

JCTVC-N0224 SEI MESSAGE: POST FILTERS TO ENHANCE THE CHROMA PLANES

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invention | collaboration | contribution

Introduction

- This contribution proposes an SEI message for HEVC
 - Carrying post filter coefficients used to enhance the quality of the reconstructed chroma planes.
- Methodology: enhance the chroma planes using the corresponding information from the luma plane.
 - Filters derived on the encoder side have high-pass characteristics.
 - Filters are applied to the surrounding luma pixels, in order to extract high-frequency components.
 - Output of the filtering is added to the chroma pixel to be enhanced, in order to restore the edges.
- Achieve significant chroma quality improvement in Class A, Class B, and screen content sequences (up to 1.5 dB).
- Has been proposed to SHVC for inter-layer prediction in previous meetings

Overview of Chroma Enhancement Filtering

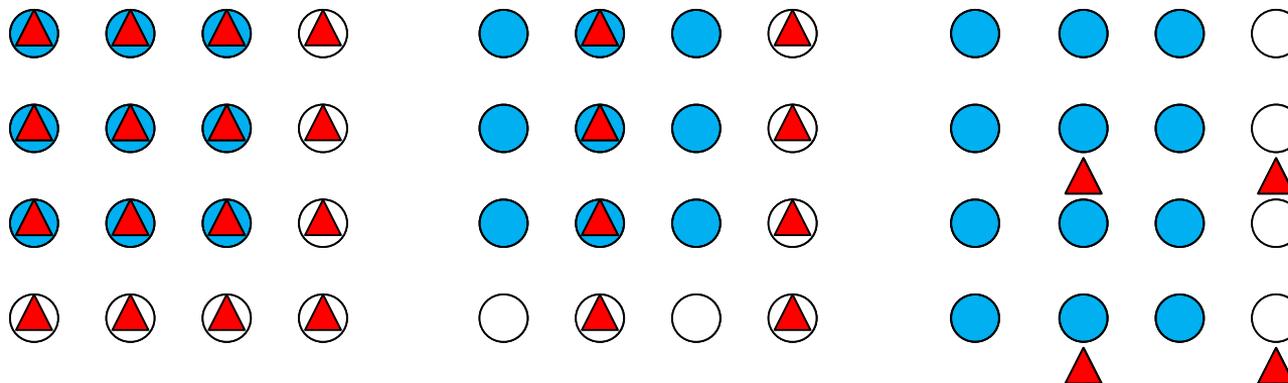
- Each chroma pixel is added by an offset

$$Cb_{enh}(x,y) = Cb(x,y) + o(x,y)$$

- Offset is the output of applying a high-pass filter f_{Cb} to the surrounding $W \times H$ luma pixels (W and H are signaled in bitstream)

$$o(x,y) = \sum_{j=-H/2}^{H/2} \sum_{i=-W/2}^{W/2} f_{Cb}(i,j) Y(s_x x - i, s_y y - j)$$

(s_x, s_y) equal to (1, 1), (2, 1), and (2, 2) for 4:4:4, 4:2:2, and 4:2:0, respectively.



4:4:4

4:2:2

4:2:0

○ Luma sample

▲ Chroma sample

Filter Training and Signaling

- Filter derivation on the encoder side
 - Use Least Minimum MSE (LMMSE) estimator to minimize the MSE between the reconstructed and original chroma planes
- Quantization:
 - 16-level uniform quantizer
 - Quantization stepsize: $Q_{Cb}/2^{N_{Cb}}$
- $$h_{Cb,opt}(i, j) = f_{Cb}(i, j) \times \frac{Q_{Cb}}{2^{N_{Cb}}}$$
- Signaling
 - W and H : coded using ue(v)
 - Flag indicating On/Off for certain chroma plane: 1-bit
 - ($W - 1$) filter coefficients: 4 bits each, the rest one is derived based on zero-sum constraint
 - Q_{Cb} : 11 bits (10 bits for magnitude and 1 bit for sign)
 - N_{Cb} : 5 bits

