Chroma ALF with reduced vertical filter size

(JCTVC-E287)

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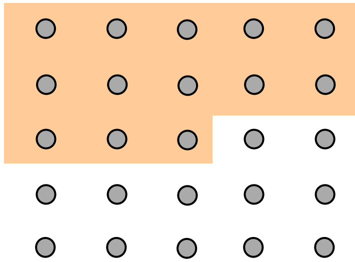
HM 2.0 Chroma ALF



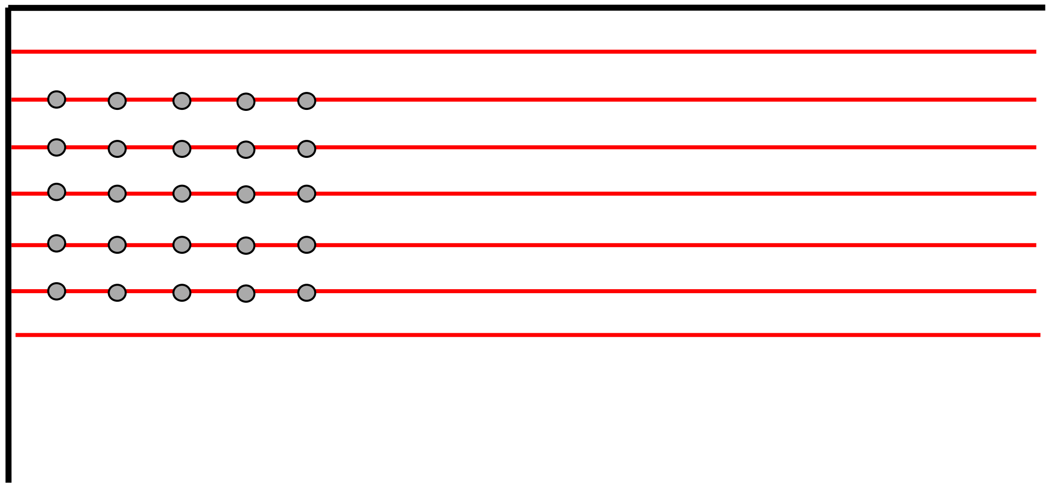
5x5-Square

- HM 2.0 Chroma ALF uses 5x5 square
  - Symmetric – so requires 13 multiplications
- Same filter is used for both chroma planes
- Two-bit chroma_idc flag is used to signal which chroma plane(s) are filtered
- Chroma does not use CU adaptive filtering, ALF is applied on whole frame or not applied at all

Chroma ALF decode complexity

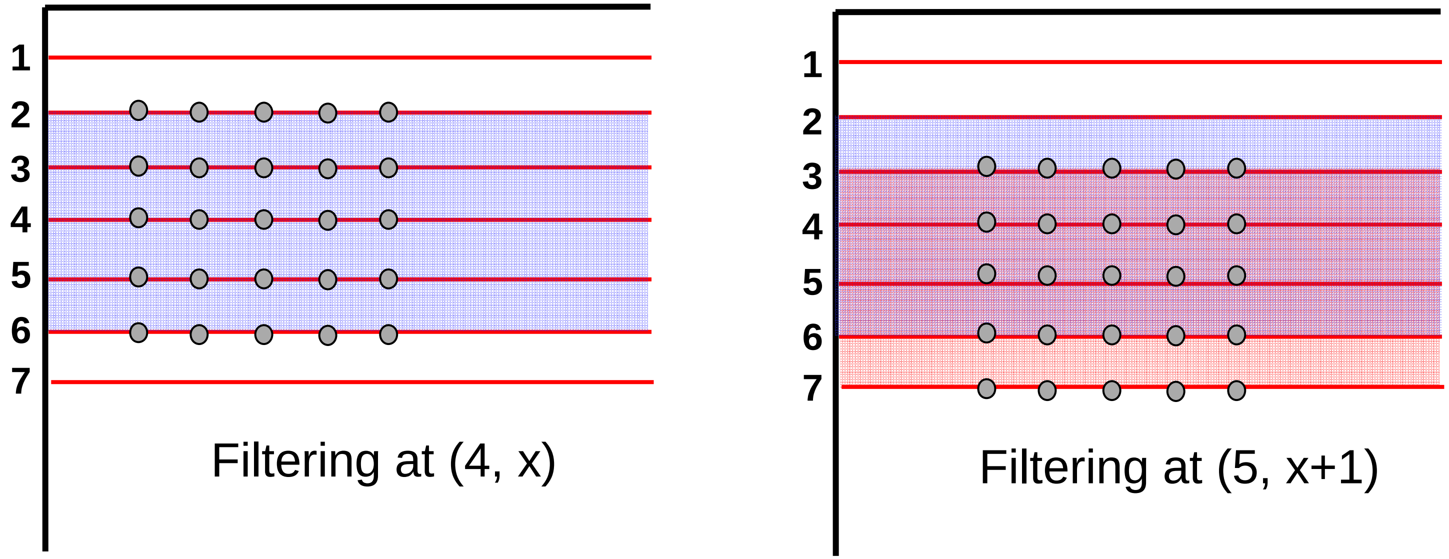
- Complexity considerations
  - Computational complexity
  - Memory bandwidth
  - Memory size (line buffer)
- ALF filtering can be carried out in either frame-based or LCU-based fashion
- For a given image size, the vertical size of ALF filters determines the size of line buffer/memory bandwidth requirements
  - Reducing vertical size of filter reduces line buffer/memory bandwidth requirements

