

JCTVC-L0127

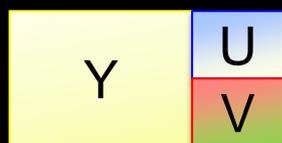
**AHG7: LCU-based non-local means filter  
for chroma components  
in HEVC range extensions**

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# INTRODUCTION

- In non-YUV4:2:0 formats, the improvement of the chroma component might affect the coding gain and visual quality than YUV4:2:0 format.

Resolution



YUV4:2:0



YUV4:2:2



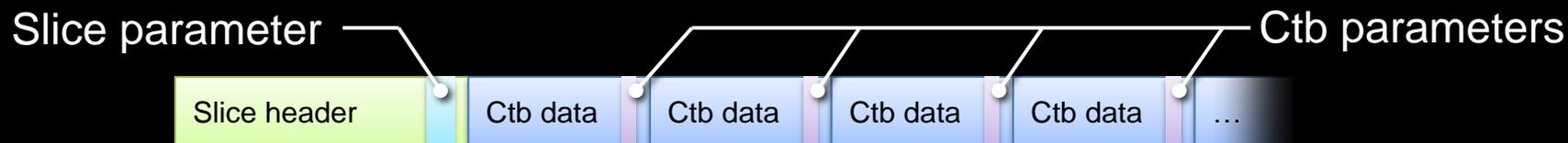
YUV4:4:4

- Proposal: NLM filter focused on chroma components
  - Also available for luma component
  - Utilized NLM filter as final filter of HM9.0 RExt.



# EXPERIMENTAL CONDITIONS

- Two component patterns
  - Chroma only (UV)
  - All components (YUV)
- Two filter patterns
  - as in-loop filter
    - Picture-based RD-opt. is applied only to RA.
    - The other GOPs are set to LCU-based RD-opt.



- As post filter (with overhead coded into SEI message)
  - Employed same RD-opt. as in-loop filter



# EXPERIMENTAL RESULTS (YUV 4:4:4)

	All Intra HE10 (BD-rate in YUV-psnr)							
	High tier (Qp17-32)				Main tier (Qp22-37)			
	In-loop filter		Post filter		In-loop filter		Post filter	
	chroma only	all components	chroma only	all components	chroma only	all components	chroma only	all components
Traffic	-0.05%	-0.12%	-0.04%	-0.10%	-0.12%	-0.29%	-0.10%	-0.24%
Kimono	-0.02%	-0.02%	-0.01%	0.00%	-0.03%	-0.08%	-0.02%	-0.01%
EBULupoCandlelight	-0.24%	-0.22%	-0.24%	-0.17%	-0.32%	-0.34%	-0.29%	-0.24%
EBURainFruits	-0.20%	-0.19%	-0.20%	-0.17%	-0.34%	-0.37%	-0.32%	-0.33%
VenueVu	-0.25%	-0.28%	-0.23%	-0.24%	-0.35%	-0.35%	-0.31%	-0.27%
BirdsInCage	-0.02%	-0.03%	-0.01%	0.01%	-0.04%	-0.08%	-0.01%	0.03%
CrowdRun	-0.03%	-0.04%	-0.03%	-0.03%	-0.15%	-0.15%	-0.14%	-0.13%
Overall	-0.12%	-0.13%	-0.11%	-0.10%	-0.19%	-0.24%	-0.17%	-0.17%
	-0.12%	-0.14%	-0.11%	-0.10%	-0.19%	-0.23%	-0.16%	-0.16%
Enc Time[%]	101.80%	102.49%	101.11%	101.65%	102.02%	102.72%	101.15%	101.75%
Dec Time[%]	108.64%	106.52%	108.50%	106.83%	111.41%	107.80%	111.13%	108.33%

