

JCTVC-E206

In-loop filter based on non-local means filter

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Summary

□ Background

- Current in-loop filter design of HM2.0
 - Deblocking filter (DF): similar to H.264/AVC
 - Adaptive loop filter (ALF): Wiener filter based
- These are kind of local filter

□ Proposal

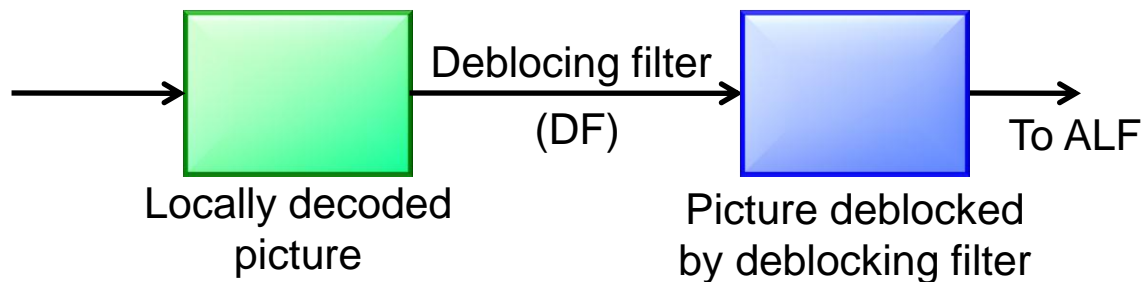
- Denoising filter based on non-local means (NLM) operation as a part of the in-loop filter

□ Results

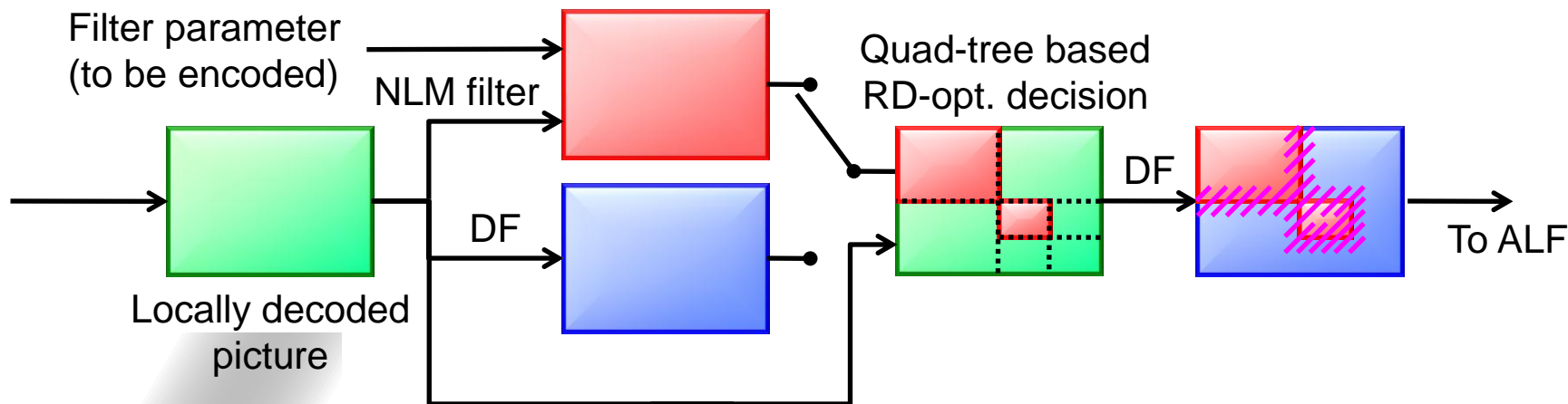
- 1.6 - 2.9% BD-rate (Y) improvements on average
- 4.1% BD-rate (Y) improvements at maximum