For 3x3 filter, 104 bits per SEI message payload; for 3x4 filter, 122 bits; for 5x5 filter, 236 bits

Process of Chroma Enhancement

- Performed out of the coding loop
- Filter the surrounding $W \times H$ luma pixels to get the scaled offset $z(x,y)$

$$z(x, y) = \sum_{j=-H/2}^{H/2} \sum_{i=-W/2}^{W/2} f_{Cb}(i, j) Y(s_x x - i, s_y y - j)$$

- Normalize and round $z(x,y)$ to $o(x,y)$

$$o(x,y) = \text{Sign}(z(x,y) \cdot Q_{Cb}) \left(\left(\text{Abs}(z(x,y) \cdot Q_{Cb}) + (1 \ll (N_{Cb} - 1)) \right) \gg N_{Cb} \right)$$

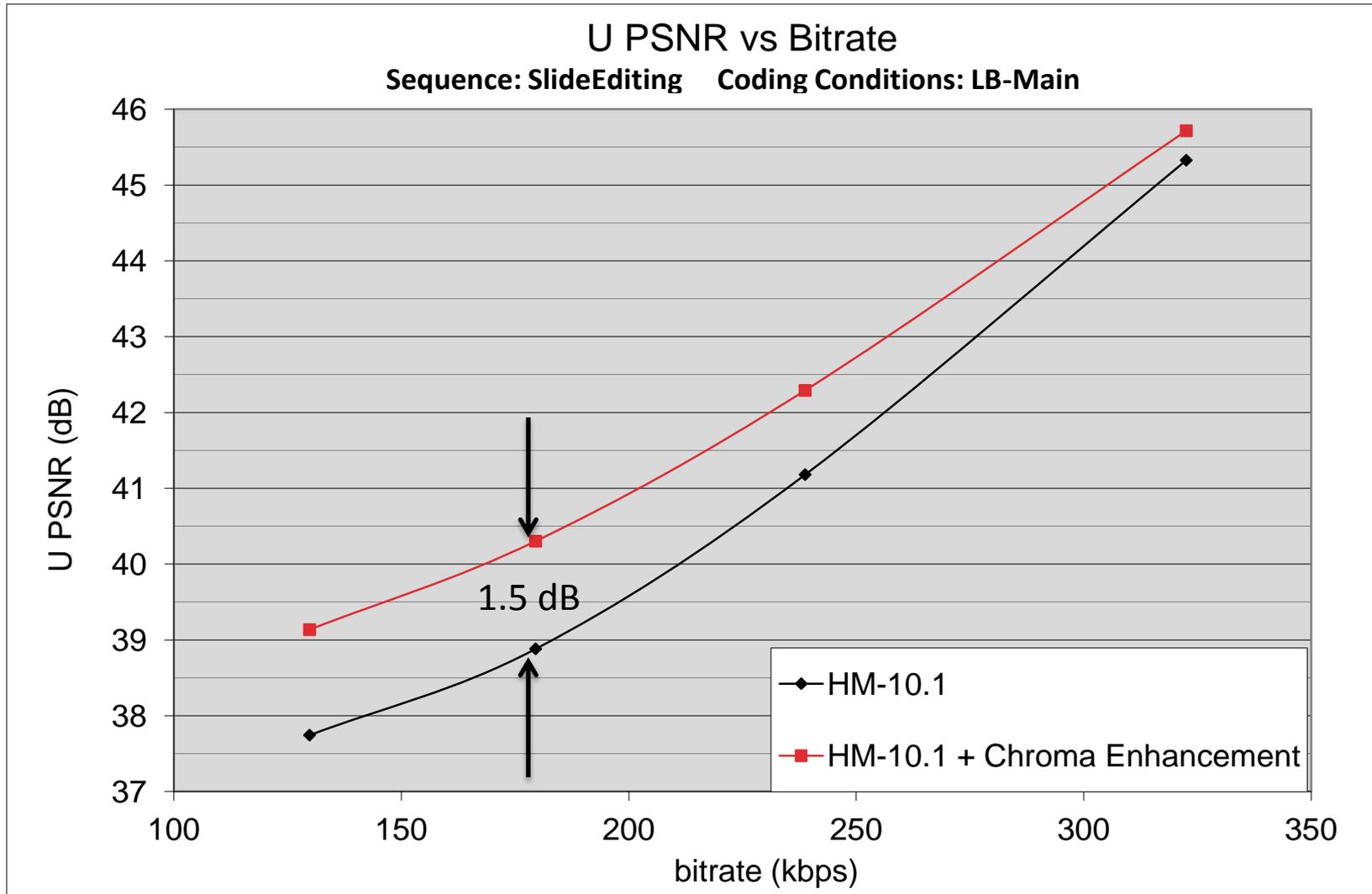
- Add offset $o(x,y)$

$$Cb_{enh}(x,y) = Cb(x,y) + o(x,y)$$

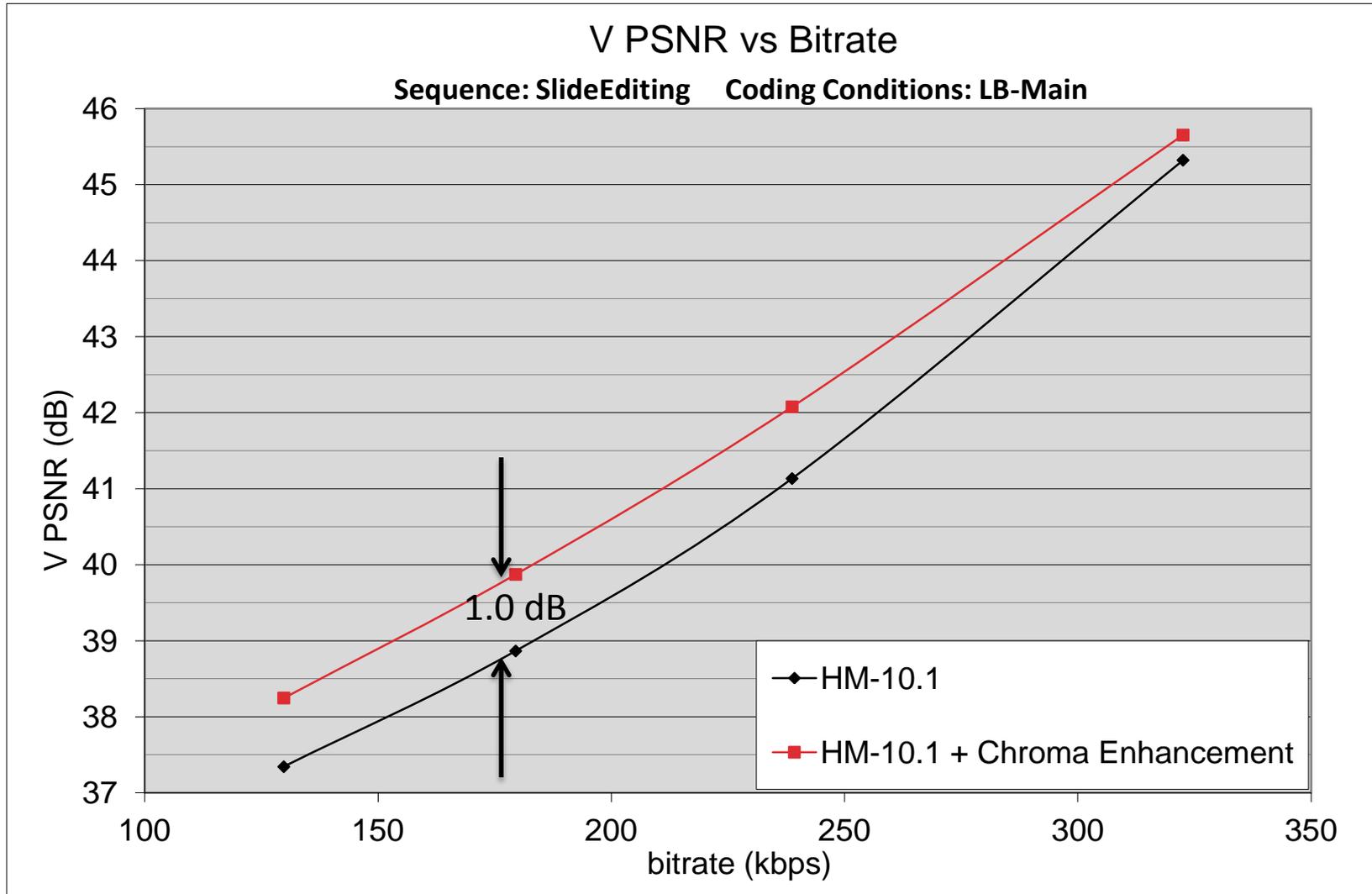
Payload of the Proposed SEI message

	Descriptor
chroma_enhancement_filter (payloadSize) {	
chroma_enhancement_filter_enabled_flag	u(1)
if (chroma_enhancement_filter_enabled_flag) {	
num_coeff_hori_minus1	ue()
num_coeff_verti_minus1	ue()
cb_enhancement_flag	u(1)
if (cb_enhancement_flag) {	
for (i=0; i<((num_coeff_hori_minus1+1)×(num_coeff_verti_minus1+1)-1); i++)	
cb_filter_coeff_plus8 [i]	u(4)
cb_scaling_factor_abs_minus1	u(10)
cb_scaling_factor_sign	u(1)
cb_bit_shifting	u(5)
}	
cr_enhancement_flag	u(1)
if (cr_enhancement_flag) {	
for (i=0; i<((num_coeff_hori_minus1+1)×(num_coeff_verti_minus1+1)-1); i++)	
cr_filter_coeff_plus8 [i]	u(4)
cr_scaling_factor_abs_minus1	u(10)
cr_scaling_factor_sign	u(1)
cr_bit_shifting	u(5)
}	
}	
}	