Frame based ALF decode (No line buffers)



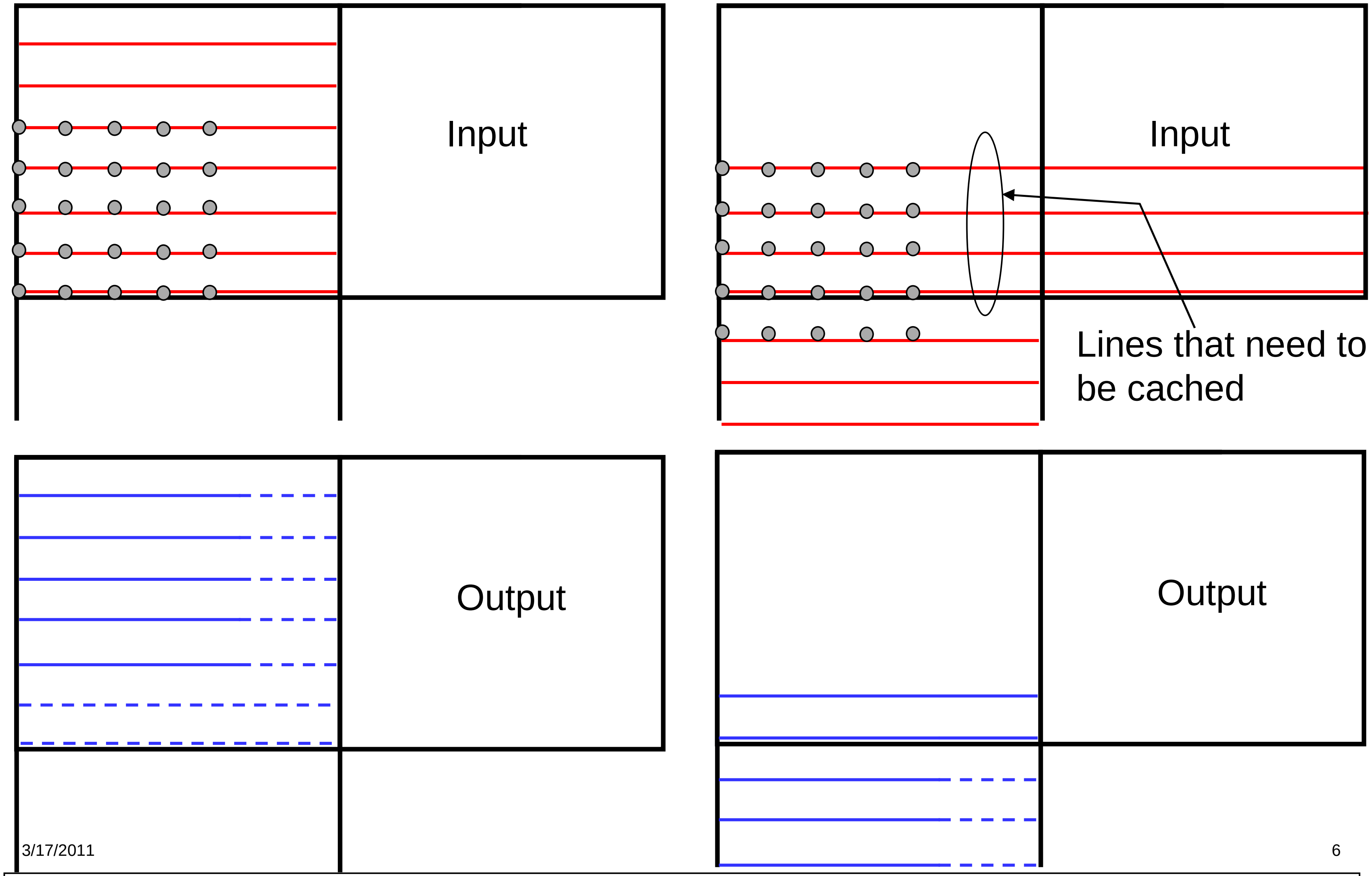
- Each filtering operation requires 25 pixel reads
- Memory bandwidth implications
  - Deblock output frame buffer needs to be read 25 times (also written to 1 time)
  - Not practical
- Memory requirements: 1 frame buffer for storing deblock output

