JCTVC-F053

MEDIATEK

Deblocking Filter with Reduced Pixel Line Buffers for LCU-based Processing

Chih-Wei Hsu, Jicheng An, Xun Guo, Jian-Liang Lin, Yu-Wen Huang, and Shawmin Lei

Presented by Yu-Wen Huang
6th JCT-VC Meeting in Torino
14-22 July, 2011

Copyright © MediaTek Inc. All rights reserved.

Overall Summary

- Two vertical filtering methods were proposed for deblocking filter (DF) only for horizontal LCU edges in order to reduce line buffers
  - Method 1: use DF intermediate pixels for filtering decisions
  - Method 2: avoid using p'1-p'3 and avoid changing p0-p3
- The DF in HM-3.0 was applied for the rest edges

	Luma line buffers	Chroma line buffers
HM3.0	4 (reconstructed pixels) 4 (intermediate pixels)	2 (intermediate pixels)
Method 1	4 (intermediate pixels)	2 (intermediate pixels)
Method 2	1 (reconstructed pixels, can be shared with intra prediction)	1 (reconstructed pixels, can be shared with intra prediction)

BD-Rate	HE-AI	HE-RA	HE-LD	LC-AI	LC-RA	LC-LD
Method 1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Method 2	0.2%	0.2%	0.3%	0.2%	0.2%	0.3%

Copyright © MediaTek Inc. All rights reserved.

Outline

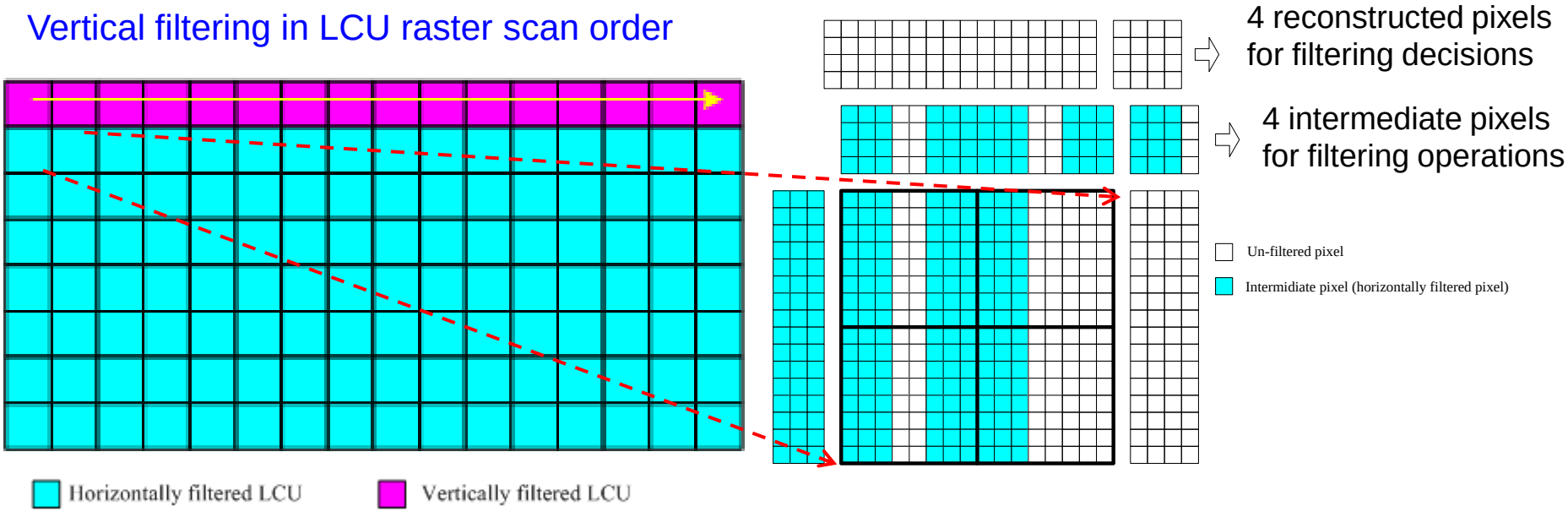
- Problem definition
- Proposed methods
- Simulations results
- Conclusions

Copyright © MediaTek Inc. All rights reserved.

Problem Definition

- When DF processes LCUs in a raster scan order, each LCU needs pixels from its upper LCU, so pixel line buffers are required.
- In HM-3.0, for luma vertical filtering
  - 4 intermediate pixels and 4 reconstructed pixels on each side of an edge are used, which requires 8 luma line buffers
  - It is desirable to reduce line buffers

Vertical filtering in LCU raster scan order



Copyright © MediaTek Inc. All rights reserved.

