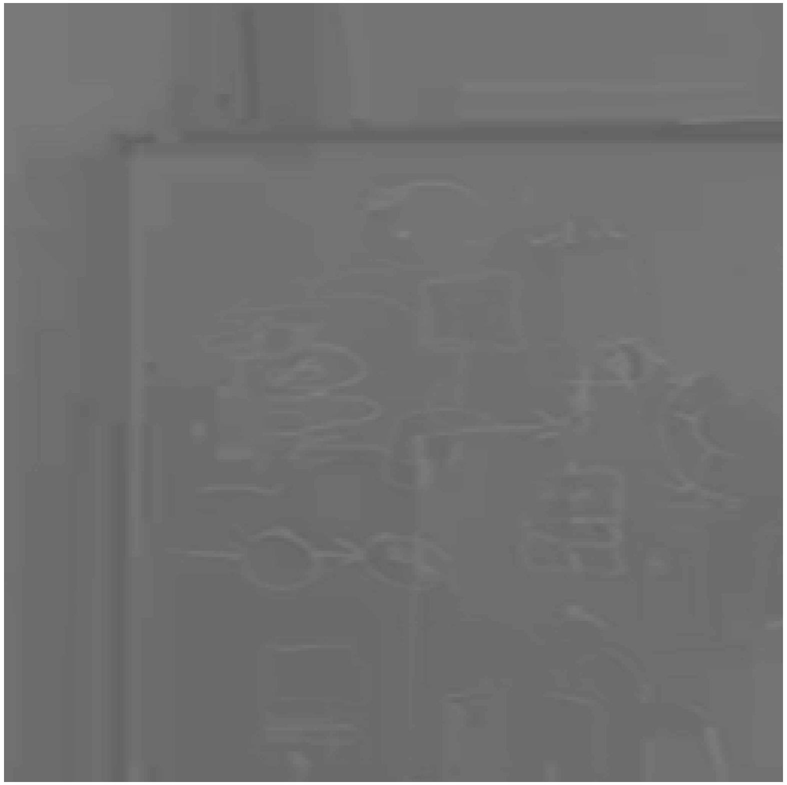
- Nebuta, 6th frame, AILC, QP37: our method vs. HM4.0





Visual inspection

- Vidyo3, 6th frame, QP 27, AILC: our method vs. HM4.0 (contrast to 30%)



Visual inspection

- People on street, 6th frame, QP 37, AILC: ours / original / HM4.0

Further simplifications

- Decimation of the borders: 1:2 for 8x8, 1:4 for 16x16
  - Results from CE6a and contribution G.129 from M. Budagavi (TI) and K. Sato (Sony) when applying this to HM4.0 with bugfix:

	All Intra HE			All Intra LC		
Subsampling factor	Y	U	V	Y	U	V
1:2 for 16x16	0.0%	0.2%	0.1%	0.0%	0.1%	0.0%
1:2 for 8x8, 16x16	0.1%	0.5%	0.4%	0.1%	0.5%	0.3%
1:2 for 8x8, 1:4 for 16x16	0.1%	0.8%	0.5%	0.1%	0.7%	0.3%

- Number of bits: proposed is 6 bits, as current value of 7 results in 17 bits intermediate values for HE scenarios

- Results for all simplifications with previous results as reference:
  - Reference is use of adaptive alternate alpha values and alpha bits set to 7
  - Cross-check by M. Budagavi (TI) in G.646

	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V
Class A	0.1%	0.9%	0.7%	0.1%	0.7%	0.5%
Class B	0.0%	0.3%	0.2%	0.0%	0.2%	0.1%
Class C	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%
Class D	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%
Class E	0.0%	0.3%	0.0%	0.0%	0.2%	0.1%
Overall	0.0%	0.3%	0.2%	0.0%	0.3%	0.2%
	0.0%	0.3%	0.2%	0.0%	0.3%	0.2%
Enc Time[%]	99.8%			100.1%		
Dec Time[%]	98.9%			100.9%		