

Improving Deblocking filter efficiency

(JCTVC-256)

Mangesh Sadafale



Proposal

- Unified Chroma Filter
 - Improve BD-rate
 - Make Chroma-filter sub-set of Luma-week filter
- Parallel decision
 - Complexity analysis and corresponding changes.

Unified Chroma Filter

Motivation : harmonized chroma and Luma weak filter

Unified Chroma Filter

- Changes
 - **Chroma filter equation**
 - Increase chroma filter precision by 2-bit.
 - New Chroma filter is sub-set of Luma-Weak filter

Chroma HM-3.0 : $\text{delta} = \text{Clip3}(-tc, tc, ((4 * (m4 - m3) - (m5 - m2) + 4) \gg 3));$

Chroma proposed : $\text{delta} = \text{Clip3}(-tc, tc, ((13 * (m4 - m3) - 4 * (m5 - m2) + 16) \gg 5));$

Luma-Weak HM3.0 : $\text{delta} = \text{Clip3}(-tc, tc, ((13 * (m4 - m3) + 4 * (m5 - m2) - 5 * (m6 - m1) + 16) \gg 5));$

– Apply Chroma filter to Inter Edge

- Condition to apply filter to Inter is also sub-set of Luma.

```
Int d_inter = abs(m0-m3) + abs(m7-m4);
```

```
if ( (bs>2) || ((d_inter < (beta>>3)) && (abs(m3-m4) < ((tc*5+1)>>1))) ) {
```

Impact of Unified Chroma Filter

- Good Chroma BD-Rate Improvement to
- No Change in encoder
- No extra signaling in bit-stream
- No Impact to performance by filter change
 - Number of operations remains same in filter equation
- No Impact to hardware performance by Inter filter
 - hardware will be design for Worst case, that is Scene-change/I-Frame
 - Even if we consider 4Kx2K@60fps with all 8x8 edge
 - 189MHz of 1-line/clock hardware is enough for all 8x8 edge
- Small impact to software performance by Inter filter
 - Software budgeting will be done for worst case, Scene-change/I-Frame
 - Compute requirement of deblockign filter is low, memory access will define performance.
 - Negligible impact to encode and decode

Result Of Unified Chroma Filter

| | Intra | | | Intra LC | | |
|---------|-----------|-----------|-----------|-----------|-----------|-----------|
| | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | 0.0 | -0.4 | -0.2 | 0.0 | -0.6 | -0.4 |
| Class B | 0.0 | -0.2 | -0.1 | 0.0 | -0.7 | -0.5 |
| Class C | 0.0 | -0.2 | -0.2 | 0.0 | -0.7 | -0.6 |
| Class D | 0.0 | -0.2 | -0.1 | 0.0 | -0.6 | -0.5 |
| Class E | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 | -0.1 |
| All | 0.0 | -0.2 | -0.1 | 0.0 | -0.5 | -0.5 |

| | Random access | | | Random access LC | | |
|---------|---------------|-----------|-----------|------------------|-----------|-----------|
| | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | -0.1 | -0.6 | -0.6 | 0.1 | -0.7 | -0.4 |
| Class B | 0.0 | -0.6 | -0.5 | 0.0 | -0.7 | -0.6 |
| Class C | 0.0 | -0.6 | -0.5 | 0.0 | -0.6 | -0.6 |
| Class D | 0.0 | -0.5 | -0.5 | 0.0 | -0.4 | -0.6 |
| Class E | | | | | | |
| All | 0.0 | -0.6 | -0.5 | 0.0 | -0.6 | -0.5 |

| | Low delay | | | Low delay LC | | |
|---------|-----------|-----------|-----------|--------------|-----------|-----------|
| | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | | | | | | |
| Class B | 0.0 | -0.7 | -1.0 | 0.0 | -0.9 | -1.0 |
| Class C | 0.0 | -0.8 | -0.8 | 0.0 | -0.5 | -0.8 |
| Class D | 0.0 | -0.2 | -0.4 | 0.0 | -0.4 | -0.6 |
| Class E | 0.1 | -0.8 | -1.4 | 0.0 | -1.9 | -1.5 |
| All | 0.0 | -0.6 | -0.9 | 0.0 | -0.9 | -1.0 |