Proposed in-loop filter

Conventional in-loop filter



Proposed in-loop filter

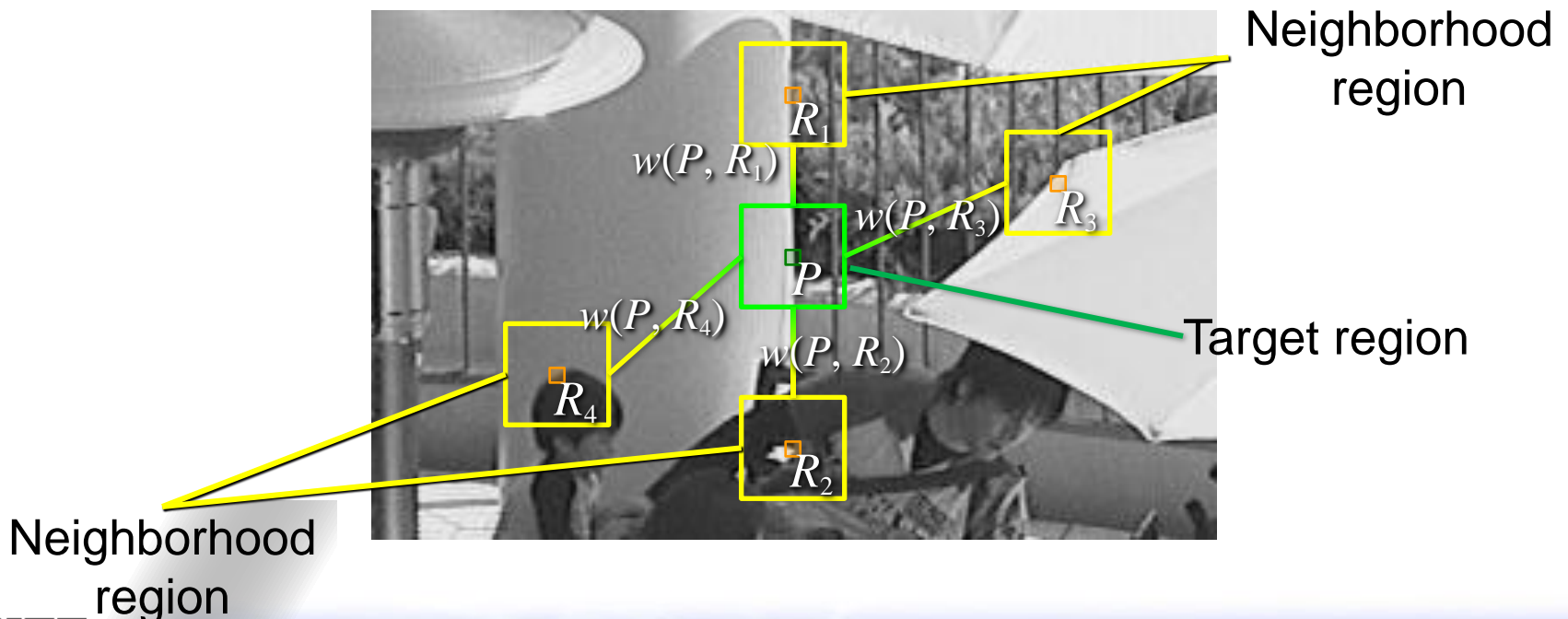


Non-local means (NLM) filter

Shift-variant filter based on a similarity between regions

Idea: Regions with high *similarity* are assigned large weights

Similarity: SSD between the target and neighborhood



Performance (All Intra)

Anchor: HM2.0-r598 (high efficiency).

	Intra		
	Y BD-rate	U BD-rate	V BD-rate
Class A	-1.7	-1.0	-0.9
Class B	-1.3	-1.3	-2.0
Class C	-2.1	-2.6	-3.0
Class D	-1.3	-2.1	-3.1
Class E	-1.8	0.6	0.5
All	-1.6	-1.4	-1.8
Enc Time[%]	145%		
Dec Time[%] (single-thread)	152%		
Dec Time[%] (multi-thread)	126%		

Performance (RA)

Anchor: HM2.0-r598 (high efficiency).

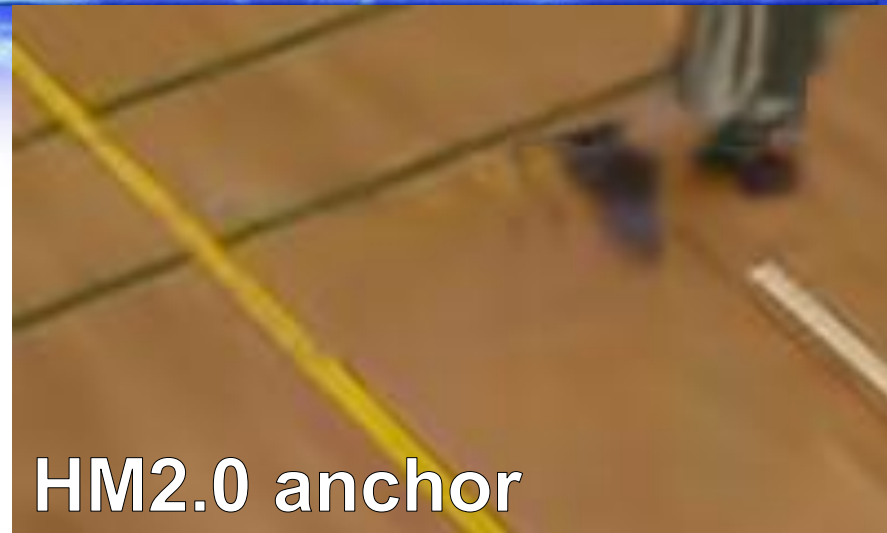
	Random access		
	Y BD-rate	U BD-rate	V BD-rate
Class A	-1.6	-2.0	-1.9
Class B	-2.1	-2.6	-2.1
Class C	-2.3	-4.1	-4.0
Class D	-1.5	-2.5	-3.2
Class E			
All	-1.9	-2.8	-2.8
Enc Time[%]	118%		
Dec Time[%] (single-thread)	124%		
Dec Time[%] (multi-thread)	114%		