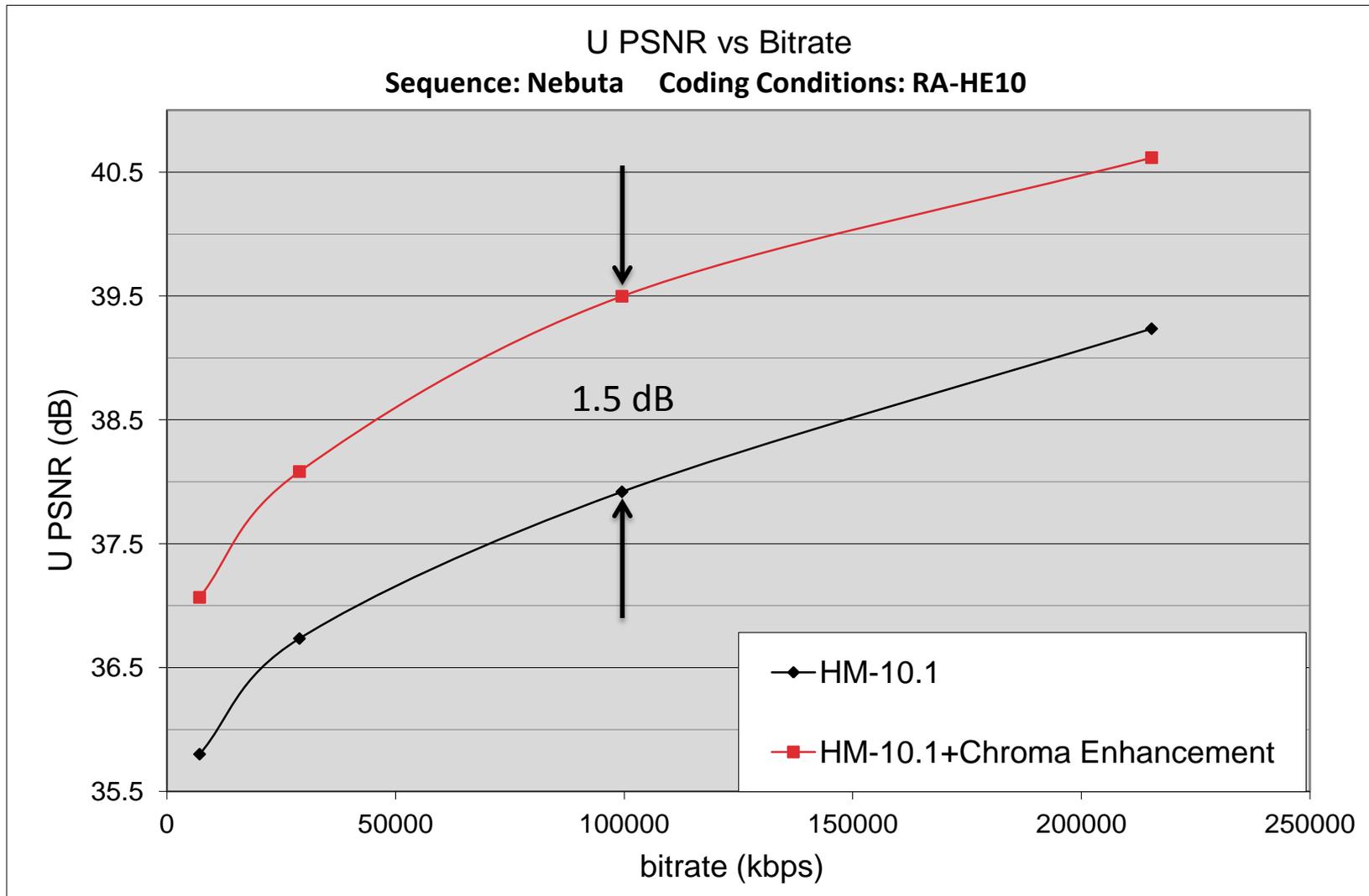
Cb R-D Curve of SlideEditing (LD-B Main)