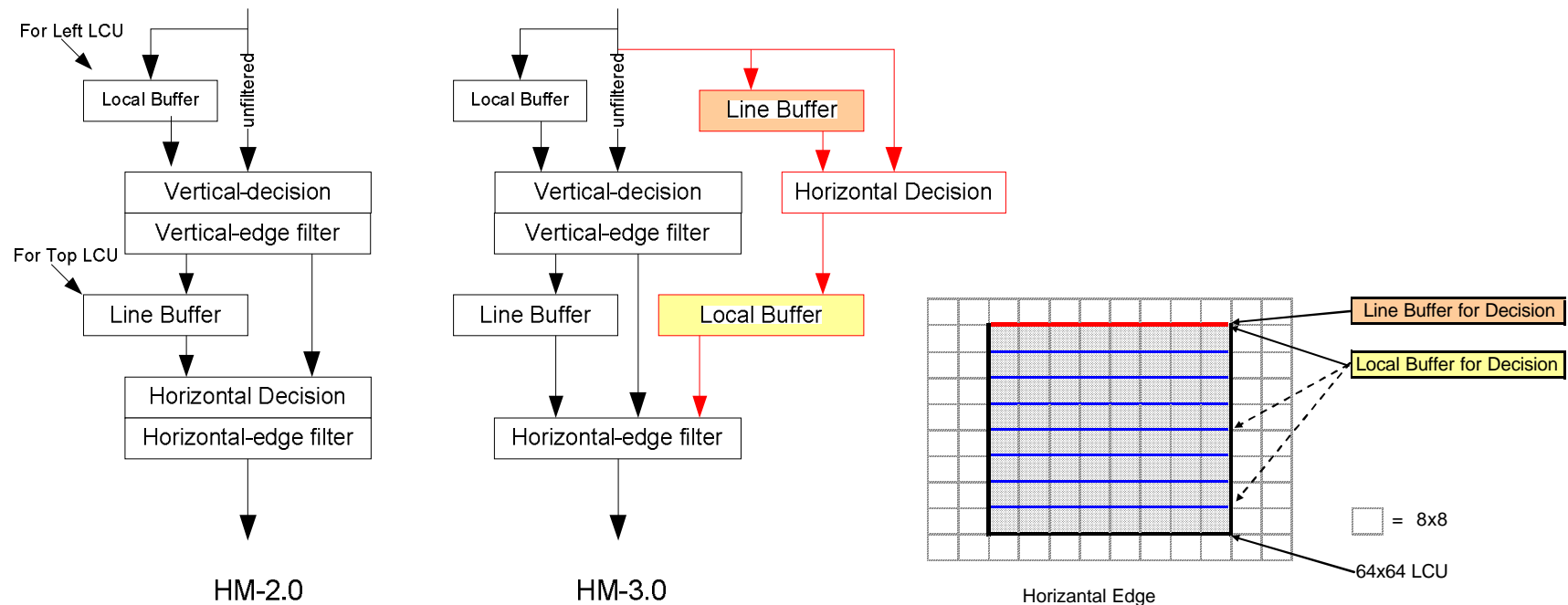
Parallel Decision

Parallel Decision

- Parallel decision was introduced in HM-3.0
 - To dissolve dependency of vertical filter for Horizontal filter decision
- Unfiltered data is used for all Horizontal edge of
 - Filter ON/OFF decision
 - Filter Strong/Weak decision
- Decision making is parallel but usage is sequential
 - Can't use Horizontal decision till Vertical filter is done.
 - Adds Local buffer for filter decision inside LCU
 - Adds Line buffer for storing Pixels for TOP-LCU

HM3.0 LCU processing

- We will have to design system for worst case
 - TuSize= 8x8 and strong filter.
 - TuSize and Filter decision is unpredictable and random