# EXPERIMENTAL RESULTS (YUV 4:4:4)

	Low Delay B HE10 (BD-rate in YUV-psnr)							
	High tier (Qp17-32)				Main tier (Qp22-37)			
	In-loop filter		Post filter		In-loop filter		Post filter	
	chroma only	all components	chroma only	all components	chroma only	all components	chroma only	all components
Traffic	-0.35%	-0.47%	0.04%	0.05%	0.06%	-0.57%	1.19%	1.00%
Kimono	-1.69%	-1.23%	-0.82%	-0.62%	-1.00%	-0.66%	0.24%	0.44%
EBULupoCandlelight	0.09%	-0.36%	2.31%	1.87%	0.27%	-0.11%	5.19%	4.21%
EBURainFruits	-0.07%	-0.25%	0.67%	0.60%	-0.17%	-0.44%	1.49%	1.44%
VenueVu	-0.50%	-0.63%	0.05%	0.03%	-0.41%	-0.67%	0.51%	0.45%
BirdsInCage	-4.45%	-4.00%	-1.25%	-1.19%	-7.32%	-6.92%	3.80%	3.03%
CrowdRun	-0.33%	-0.47%	-0.30%	-0.31%	-0.16%	-0.73%	-0.32%	-0.42%
Overall	-1.04%	-1.06%	0.10%	0.06%	-1.25%	-1.44%	1.73%	1.45%
	-0.69%	-0.74%	0.41%	0.32%	-1.69%	-1.84%	1.31%	1.06%
Enc Time[%]	100.23%	100.64%	100.25%	100.37%	100.34%	100.78%	100.28%	100.42%
Dec Time[%]	111.22%	109.21%	123.16%	117.85%	112.96%	111.09%	129.62%	122.49%

# EXPERIMENTAL RESULTS (YUV 4:4:4)

	Random Access HE10 (BD-rate in YUV-psnr)							
	High tier (Qp17-32)				Main tier (Qp22-37)			
	In-loop filter		Post filter		In-loop filter		Post filter	
	chroma only	all components	chroma only	all components	chroma only	all components	chroma only	all components
Traffic	-0.71%	-0.58%	-0.18%	-0.37%	-0.60%	-0.72%	0.31%	-0.21%
Kimono	-2.93%	-2.75%	-2.53%	-2.48%	-1.70%	-1.61%	-1.07%	-1.28%
EBULupoCandlelight	-0.60%	-0.62%	0.38%	-0.04%	-0.39%	-0.59%	1.87%	0.47%
EBURainFruits	-0.10%	-0.14%	0.22%	0.01%	-0.17%	-0.28%	0.51%	0.03%
VenueVu	0.06%	-0.06%	0.13%	-0.15%	0.00%	-0.15%	0.27%	-0.17%
BirdsInCage	-6.05%	-5.69%	-5.04%	-5.09%	-5.58%	-5.25%	-1.90%	-3.82%
CrowdRun	-0.38%	-0.43%	-0.38%	-0.50%	-0.29%	-0.57%	-0.29%	-0.64%
Overall	-1.53%	-1.47%	-1.06%	-1.23%	-1.25%	-1.31%	-0.04%	-0.80%
	-1.77%	-1.76%	-1.47%	-1.65%	-1.16%	-1.22%	0.05%	-0.70%
Enc Time[%]	100.82%	101.05%	100.37%	100.55%	100.95%	101.13%	100.42%	100.62%
Dec Time[%]	111.63%	112.95%	123.53%	121.15%	112.53%	114.39%	129.78%	124.61%

# EXPERIMENTAL RESULTS (YUV 4:2:2)

	All Intra HE10 (BD-rate in YUV-psnr)							
	High tier (Qp17-32)				Main tier (Qp22-37)			
	In-loop filter		Post filter		In-loop filter		Post filter	
	chroma only	all components	chroma only	all components	chroma only	all components	chroma only	all components
Traffic	-0.05%	-0.13%	-0.04%	-0.11%	-0.08%	-0.29%	-0.07%	-0.24%
Kimono	0.00%	-0.03%	0.01%	0.01%	0.01%	-0.10%	0.04%	0.00%
EBUHorse	-0.02%	-0.01%	-0.01%	0.00%	-0.05%	-0.05%	-0.04%	-0.02%
EBUGraphics	-0.19%	-0.27%	-0.18%	-0.26%	-0.46%	-0.67%	-0.45%	-0.63%
EBUWater RocksClose	-0.02%	-0.03%	-0.02%	-0.01%	-0.06%	-0.10%	-0.06%	-0.08%
EBUKidsSoccer	-0.01%	-0.01%	-0.01%	0.00%	-0.03%	-0.03%	-0.03%	-0.01%
Seeking	-0.02%	-0.02%	-0.02%	0.00%	-0.06%	-0.07%	-0.05%	-0.04%
Overall	-0.04%	-0.07%	-0.04%	-0.05%	-0.10%	-0.19%	-0.09%	-0.14%
	-0.05%	-0.08%	-0.04%	-0.06%	-0.10%	-0.18%	-0.09%	-0.14%
Enc Time[%]	100.74%	101.72%	100.71%	101.46%	100.96%	102.05%	100.77%	101.62%
Dec Time[%]	105.51%	105.80%	105.27%	105.38%	107.50%	107.68%	107.03%	107.18%

