



# Non-CE12.3: Reducing pixel line buffers by modifying DF to R3W2 for horizontal LCU boundaries

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# Overall Summary

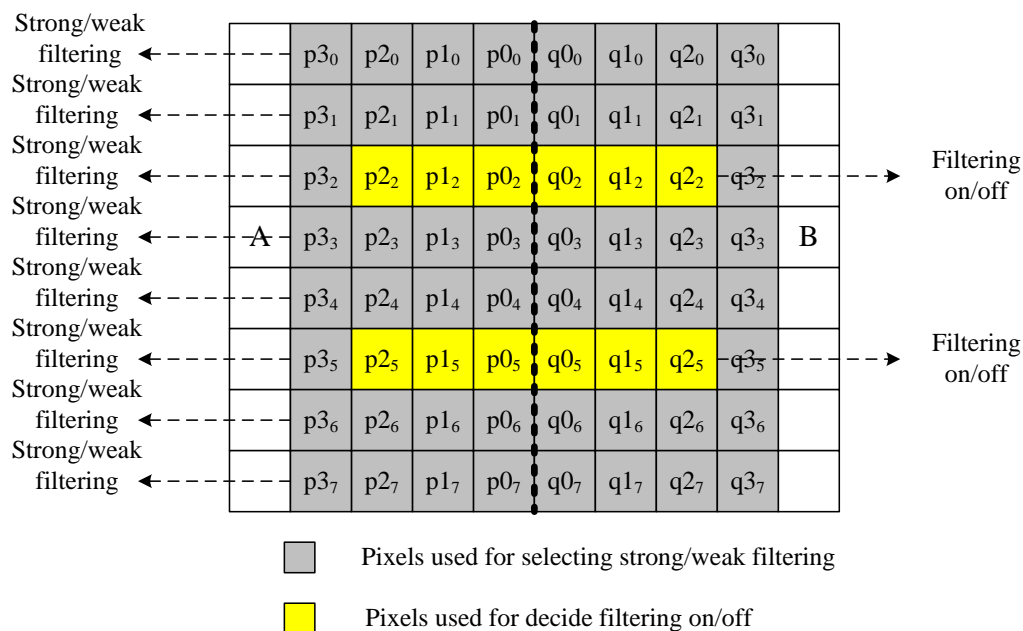
- In this contribution, modified vertical filtering with reading 3 pixels and writing 2 pixels (R3W2) for DF is proposed
  - Only applied to pixels above horizontal LCU boundaries to reduce pixel line buffers for DF
  - DF in HM-4.0(R4W3) is still used for the rest edges
- The proposed method can save one pixel line buffer for DF compared with the current HM-4.0
  - Fewer pre-DF pixels above the edge are used for the filtering decisions, and filtering operations are also modified
- Simulation results show 0% bit rate increase with unchanged run time
  - Similar subjective quality in comparison with HM-4.0 by proponents

# 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
  - Since reading 4 pixels and writing 4 pixels are required above LCU horizontal boundaries, we call it “Read 4 and Write 3” case, which is **R4W3** in short
- DF with R3W2 are proposed to reduce the number of pixel line buffers
  - Only applied to horizontal LCU edges

# Proposed Method (1/2)

- In HM4.0 DF filtering decisions (applicable to both horizontal and vertical edges)
  - Reconstructed pixels are used
  - At most 3 pixels above LCU boundaries will be used in filtering on/off decision
  - At most 4 pixels above LCU boundaries will be used in filtering strong/weak selection



# Proposed Method (2/2)

- There are two parts of modifications for R3W2

- Part 1:

- Filtering on/off decision
  - **Unchanged**
- Filtering strong/weak selection
  - Use  $p'2$  instead of  $p'3$

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

- Part 2:

- Strong filter

- Only filtering 2 pixels above horizontal LCU edges

$$p2_i = \text{Clip}(0, 255, (2 \cdot p3_i + 3 \cdot p2_i + p1_i + p0_i + q0_i + 4) \gg 3)$$

$$p1_i = \text{Clip}(0, 255, (p2_i + p1_i + p0_i + q0_i + 2) \gg 2)$$

$$p0_i = \text{Clip}(0, 255, (p2_i + 2 \cdot p1_i + 2 \cdot p0_i + 2 \cdot q0_i + q1_i + 4) \gg 3)$$



$$p1_i = \text{Clip}(0, 255, (4 \cdot p2_i + 5 \cdot p1_i + 4 \cdot p0_i + 3 \cdot q0_i + 8) \gg 4)$$