Filtering Decisions in HM-3.0

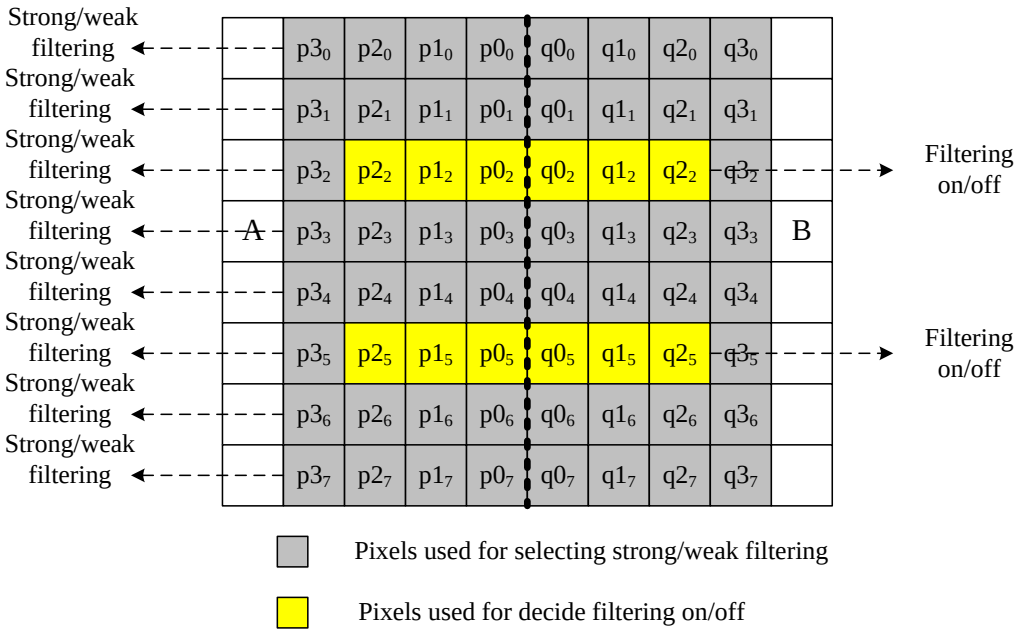
- Filtering on/off decision

$$d = |p'2_2 - 2\cdot p'1_2 + p'0_2| + |q'2_2 - 2\cdot q'1_2 + q'0_2| + |p'2_5 - 2\cdot p'1_5 + p'0_5| + |q'2_5 - 2\cdot q'1_5 + q'0_5| < \beta$$

- Filtering strong/weak selection

$$d < (\beta >> 2) and (|p'3_i - p'0_i| + |q'0_i - q'3_i|) < (\beta >> 3) and |p'0_i - q'0_i| < ((5\cdot t_c + 1) >> 1)$$

- p' and q' pixels are reconstructed pixels



Copyright © MediaTek Inc. All rights reserved.

Proposed Method 1

- Instead of using reconstructed pixels, intermediate pixels are used in filtering decisions
  - Filtering on/off decision

$$d = |p2_2 - 2\cdot p1_2 + p0_2| + |q2_2 - 2\cdot q1_2 + q0_2| + |p2_5 - 2\cdot p1_5 + p0_5| + |q2_5 - 2\cdot q1_5 + q0_5| < \beta$$

  - Filtering strong/weak selection

$$d < (\beta >> 2) and (|p3_i - p0_i| + |q0_i - q3_i|) < (\beta >> 3) and |p0_i - q0_i| < ((5\cdot t_c + 1) >> 1)$$

  - p and q pixels are intermediate pixels
- The 4 luma line buffers to store reconstructed pixels (p’0-p’3) for filtering decisions can be saved.
- Does not change the chroma DF

Copyright © MediaTek Inc. All rights reserved.

Proposed Method 2

- Modified filtering decisions
  - Pixels from the upper side of the LCU edge (p' pixels) are not used in the filtering decisions except p'0
  - Filtering on/off decision

$$d = |q'2_2 - 2 \cdot q'1_2 + q'0_2| + |q'2_5 - 2 \cdot q'1_5 + q'0_5| < \beta / 2$$

  - Filtering strong/weak selection

$$d < (\beta >> 3) and (|q'3_i - q'0_i|) < (\beta >> 4) and |p'0_i - q'0_i| < ((5 \cdot t_c + 1) >> 1)$$

- Modified filtering operations
  - Pixels from the upper side of the LCU edge (p' pixels) are NOT used in the filtering operations except p'0
  - Pixels from the upper side of the LCU edge (p0-p3) will NOT be changed by the filtering operations
- Only 1 luma line buffer is required to store p'0 and can be shared with intra prediction.
- Similar concept applied for the chroma DF

Copyright © MediaTek Inc. All rights reserved.

Comparison of Pixel Line Buffers

	Luma line buffers	Chroma line buffers
HM3.0	4 (reconstructed pixels) 4 (intermediate pixels)	2 (intermediate pixels)
Method 1	4 (intermediate pixels)	2 (intermediate pixels)
Method 2	1 (reconstructed pixels, can be shared with intra prediction)	1 (reconstructed pixels, can be shared with intra prediction)

Copyright © MediaTek Inc. All rights reserved.