# EXPERIMENTAL RESULTS (YUV 4:2:2)

	Low Delay B HE10 (BD-rate in YUV-psnr)							
	High tier (Qp17-32)				Main tier (Qp22-37)			
	In-loop filter		Post filter		In-loop filter		Post filter	
	chroma only	all components	chroma only	all components	chroma only	all components	chroma only	all components
Traffic	-0.08%	-0.35%	0.52%	0.43%	0.13%	-0.47%	1.78%	1.52%
Kimono	-0.78%	-0.45%	-0.01%	0.09%	-0.30%	-0.31%	0.96%	0.93%
EBUHorse	0.04%	-0.13%	0.49%	0.32%	0.16%	-0.12%	2.51%	1.85%
EBUGraphics	-0.02%	-0.32%	0.30%	0.30%	-0.06%	-0.72%	0.46%	0.76%
EBUWater RocksClose	-0.21%	-0.25%	-0.15%	-0.20%	-0.11%	-0.37%	-0.04%	-0.28%
EBUKidsSoccer	0.00%	-0.07%	0.24%	0.17%	0.03%	-0.14%	1.25%	1.06%
Seeking	-0.15%	-0.26%	-0.04%	-0.10%	-0.05%	-0.45%	0.31%	0.13%
Overall	-0.17%	-0.26%	0.19%	0.14%	-0.03%	-0.37%	1.03%	0.85%
	-0.17%	-0.27%	0.18%	0.13%	-0.03%	-0.37%	1.02%	0.86%
Enc Time[%]	100.30%	100.80%	100.18%	100.37%	100.44%	100.91%	100.21%	100.43%
Dec Time[%]	107.87%	108.22%	116.54%	115.93%	109.62%	110.67%	121.93%	121.52%

# EXPERIMENTAL RESULTS (YUV 4:2:2)

	Random Access HE10 (BD-rate in YUV-psnr)							
	High tier (Qp17-32)				Main tier (Qp22-37)			
	In-loop filter		Post filter		In-loop filter		Post filter	
	chroma only	all components	chroma only	all components	chroma only	all components	chroma only	all components
Traffic	-0.32%	-0.41%	0.09%	-0.13%	-0.25%	-0.54%	0.50%	0.01%
Kimono	-1.15%	-1.07%	-0.84%	-0.91%	-0.43%	-0.50%	0.05%	-0.17%
EBUHorse	-0.48%	-0.38%	-0.17%	-0.32%	-0.29%	-0.28%	0.43%	0.00%
EBUGraphics	-0.15%	-0.26%	0.14%	-0.16%	-0.33%	-0.59%	0.17%	-0.41%
EBUWater RocksClose	-0.23%	-0.37%	-0.19%	-0.37%	-0.17%	-0.63%	-0.12%	-0.57%
EBUKidsSoccer	-0.15%	-0.11%	-0.02%	-0.07%	-0.10%	-0.12%	0.30%	0.01%
Seeking	-0.19%	-0.32%	-0.15%	-0.36%	-0.10%	-0.38%	0.05%	-0.34%
Overall	-0.38%	-0.42%	-0.16%	-0.33%	-0.24%	-0.43%	0.20%	-0.21%
	-0.38%	-0.41%	-0.17%	-0.33%	-0.24%	-0.43%	0.19%	-0.21%
Enc Time[%]	100.70%	101.11%	100.26%	100.53%	100.74%	101.12%	100.29%	100.61%
Dec Time[%]	108.70%	111.63%	117.22%	120.08%	109.73%	113.91%	122.25%	125.65%

# CONCLUSION

- Proposal: NLM filter focused on chroma components
- Objective evaluations (**improving**/**worsening**)
  - All Intra (LCU-based opt.)
    - In-loop filter      BD-rate: **0.04-0.24%**,      DecTime: +5.51-11.41%
    - Post filter:      BD-rate: **0.04-0.17%**,      DecTime: +5.27-11.13%
  - Low delay-B (LCU-based opt.)
    - In-loop filter:      BD-rate: **0.03-1.44%**,      DecTime: +7.87-12.96%
    - Post filter:      BD-rate: **1.73-0.06%**,      DecTime: +15.93-29.62%
  - Random Access (picture-based opt.)
    - In-loop filter:      BD-rate: **0.24-1.53%**,      DecTime: +8.70-14.39%
    - Post filter:      BD-rate: **0.20-1.23%**,      DecTime: +17.22-29.78%
- Subjective improvements
  - Chroma only: could not distinguish
  - All component: could distinguish in some still picture