



CE8.a.1: One-stage SAO and ALF with LCU-based Syntax

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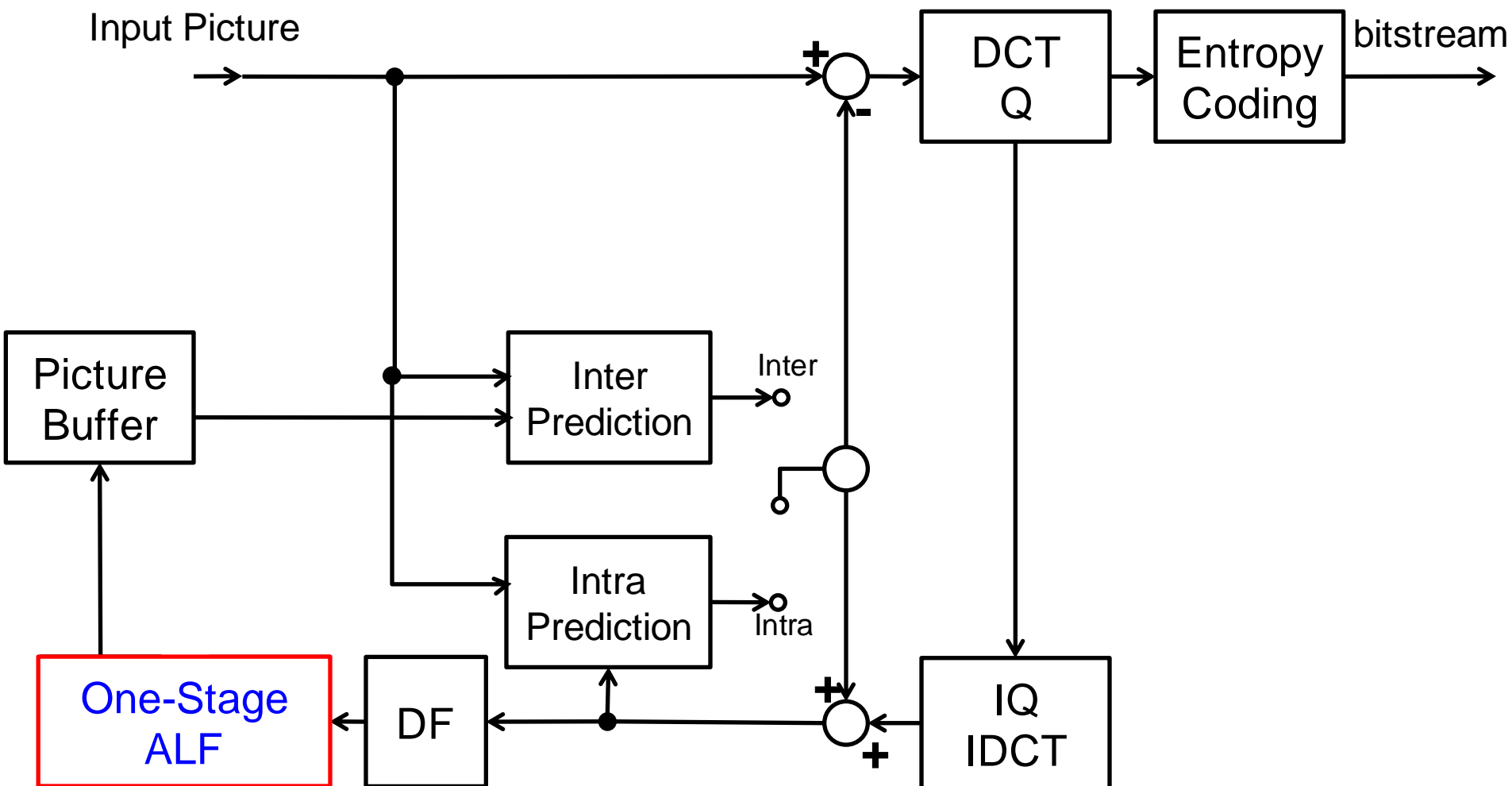
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Overall Summary

