JCTVC-G228

MEDIATEK

CE12.3.2: Reducing pixel line buffers by modifying DF for horizontal LCU boundaries

Chih-Wei Hsu, Yu-Wen Huang, Shawmin Lei

Presented by Chih-Wei Hsu
7th JCT-VC Meeting in Geneva
21-30 November, 2011

Overall Summary

- This contribution reports the results of CE12.3.2
  - Based on JCTVC-F053 method2 to modify DF for horizontal LCU boundaries
  - Keep DF unchanged for the rest edges
- In the proposed method
  - One pre-DF pixel above the edge is used for filtering decisions
  - Filtering operations only modify one pixel above the edge
- In comparison with HM-4.0, the proposed method can remove all pixel line buffers dedicated for DF
  - 0.0-0.2% coding efficiency loss with roughly unchanged run time and similar visual quality in most cases

Introduction

- When LCUs are processed by DF in a raster scan order, each LCU needs pixels from its upper LCU
  - Pixel line buffers are required
- In HM-4.0, for luma vertical filtering
  - 4 reconstructed pixels on each side of an edge are read for filtering decisions
  - 3 pixels at most are filtered and written back
  - 4 luma line buffers are required
- DF with modified vertical filtering are proposed to reduce the number of pixel line buffers
  - Only applied to horizontal LCU boundaries

Proposed Method (1/2)

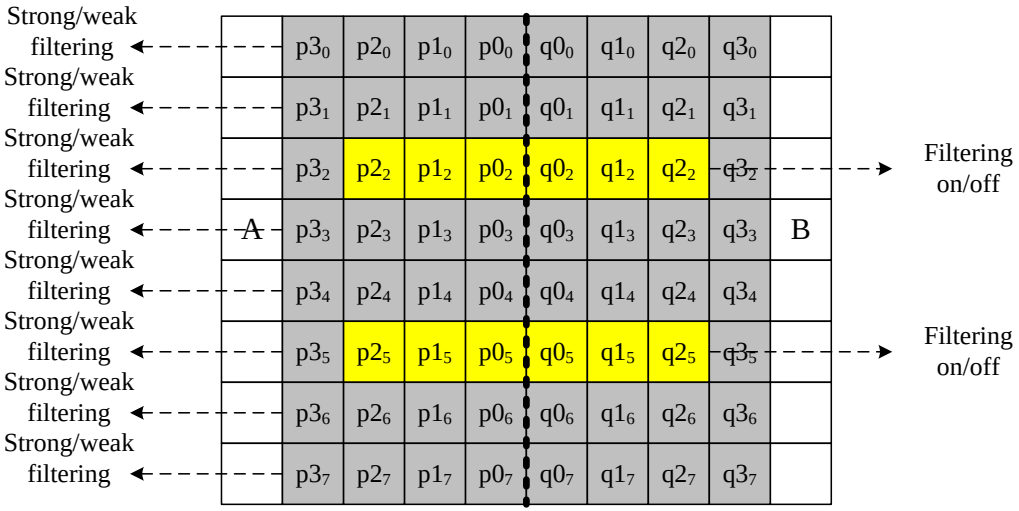
- In HM4.0 DF filtering decisions (applicable to both horizontal and vertical edges)
  - Filtering on/off decision

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

  - Filtering strong/weak selection

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

  - Where p' and q' pixels are reconstructed pixels



Proposed Method (2/2)

- There are two parts of modifications
- Part 1:
  - Pixels from the upper side of the edge (p' pixels) are not used in the filtering decisions except to 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

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

- Part 2:
  - Pixels from the upper side of the edge (p' pixels) are not used in the filtering operations except to p'0
  - Pixels of the upper side of the edge will not be changed in the filtering operations except to p0

Modified Strong/Weak Filters

Original

- Luma strong filter

$$p2_i = Clip(0,255,(2\cdot p3_i + 3\cdot p2_i + p1_i + p0_i + q0_i + 4) >> 3)$$
$$p1_i = Clip(0,255,(p2_i + p1_i + p0_i + q0_i + 2) >> 2)$$
$$p0_i = Clip(0,255,(p2_i + 2\cdot p1_i + 2\cdot p0_i + 2\cdot q0_i + q1_i + 4) >> 3)$$
$$q0_i = Clip(0,255,(p1_i + 2\cdot p0_i + 2\cdot q0_i + 2\cdot q1_i + q2_i + 4) >> 3)$$
$$q1_i = Clip(0,255,(p0_i + q0_i + q1_i + q2_i + 2) >> 2)$$
$$q2_i = Clip(0,255,(p0_i + q0_i + q1_i + 3\cdot q2_i + 2\cdot q3_i + 4) >> 3)$$