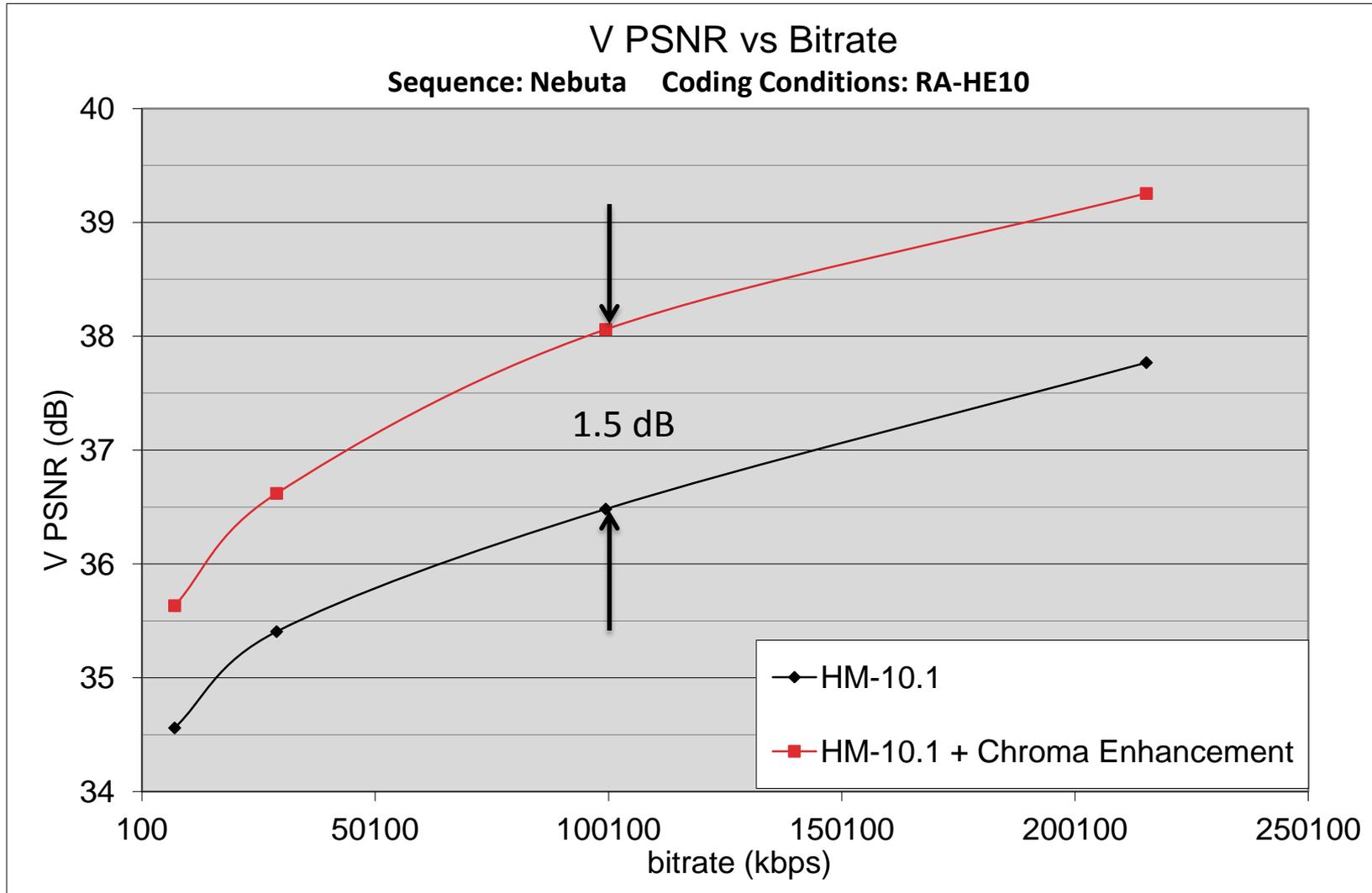
Cr R-D Curve of SlideEditing (LD-B Main)



Cb R-D Curve of Nebuta (RA Main10)



Cr R-D Curve of Nebuta (RA Main10)



Example of Restored Edges in Chroma Plane

- Cr plane of the 1st frame of Kimono (RA, QP=32)

Original Image



Original Cr plane



Rec. Cr plane w/ enh.

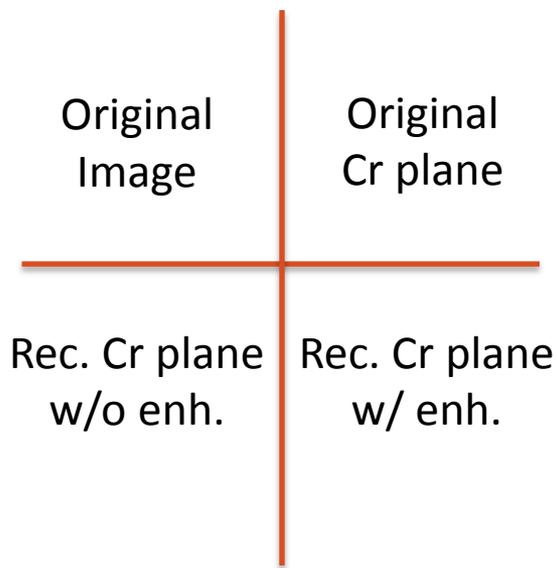


Rec. Cr plane w/o enh.



Example of Restored Edges in Chroma Plane

- Cr plane of the 1st frame of ParkScene (RA, QP=32)



Conclusion

- This contribution proposes an SEI message for HEVC
 - Carrying post filter coefficients used to enhance the quality of the reconstructed chroma planes.
- Achieve significant chroma quality improvement (up to 1.5 dB) for various test sequences, including Class A, Class B, and screen content sequences
- Marginal payload size (104 bits with 3x3 filter, 236 bits with 5x5 filter)
- We suggest adopting this SEI message into HEVC.