- Two-stage non-deblocking loop filtering (SAO & ALF) may require two additional encoding passes if picture-based encoding is used
- In this contribution, one-stage non-deblocking loop filtering is proposed
 - LCU-based adaptation to switch among {ALF+SAO, SAO, OFF}
 - “ALF+SAO” means the ALF offset is an SAO-like offset (i.e. apply pixel classification to unfiltered pixels and then add one offset to each filtered pixel according to the pixel classification)
 - Support picture-based and LCU-based encoding algorithms
- Results
 - Picture-based encoding provides a similar gain of HM-5.0 SAO & ALF
 - LCU-based encoding keeps 63% - 87% coding gain of HM-5.0 SAO & ALF

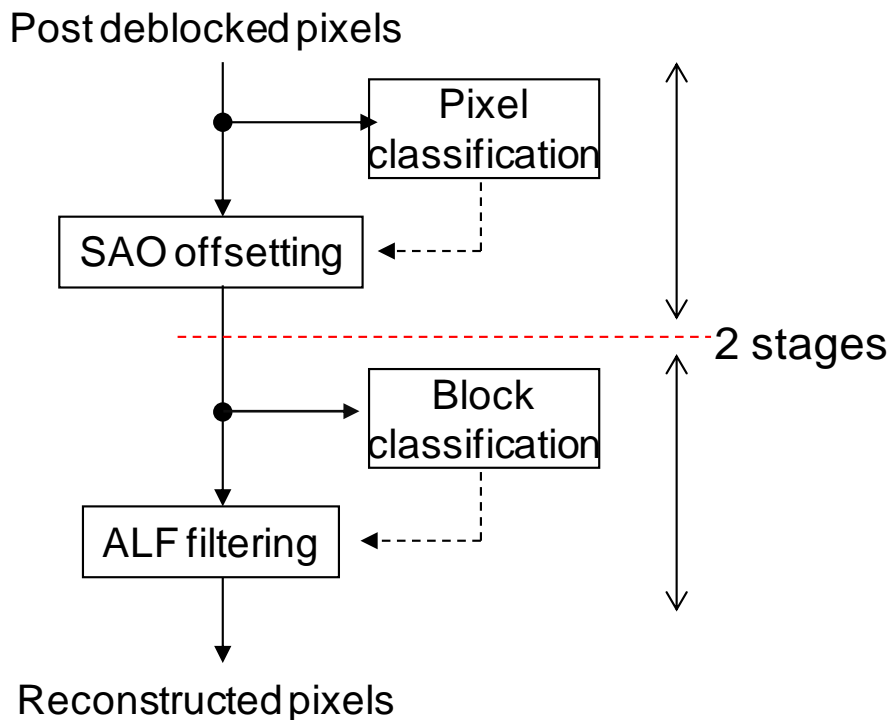
	BD-Rate				Decoding Time			
Encoding Algorithm	HE-AI	HE-RA	HE-LDB	HE-LDP	HE-AI	HE-RA	HE-LDB	HE-LDP
PIC-based Enc.	0.0%	0.0%	0.2%	0.3%	101%	99%	101%	101%
LCU-based Enc.	0.9%	0.9%	1.5%	2.0%	93%	95%	97%	91%