- Luma weak filter

$$\Delta = Clip(-t_c, t_c, (9\cdot(q0_i - p0_i) - 3\cdot(q1_i - p1_i) + 8) >> 4)$$
$$p0_i = Clip(0,255, p0_i + \Delta)$$
$$q0_i = Clip(0,255, q0_i - \Delta)$$
$$\Delta 1 = Clip\left(-\frac{t_c}{2}, \frac{t_c}{2}, ((p0_i + p2_i + 1) >> 1 - p1_i + \Delta) >> 1\right)$$
$$p1_i = Clip(0,255, p1_i + \Delta 1)$$
$$\Delta 2 = Clip\left(-\frac{t_c}{2}, \frac{t_c}{2}, ((q0_i + q2_i + 1) >> 1 - q1_i + \Delta) >> 1\right)$$
$$q1_i = Clip(0,255, q1_i + \Delta 2)$$

Proposed

- Luma strong filter

$$p0_i = Clip(0,255,(p0_i + 2\cdot p0_i + 2\cdot p0_i + 2\cdot q0_i + q1_i + 4) >> 3)$$
$$q0_i = Clip(0,255,(p0_i + 2\cdot p0_i + 2\cdot q0_i + 2\cdot q1_i + q2_i + 4) >> 3)$$
$$q1_i = Clip(0,255,(p0_i + q0_i + q1_i + q2_i + 2) >> 2)$$
$$q2_i = Clip(0,255,(p0_i + q0_i + q1_i + 3\cdot q2_i + 2\cdot q3_i + 4) >> 3)$$

- Luma weak filter

$$\Delta = Clip(-t_c, t_c, (9\cdot(q0_i - p0_i) - 3\cdot(q1_i - p0_i) + 8) >> 4)$$
$$p0_i = Clip(0,255, p0_i + \Delta)$$
$$q0_i = Clip(0,255, q0_i - \Delta)$$

p1 is not allowed to be modified

$$\Delta 2 = Clip\left(-\frac{t_c}{2}, \frac{t_c}{2}, ((q0_i + q2_i + 1) >> 1 - q1_i + \Delta) >> 1\right)$$
$$q1_i = Clip(0,255, q1_i + \Delta 2)$$

p0 is used in a padding way to replace other p pixel ,which can be filtered from reconstructed pixel in line buffer and could be shared with intra prediction

Simulation Results

- Anchor: HM-4.0
- No noticeable change in terms of BD-rate, run time

	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V
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%
Overall	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	100%			100%		
Dec Time[%]	100%			101%		

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	0.0%	-0.2%	-0.2%	0.0%	0.1%	0.0%
Class B	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%
Class C	0.0%	-0.1%	0.1%	0.0%	0.1%	0.1%
Class D	0.0%	0.0%	-0.1%	0.0%	0.0%	0.1%
Class E						
Overall	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%
	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	100%			100%		
Dec Time[%]	100%			100%		

	Low Delay B HE			Low Delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	0.0%	-0.1%	-0.1%	0.0%	0.1%	0.2%
Class C	0.0%	0.2%	0.0%	0.0%	0.3%	-0.1%
Class D	0.0%	0.5%	0.1%	0.0%	-0.1%	-0.4%
Class E	0.0%	0.1%	0.5%	0.0%	-0.2%	-0.4%
Overall	0.0%	0.2%	0.1%	0.0%	0.0%	-0.2%
	0.0%	0.2%	0.1%	0.0%	0.0%	-0.1%
Enc Time[%]	100%			100%		
Dec Time[%]	100%			101%		

Conclusions

- In this contribution, vertical filtering method based on JCTVC-F053 method2 was proposed
  - Only applied to horizontal LCU boundaries to reduce pixel line buffers for DF
  - DF in HM-4.0 was still used for the rest edges
- The proposed method can remove all pixel line buffers dedicated for DF
  - One pre-DF pixels above the edge were used for filtering decisions, which could be shared with intra prediction
  - Filtering operations only modified one pixel above the edge
- Simulation results show 0.0-0.2% BD rate increases with roughly unchanged run time
  - It is claimed that that the proposed method has similar subjective quality in most cases when compared with HM-4.0