

JCTVC-F047

**Modification of
in-loop filter based on
non-local means filter**

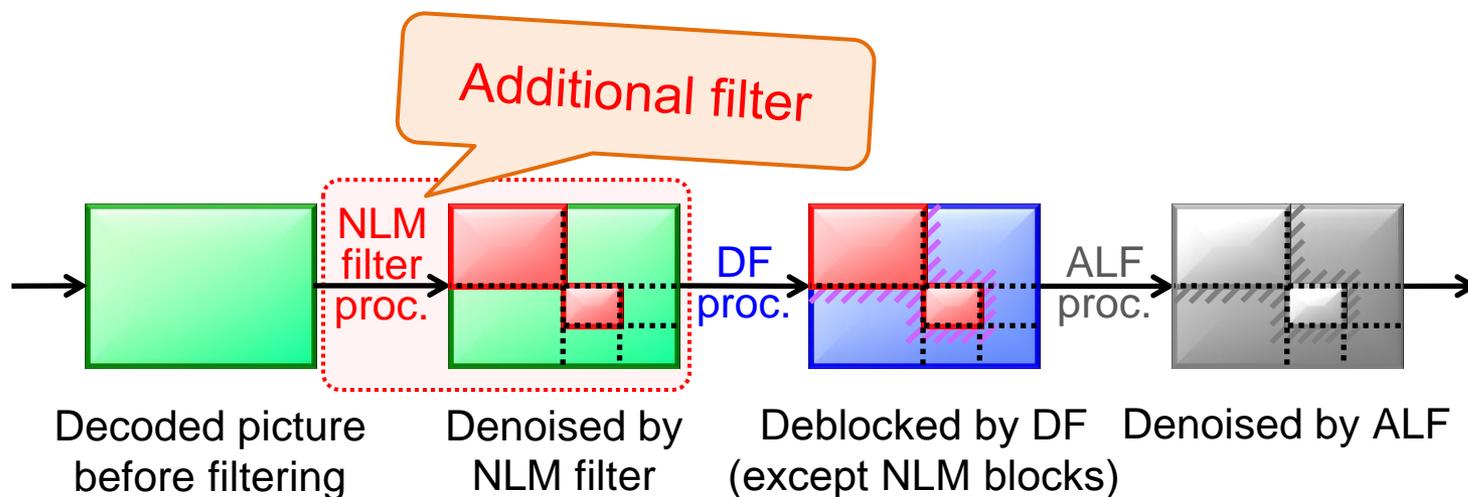
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OVERVIEW

- Additional in-loop filter (high efficiency)
 - Denoising filter: based on non-local means (NLM filter)
 - + (existing) Deblocking filter (DF)
 - + (existing) Adaptive loop filter (ALF)



	Luma	Chroma
Average	-1.0 – -1.3	-0.9 – -3.9
Maximum	-2.0	-9.4
Enc Time	113 – 118%	
Dec Time	107 – 111%	

was 124-152%
(JCTVC-E206@Geneva)

	All Intra HE		
	Y	U	V
Class A	-1.0	-1.2	-1.1
Class B	-1.0	-0.9	-1.3
Class C	-1.0	-1.5	-1.6
Class D	-0.7	-0.7	-1.4
Class E	-1.0	0.2	0.0
Overall	-1.0	-0.9	-1.2
Enc Time[%]	114%		
Dec Time[%]	110%		

	Low delay B HE		
	Y	U	V
Class A			
Class B	-1.0	-2.7	-2.6
Class C	-1.3	-4.7	-5.4
Class D	-1.2	-2.2	-2.9
Class E	-1.4	-1.0	-2.3
Overall	-1.2	-2.8	-3.3
Enc Time[%]	113%		
Dec Time[%]	110%		

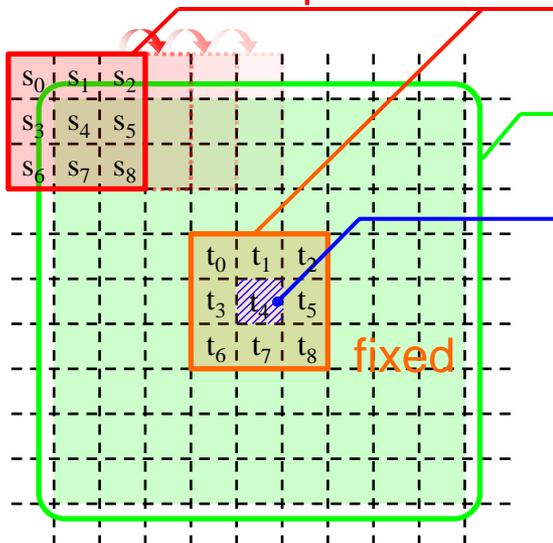
	Random Access HE		
	Y	U	V
Class A	-0.8	-2.3	-2.1
Class B	-1.0	-2.2	-1.7
Class C	-1.1	-2.6	-2.7
Class D	-0.9	-1.5	-2.1
Class E			
Overall	-1.0	-2.2	-2.1
Enc Time[%]	118%		
Dec Time[%]	107%		