Encoder Block Diagram with One-stage ALF

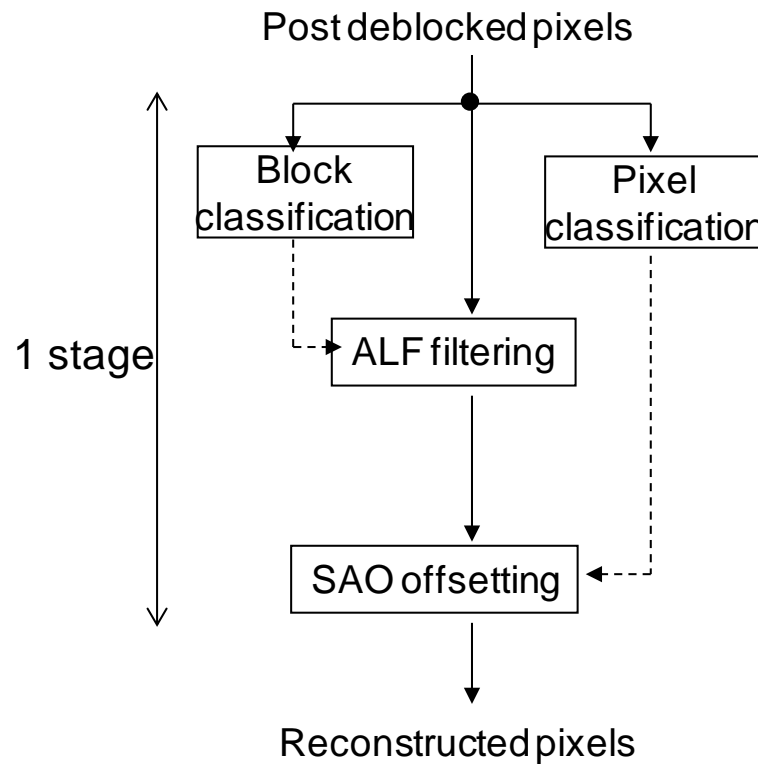


Proposed One-stage ALF

Two-stage non-deblocking loop filtering



One-stage non-deblocking loop filtering



Features of One-stage ALF

- Combine SAO and ALF into one stage
- LCU-based adaptation to switch among three modes
 - {ALF+SAO, SAO, OFF}
 - Run-based coding with merge-up flag to allow information copy from the left or upper LCU
 - Also allow to copy information from space-delayed filters
- Constrain the number of filters and offsets in a picture
 - Reduce the worst-case buffer size
- One flag in SPS to indicate ALF bitstream is located in APS or slice header
 - Provide flexibility for different video applications
- Encoding algorithm: 1 encoding pass + N-pass coeff. re-design
 - N =1 for picture-based encoding algorithm
 - N =0 for LCU-based encoding algorithm

The ALF+SAO Mode

- The filter selection is the same as the block-adaptation (BA) mode in the ALF of HM-5.0
- The offset selection (pixel classification) is the same as that in the SAO of HM-5.0
- Filter selection and pixel classification are applied to unprocessed pixels and can be done in parallel.
- Next, apply filtering on unprocessed pixels
- Finally, add offsets to filtered pixels.

Results of Single-slice, PIC-based ENC

- HM5.0
 - JCTVC-G1200
 - Single slice per picture
- One-stage ALF
 - Picture-based encoding algorithm
- Summary

PIC-based Enc.	HE-AI	HE-RA	HE-LDB	HE-LDP
BD-Rate	0.0%	0.0%	0.2%	0.3%
Decoding Time	101%	99%	101%	101%

	All Intra HE		
	Y	U	V
Class A (8bit)	-0.2%	-0.8%	-0.3%
Class B	0.0%	-0.1%	-0.2%
Class C	-0.2%	0.4%	0.4%
Class D	0.0%	0.3%	0.6%
Class E	0.0%	1.4%	1.0%
Overall	0.0%	0.3%	0.3%
	0.0%	0.3%	0.3%
Class F	-0.2%	0.0%	0.3%
Enc Time[%]	108%		
Dec Time[%]	101%		

	Random Access HE		
	Y	U	V
Class A (8bit)	-0.1%	-0.8%	-0.3%
Class B	0.1%	-0.6%	-0.4%
Class C	0.0%	-0.2%	0.3%
Class D	0.0%	0.4%	0.4%
Class E			
Overall	0.0%	-0.2%	0.0%
	0.0%	-0.3%	0.0%
Class F	0.1%	0.5%	0.5%
Enc Time[%]	102%		
Dec Time[%]	99%		

	Low Delay B HE		
	Y	U	V
Class A			
Class B	0.3%	-0.3%	0.1%
Class C	0.2%	-1.3%	-0.5%
Class D	0.2%	1.0%	1.6%
Class E	0.1%	5.7%	0.7%
Overall	0.2%	0.9%	0.5%
	0.2%	1.0%	0.5%
Class F	0.2%	0.3%	0.8%
Enc Time[%]	101%		
Dec Time[%]	101%		

	Low Delay P HE		
	Y	U	V
Class A			
Class B	0.5%	-0.1%	-0.2%
Class C	0.3%	-1.0%	-0.8%
Class D	0.1%	1.0%	1.6%
Class E	0.2%	6.8%	0.0%
Overall	0.3%	1.3%	0.2%
	0.3%	1.3%	0.1%
Class F	0.4%	1.1%	1.4%
Enc Time[%]	102%		
Dec Time[%]	101%		