Frame based ALF decode (with line buffers)

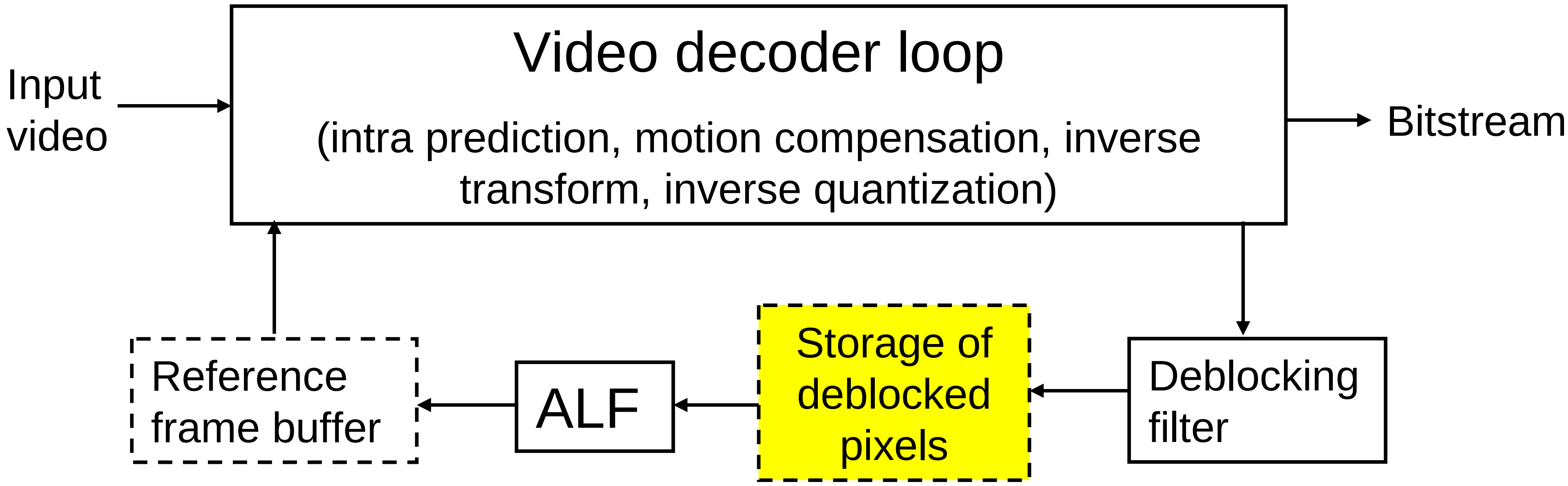


- Overlapping input data from one line to next need not be fetched when internal line buffers are used
- Number of input pixel reads for each filtering operation = 1
- Memory bandwidth implications
  - Deblock output frame buffer needs to be read 1 time (also written to 1 time)
  - Still very expensive
- Memory requirements: ~ 4*2*(picWidth/2) local memory, + 2 chroma frame buffers for storing deblock output