Performance (LD)

Anchor: HM2.0-r598 (high efficiency).

	Low delay		
	Y BD-rate	U BD-rate	V BD-rate
Class A			
Class B	-2.3	-2.5	-2.9
Class C	-3.1	-4.8	-5.3
Class D	-2.7	-2.1	-2.8
Class E	-4.1	0.1	-1.8
All	-2.9	-2.5	-3.3
Enc Time[%]	112%		
Dec Time[%] (single-thread)	131%		
Dec Time[%] (multi-thread)	117%		

Subjective quality



BasketballDrill, LD, QP=37,
BD-rate: -4.1%(Y), -8.8%(U),
-8.9%(V)
Frame #499



- ❑ Reduces mosquito noise
- ❑ Preserves chroma
(exp. lines on the floor)

Conclusion

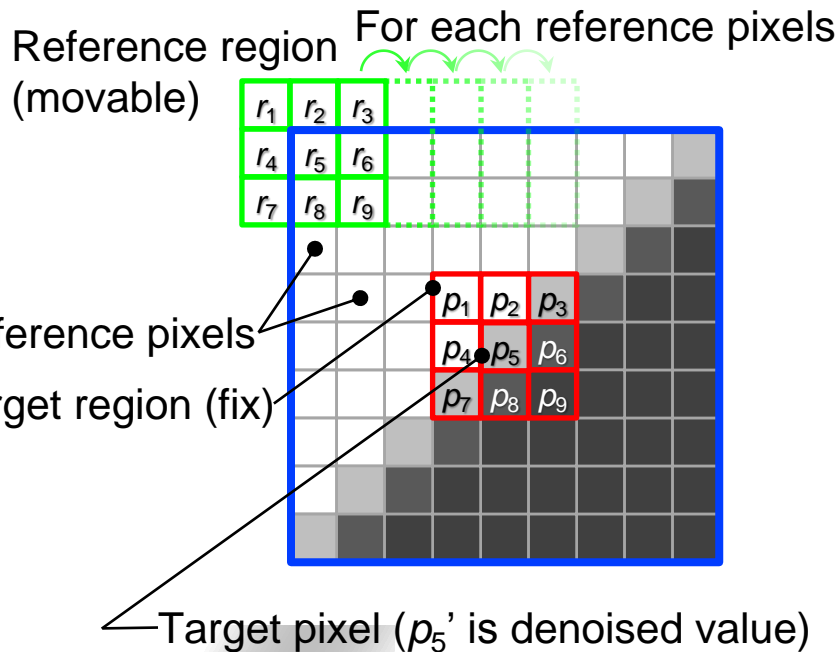
- A denoising filter as a part of the in-loop filter is presented
- Results
 - 1.6 - 2.9% BD-rate (Y) improvements on average
 - 4.1% BD-rate (Y) improvements at maximum
 - Enhanced subjective quality
 - EncTime: 112-145%, DecTime: 124-152% (Parallel processing friendly -- DecTime 114-126%)
 - Further speeding up has been pursued
- Proposal
 - To be studied in CE (current CE8 or CE12) to find the optimal combination with DF/ALF

A photograph of a large, modern, multi-story office building with a distinctive horizontal striped facade. The building is situated on a green, landscaped hillside. The text "Thank you, questions?" is overlaid diagonally across the middle of the image.

Thank you, questions?

Basic algorithm of NLM

NLM filter: non-linear operation based on a similarity between pixel neighborhoods.
 Basic idea: pixel neighborhoods with high similarity provide large weight for filtering.
 Similarity: SSD between the neighborhood of target pixel and the neighborhood area in the reference region.



initialize: $SumWeights = 0$, $SumPixels = 0$

for all reference pixels **do**

$$Weight = \exp\left(\sum_{n=1}^9 (r_n - p_n)^2 / DenoiseParameter\right)$$

$$SumWeights = SumWeights + Weight$$

$$SumPixels = SumPixels + Weight \times r_5$$

end for

$$p_5' = SumPixels / SumWeights$$

Note: $DenoiseParameter$ is negative value