Results of Single-slice, LCU-based ENC

- HM5.0
 - JCTVC-G1200
 - Single slice per picture
- One-stage ALF
 - LCU-based encoding algorithm
- Summary
 - % Gain: the percentage of preserved gain in OSALF compared to the coding gain of SAO and ALF in HM5.0

LCU-Based Enc.	HE-AI	HE-RA	HE-LDB	HE-LDP
BD-Rate	0.9%	0.9%	1.5%	2.0%
Decoding Time	93%	97%	92%	91%
SAO & ALF OFF	2.4%	5.1%	5.3%	15.3%
% Gain	63%	82%	72%	87%

	All Intra HE		
	Y	U	V
Class A (8bit)	1.3%	2.0%	2.4%
Class B	0.9%	2.8%	2.9%
Class C	0.4%	3.3%	3.8%
Class D	0.6%	3.1%	3.7%
Class E	1.5%	6.4%	7.2%
Overall	0.9%	3.5%	4.0%
	0.9%	3.4%	3.9%
Class F	0.0%	2.2%	2.3%
Enc Time[%]	106%		
Dec Time[%]	93%		

	Random Access HE		
	Y	U	V
Class A (8bit)	1.2%	0.6%	0.9%
Class B	1.0%	1.7%	1.2%
Class C	0.6%	1.0%	1.8%
Class D	0.8%	0.9%	1.4%
Class E			
Overall	0.9%	1.2%	1.4%
	0.9%	1.1%	1.4%
Class F	0.8%	2.6%	2.6%
Enc Time[%]	104%		
Dec Time[%]	97%		

	Low Delay B HE		
	Y	U	V
Class A			
Class B	2.0%	4.1%	4.8%
Class C	1.1%	2.1%	3.3%
Class D	1.5%	1.9%	3.4%
Class E	1.2%	10.0%	6.0%
Overall	1.5%	4.2%	4.3%
	1.5%	4.1%	4.2%
Class F	1.7%	4.5%	5.8%
Enc Time[%]	103%		
Dec Time[%]	92%		

	Low Delay P HE		
	Y	U	V
Class A			
Class B	3.0%	6.1%	5.9%
Class C	1.5%	3.3%	4.1%
Class D	1.4%	2.8%	3.2%
Class E	1.9%	12.2%	7.3%
Overall	2.0%	5.7%	5.0%
	2.0%	5.6%	4.9%
Class F	2.0%	5.2%	6.4%
Enc Time[%]	104%		
Dec Time[%]	91%		

Results of Multi-slice, LCU-based ENC

- HM5.0
 - JCTVC-G1200
 - Multiple slices per picture
 - SAO on and ALF off in anchor
- One-stage ALF
 - LCU-based encoding algorithm
- Summary
 - 0.7% BD-rate gain in HE-LDB
 - 1.4% BD-rate gain in HE-LDP

	Low Delay B HE		
	Y	U	V
Class A			
Class B	0.4%	5.0%	5.7%
Class C	-1.5%	1.7%	2.3%
Class D	-0.8%	1.3%	1.5%
Class E	-1.5%	10.1%	8.3%
Overall	-0.7%	4.2%	4.3%
	-0.7%	4.1%	4.2%
Class F	-0.3%	3.8%	5.2%
Enc Time[%]	180%		
Dec Time[%]	206%		

	Low Delay P HE		
	Y	U	V
Class A			
Class B	-1.6%	6.1%	6.7%
Class C	-1.0%	2.8%	3.5%
Class D	0.3%	2.0%	2.0%
Class E	-4.0%	11.4%	8.7%
Overall	-1.4%	5.3%	5.1%
	-1.4%	5.1%	5.0%
Class F	0.2%	4.2%	5.5%
Enc Time[%]	186%		
Dec Time[%]	215%		

Conclusion

- One-stage non-deblocking loop filtering
 - Combine SAO and ALF into one stage
 - LCU-based adaptation among {ALF+SAO, SAO, OFF}
 - 0.1% BD-rate loss in picture-based encoding algorithm
 - 75% BD-rate gain can be preserved in LCU-based encoding algorithm