LCU-based ALF decode with line buffers

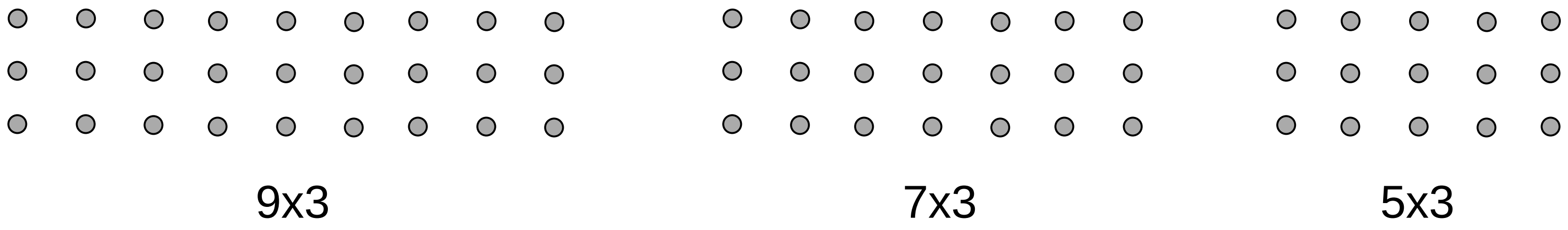


Summary of ALF implementation architecture



Chroma ALF filters with reduced vertical size (max vertical size = 3)

- Following three filters studied:



Results - Y

			Intra		Random access		Low delay	
	Line buffer size / Memory bandwidth	Worst case multiplies	BD-Rate	Dec time	BD-Rate	Dec time	BD-Rate	Dec time
No ChromaALF			-0.1	93%	0.0	95%	-0.1	95%
HM 2.0 ALF								
5x3			0.0	98%	0.0	96%	0.0	95%
7x3			0.0	99%	0.0	96%	0.0	98%
9x3			0.0	101%	0.0	101%	-0.1	105%

Table 1: Summary of Y BD-Rate, Decoder time, and complexity of ALF filters. Compared to anchor.

Results - U

			Intra		Random access		Low delay	
	Line buffer size / Memory bandwidth	Worst case multiplies	BD-Rate	Dec time	BD-Rate	Dec time	BD-Rate	Dec time
No ChromaALF	0	0	3.7	93%	2.3	95%	2.4	95%
HM 2.0 ALF	1X	13						
5x3	0.5X	8	0.4	98%	0.8	96%	0.6	95%
7x3	0.5X	11	0.2	99%	0.5	96%	0.3	98%
9x3	0.5X	14	0.1	101%	0.3	101%	-0.1	105%

Table 2: Summary of U BD-Rate, Decoder time, and complexity of ALF filters. Compared to anchor.

Results - V

			Intra		Random access		Low delay	
	Line buffer size / Memory bandwidth	Worst case multiplies	BD-Rate	Dec time	BD-Rate	Dec time	BD-Rate	Dec time
No ChromaALF	0	0	3.9	93%	2.1	95%	2.0	95%
HM 2.0 ALF	1X	13						
5x3	0.5X	8	0.5	98%	0.7	96%	0.6	95%
7x3	0.5X	11	0.3	99%	0.4	96%	0.0	98%
9x3	0.5X	14	0.1	101%	0.4	101%	-0.1	105%

Table 3: Summary of V BD-Rate, Decoder time, and complexity of ALF filters. Compared to anchor.

Conclusions

- Implementation complexity analysis involves not just analysis of computations but also analysis of memory bandwidth and memory size (area).
- For a given image size, the vertical size of ALF filters determines the size of line buffer/memory bandwidth requirements
  - Reducing vertical size of filter reduces line buffer/memory bandwidth requirements
- Contribution proposes ALF filter sets with reduced vertical size
- Proposed ALF filter sets capture most of the ALF coding gains
- 7x3 chroma ALF filters successfully cross-verified by Toshiba (JCTVC-E177). Thanks to Toshiba.
- 9x3 chroma ALF filters successfully cross-verified by MediaTek (JCTVC-E453). Thanks to MediaTek.
- Recommend that 9x3 ALF filter be adopted in HM 3.0 if there are no objections