Storage Requirement by Parallel decision

| Buffer Type | Data Type | bits/LCU | bits/line | Note |
|-------------|-------------|----------|-----------|----------------|
| Local | ON/OFF | 64 | NA | 1-bit/8-line |
| | Strong/Weak | 512 | NA | 1-bit/1-line |
| Line | ON/OFF | 80 | 5,120 | (Pel+2)/8-line |
| | Strong/Weak | 1,024 | 65,536 | 2*Pel/1-line |
| | Total | 1,680 | 70,656 | |

- Local Buffer

- ON/OFF 1-bit/8-line

- if (iD < iBeta) // ON/OFF decision

- Strong/Weak 1-bit/1-line

- if ((d_strong<(beta>>3))&&(iD<(beta>>2)) && (abs(m3j -m4j) < ((tc*5+1)>>1))) //Strong/Weak

- Line Buffer

- (Pel+2)/8-line

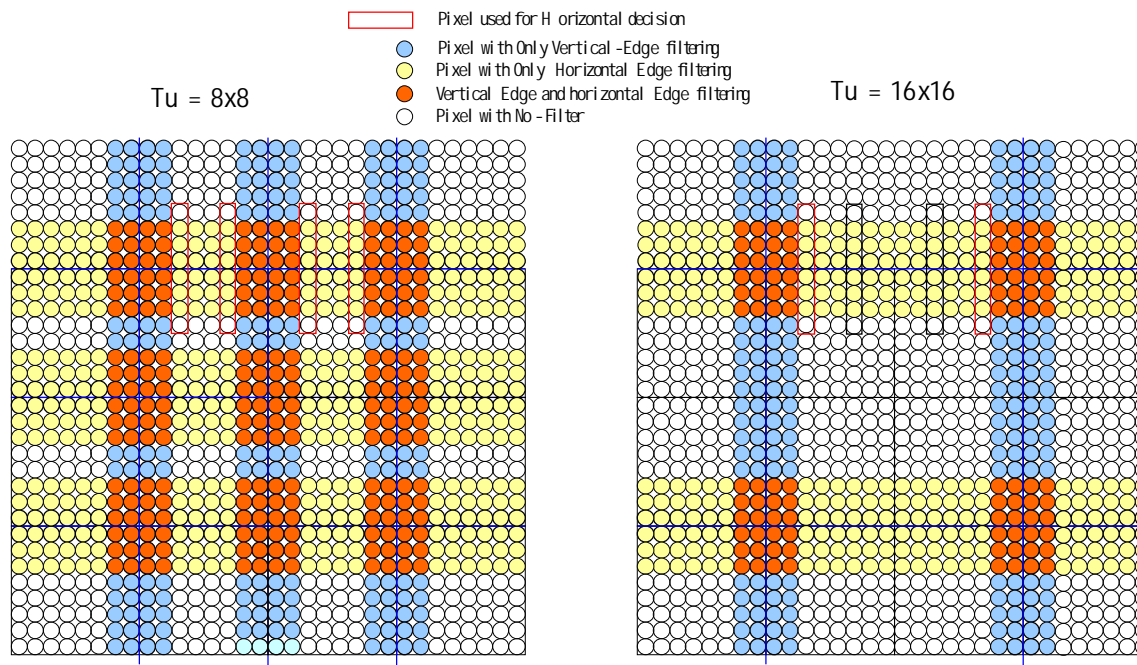
- abs(pi Src[-iOffset*3] - 2*pi Src[-iOffset*2] + pi Src[-iOffset])

- 2*Pel/1-line

- Pel m3j = pi SrcJudge[-iOffset]; Pel m0j = pi SrcJudge[-iOffset*4];

Unfiltered data usage in HM 2.0

- In HM-2.0 horizontal-decision will use vertical filtered data only when
 - Strong filter is applied to vertical edge at interaction of vertical/horizontal edge
- Diagram with Vertical Weak and Horizontal Strong filter
 - Here complete Horizontal filter decision is done on unfiltered data even in HM-2.0



Impact of Parallel decision

- Parallel decision in HM-3.0 make use of Unfiltered data for horizontal decision for all conditions.
 - In most of the conditions HM-2.0 can also use unfiltered data.
- It is adding huge storage, memory access/latency and sequential dependency with no gain in BD-rate.
- It is solving very small problem with huge overhead
- System is gating complicated by parallel-decision of horizontal edge
 - It's better to do horizontal decision and filter parallel. But, with no overhead.
- Hence we propose the removal of parallel-decision in HM-4.0.

