

JCTVC-L0127

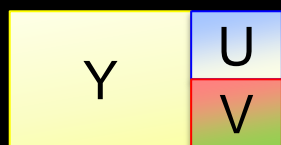
AHG7: LCU-based non-local means filter for chroma components in HEVC range extensions

M. Matsumura, S. Takamura, H. Fujii, A. Shimizu
Media Intelligence Labs., NTT corporation

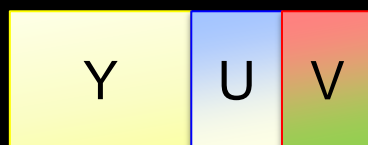
INTRODUCTION

- 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.

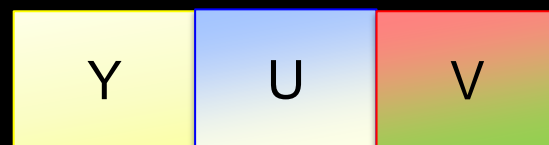
Resolution



YUV4:2:0

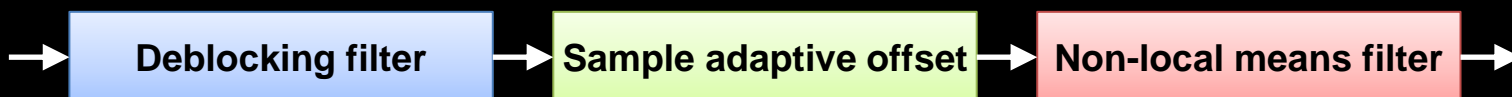


YUV4:2:2



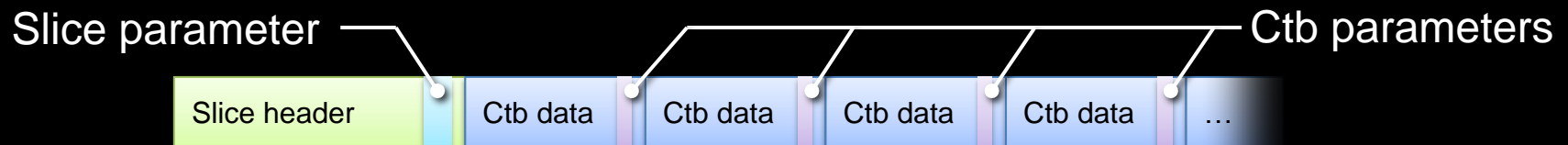
YUV4:4:4

- 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