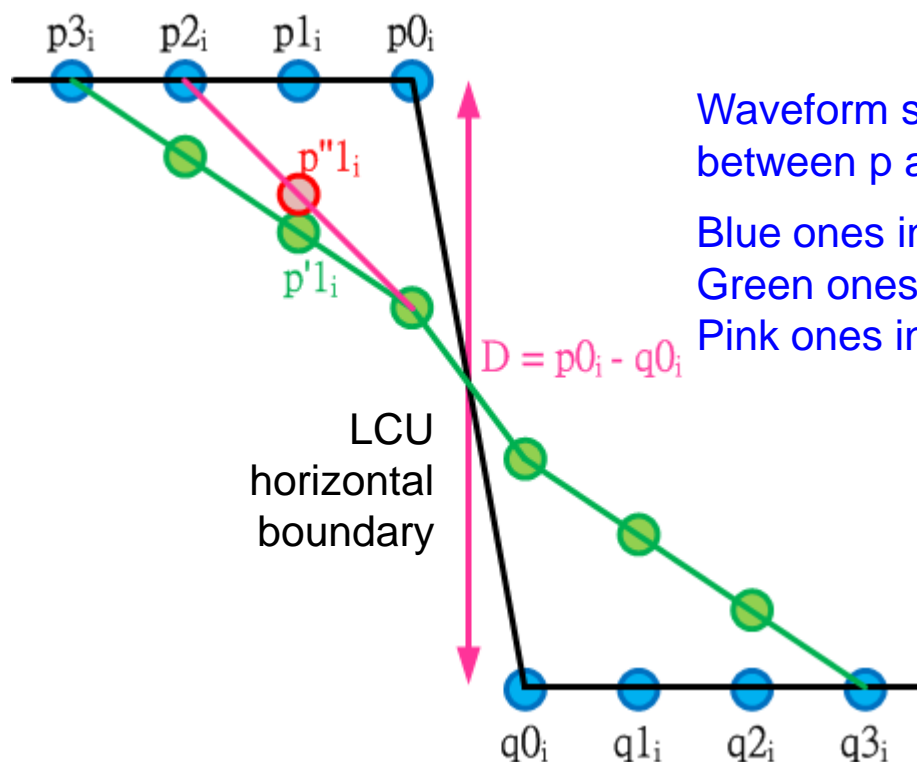
$$p0_i = \text{Clip}(0, 255, (p2_i + 2 \cdot p1_i + 2 \cdot p0_i + 2 \cdot q0_i + q1_i + 4) \gg 3)$$

- Weak filter

- **Unchanged**

# Proposed Strong Filter

- p2 will not be filtered in case of R3W2
- Modify p'1 to p''1 to smooth the waveform
- p2 and p1 are different from those of HM-4.0



Waveform showing an edge gap  $D$  between p and q sides

Blue ones indicate pre-DF pixel values

Green ones indicate post-DF pixel values in HM-4

Pink ones indicate R3W2 pixel values

# Simulation Results

- Anchor: HM-4.0
- No noticeable change in terms of BD-rate, run time
- Proponents observed similar visual quality as anchor
  - To be verified in subjective viewing sessions

	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%
Class F						
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[%]	99%			99%		
	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	0.0%	-0.2%	-0.3%	0.0%	0.1%	0.0%
Class B	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%
Class C	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%
Class D	0.1%	0.0%	0.1%	0.0%	0.0%	-0.1%
Class E						
Class F						
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%			101%		
	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%	-0.1%
Class C	0.0%	-0.1%	0.0%	0.0%	0.1%	-0.2%
Class D	0.0%	0.2%	0.3%	0.0%	0.1%	0.0%
Class E	0.0%	0.1%	0.1%	-0.1%	0.6%	-0.5%
Class F						
Overall	0.0%	0.0%	0.0%	0.0%	0.2%	-0.2%
	0.0%	0.0%	0.0%	0.0%	0.2%	-0.1%
Enc Time[%]	101%			101%		
Dec Time[%]	100%			102%		

# Conclusions

- MediaTek, Sony and LG proposed R3W2 DF for horizontal LCU edges to reduce pixel line buffers for DF
- The proposed method can save one pixel line buffer for DF compared with HM-4.0
- Simulation results show 0% bit rate increase with unchanged run time
- It is claimed that the proposed method has similar subjective quality in comparison with HM-4.0