Result after removing Parallel decision

| | Intra | | | Intra LC | | |
|---------|-----------|-----------|-----------|-----------|-----------|-----------|
| | 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 |

| | Random access | | | Random access LC | | |
|---------|---------------|-----------|-----------|------------------|-----------|-----------|
| | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | 0.0 | -0.2 | 0.2 | 0.0 | -0.1 | 0.2 |
| 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 | -0.1 |
| Class D | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 |
| Class E | | | | | | |
| All | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| | Low delay | | | Low delay LC | | |
|---------|-----------|-----------|-----------|--------------|-----------|-----------|
| | 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 | 0.1 | 0.0 | 0.0 | -0.3 |
| Class C | 0.0 | -0.1 | -0.1 | 0.0 | 0.1 | -0.1 |
| Class D | 0.0 | -0.1 | 0.2 | 0.0 | 0.1 | -0.1 |
| Class E | 0.0 | 0.2 | 0.2 | 0.1 | -0.2 | -0.7 |
| All | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | -0.3 |

Result of Complete Proposal

| | Intra | | | Intra LC | | |
|-------------|-----------|-----------|-----------|-----------|-----------|-----------|
| | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | 0.0 | -0.4 | -0.2 | 0.0 | -0.6 | -0.4 |
| Class B | 0.0 | -0.2 | -0.1 | 0.0 | -0.7 | -0.5 |
| Class C | 0.0 | -0.2 | -0.2 | 0.0 | -0.7 | -0.6 |
| Class D | 0.0 | -0.2 | -0.1 | 0.0 | -0.6 | -0.5 |
| Class E | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 | -0.1 |
| All | 0.0 | -0.2 | -0.1 | 0.0 | -0.5 | -0.5 |
| Enc Time[%] | 105% | | | 102% | | |
| Dec Time[%] | 104% | | | 101% | | |

| | Random access | | | Random access LC | | |
|-------------|---------------|-----------|-----------|------------------|-----------|-----------|
| | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | 0.0 | -0.6 | -0.6 | 0.0 | -0.7 | -0.4 |
| Class B | 0.0 | -0.6 | -0.5 | 0.0 | -0.7 | -0.6 |
| Class C | 0.0 | -0.4 | -0.5 | 0.0 | -0.6 | -0.7 |
| Class D | 0.0 | -0.5 | -0.5 | 0.0 | -0.7 | -0.5 |
| Class E | | | | | | |
| All | 0.0 | -0.6 | -0.5 | 0.0 | -0.7 | -0.6 |
| Enc Time[%] | 100% | | | 102% | | |
| Dec Time[%] | 99% | | | 101% | | |

| | Low delay | | | Low delay LC | | |
|-------------|-----------|-----------|-----------|--------------|-----------|-----------|
| | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | | | | | | |
| Class B | -0.1 | -0.8 | -0.8 | 0.0 | -1.0 | -1.1 |
| Class C | -0.1 | -0.8 | -0.8 | -0.1 | -0.6 | -0.8 |
| Class D | 0.0 | -0.3 | 0.0 | 0.0 | -0.4 | -0.5 |
| Class E | 0.0 | -1.2 | -1.3 | -0.1 | -2.4 | -1.9 |
| All | 0.0 | -0.7 | -0.7 | 0.0 | -1.0 | -1.0 |
| Enc Time[%] | 100% | | | 100% | | |
| Dec Time[%] | 100% | | | 99% | | |