Results of the Proposed Method 1

	HE-AI			LC-AI		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	0.0	0.0	0.0	0.0	0.0	0.0
Class B	0.0	0.0	0.0	0.0	0.0	0.0
Class C	0.0	0.0	0.0	0.0	0.0	0.0
Class D	0.0	0.0	0.0	0.0	0.0	0.0
Class E	0.0	0.0	0.0	0.0	0.0	0.0
All	0.0	0.0	0.0	0.0	0.0	0.0
Enc Time[%]	100%			101%		
Dec Time[%]	100%			100%		
	HE-RA			LC-RA		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	0.0	0.1	0.1	0.0	-0.1	0.1
Class B	0.0	-0.1	-0.1	0.0	0.0	0.0
Class C	0.0	0.0	-0.1	0.0	0.0	0.0
Class D	0.0	-0.1	0.0	0.0	0.0	0.0
Class E						
All	0.0	0.0	0.0	0.0	0.0	0.0
Enc Time[%]	100%			100%		
Dec Time[%]	101%			101%		
	HE-LD			LC-LD		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	0.0	0.2	0.2	0.0	0.0	-0.2
Class C	0.0	0.1	0.0	0.0	0.2	-0.2
Class D	0.0	-0.2	0.5	0.0	0.2	0.2
Class E	0.1	0.5	0.1	0.1	0.0	-0.2
All	0.0	0.1	0.2	0.0	0.1	-0.1
Enc Time[%]	100%			100%		
Dec Time[%]	99%			101%		

Copyright © MediaTek Inc. All rights reserved.

Results of the Proposed Method 2

	HE-AI			LC-AI		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	0.1	0.3	0.3	0.2	0.4	0.4
Class B	0.2	0.5	0.6	0.3	0.5	0.6
Class C	0.1	0.4	0.4	0.1	0.4	0.5
Class D	0.1	0.3	0.3	0.1	0.4	0.4
Class E	0.3	0.6	0.7	0.3	0.8	0.8
All	0.2	0.4	0.5	0.2	0.5	0.5
Enc Time[%]	100%			102%		
Dec Time[%]	102%			104%		
	HE-RA			LC-RA		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	0.2	0.4	0.3	0.3	0.3	0.5
Class B	0.3	0.6	0.6	0.3	0.6	0.6
Class C	0.2	0.5	0.5	0.2	0.4	0.4
Class D	0.1	0.3	0.3	0.1	0.3	0.3
Class E						
All	0.2	0.5	0.4	0.2	0.4	0.5
Enc Time[%]	100%			100%		
Dec Time[%]	101%			102%		
	HE-LD			LC-LD		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	0.3	0.4	0.3	0.4	0.1	0.0
Class C	0.2	0.2	0.3	0.2	0.2	0.3
Class D	0.1	0.2	0.4	0.1	0.1	0.1
Class E	0.9	0.6	0.9	0.7	0.5	0.2
All	0.3	0.3	0.4	0.3	0.2	0.1
Enc Time[%]	100%			100%		
Dec Time[%]	102%			103%		

Copyright © MediaTek Inc. All rights reserved.

Subjective Quality Evaluation

- Blind tests
  - Not knowing which one is the anchor and which one is the proposed method
  - All tested videos with 4 QP values were evaluated by 5 people.
  - 4 tested videos were evaluated by more than 20 people including video experts and non-experts.
  - All bitstreams and decoders can be downloaded, and requests of the FTP site information can be sent to cw.hsu@mediatek.com
- Method 1: no difference from the HM-3.0 anchor.
- Method 2: minor artifacts at horizontal LCU edges observed by the software author for a few videos

Copyright © MediaTek Inc. All rights reserved.

Crosscheck

- We thank Ericsson for crosscheck (JCTVC-F531).
  - All objective results were confirmed.
  - Subjectively, the method 1 is the same as the anchor.
  - Subjectively, the method 2 is slightly worse than the anchor.
  - Artifacts for Vidyo3, Vidyo4, and ParkScene were observed.

Copyright © MediaTek Inc. All rights reserved.

Conclusions

- Two vertical filtering methods were proposed for horizontal LCU edges to reduce pixel line buffers required by DF.
  - The DF in HM-3.0 is still used for rest edges
- The first method replaces reconstructed pixels by intermediate pixels in the filtering decisions.
  - The number of luma line buffers is reduced from 8 to 4.
  - The number of chroma line buffers is still 2.
  - No noticeable impact on BD-rate, run time, and visual quality
- The second method avoids using p’1-p’3 (reconstructed pixels) and avoids changing p0-p3 (intermediate pixels).
  - Only 1 luma line buffer and 1 chroma line buffer
  - No additional line buffer required to support DF due to intra prediction
  - 0.3% bitrate increase with unchanged run time
  - Slightly worse subjective quality

Copyright © MediaTek Inc. All rights reserved.