	Low delay P HE		
	Y	U	V
Class A			
Class B	-1.0	-3.2	-3.1
Class C	-1.4	-5.1	-5.7
Class D	-1.3	-2.4	-3.7
Class E	-1.5	-1.8	-3.1
Overall	-1.3	-3.2	-3.9
Enc Time[%]	118%		
Dec Time[%]	111%		

NON-LOCAL MEANS FILTER

- Filter coefficients are derived on-the-fly
 - Each coefficient is derived using SSD between templates

Scan each tap element



Template

$$SSD = \sum_{i=0}^8 (s_i - t_i)^2$$

Tap

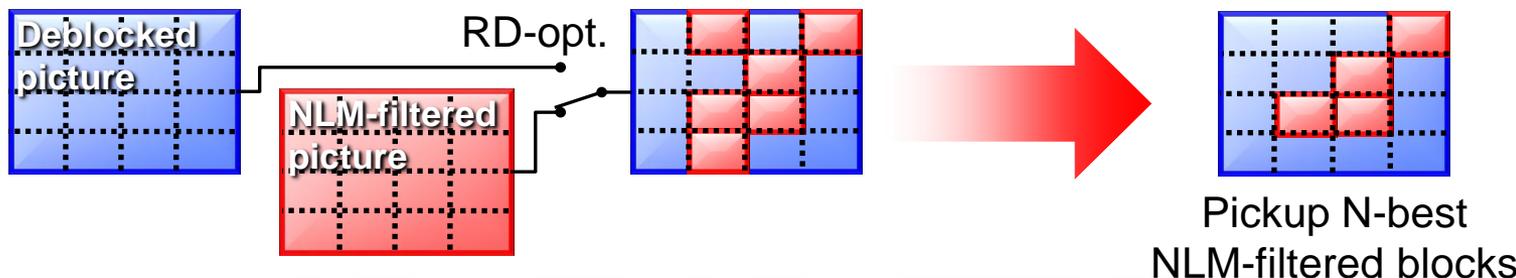
$$\text{FilterCoefficient} \propto \exp(-SSD/\alpha)$$

Target

Where α is the strength of NLM filter

Reduce the complexity of NLM filter by:

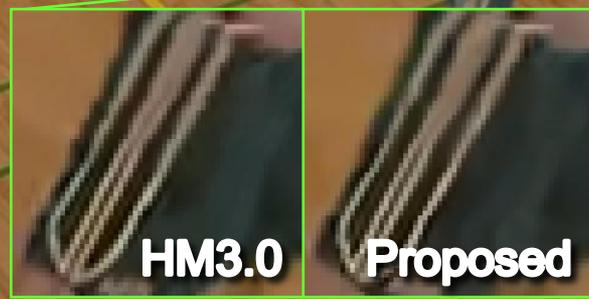
- Reduction of the number of tap elements
- Restriction of the template size
- Restriction of the number of NLM-filtered blocks



SUBJECTIVE QUALITY



Preservation of chroma clearness



Relaxation of block noise



Keep own line and shape



BasketballDrill (WVGA), LD P, BD-rate: (Y: -1.5%, U: -9.2%, V: -8.8%),
QP=32, Frame #499 (-296bits, Y:+0.024dB, U:+0.341dB, V:+0.445dB)

CONCLUSION

- Enhanced non-local means filter as a part of the in-loop filter is presented
- Results
 - Average BD-rate reductions
Luma: **1.0-1.3%** (max. **2.0%**), Chroma: **0.9-3.9%** (max. **9.2%**)
 - With **13-18/7-11%** **encoding/decoding** time increase
Achieved the complexity reduction compared to our previous proposal JCTVC-E206 (decoding time increased 24-52%)
 - Cross checked by KDDI (JCTVC-F323)
 - Enhanced subjective quality
- Suggestion
 - NLM filter should be incorporated into HEVC