



CE12 Subset1: SKT/SKKU Deblocking Filter

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JCTVC-E417

Summary

- Background: this idea has been proposed in JCTVC-C130 and D334
- The boundary strength (bS) decision in HM 2.0 is modified to pay more attention to various coding conditions of intra coded blocks.
 - bS for intra block: 3 or 4 (HM 2.0) → “0,1,2,3,4” (this proposal)
 - bS decision depends on relative direction of intraPred & deblocking boundary
- tc setting for intra is modified according to the change above.
 - From LUT with QP+4 (HM2.0) → from modified LUT with QP (this proposal)
- **LoCo**: IO(-1.1%) LD(-1.0%) RA(-0.9%); **HE**: IO(-1.2%) LD(-1.4%) RA(-1.0%)
 - Even small change of assigning different bS for intra-coded blocks have generated positive coding gain
 - *This proposal can be combined easily with other deblocking proposals*
- No encoding or decoding time increase
- Greatly appreciate cross-verification by
 - Proposed method (v2) by Institute for Infocomm Research (JCTVC-E467)
 - Proposed method (v1) by Microsoft (JCTVC-E151)

Remark

- Due to mistake in source code, E417 reports two results
 - E417_rev 1 : version 1
 - E417_rev 2 : version 2 is additionally reported
- Change in rev 2
 - chroma deblocking is changed
 - bS value is differently defined for inter and intra
 - ➔ Performance in chroma is improved
- V2 LoCo: IO(-1.1%) LD(-1.0%) RA(-0.9%); HE: IO(-1.2%) LD(-1.4%) RA(-1.0%)
- V1 LoCo: IO(-1.1%) LD(-0.6%) RA(-0.5%); HE: IO(-1.2%) LD(-1.3%) RA(-0.9%)

bS decision (1)

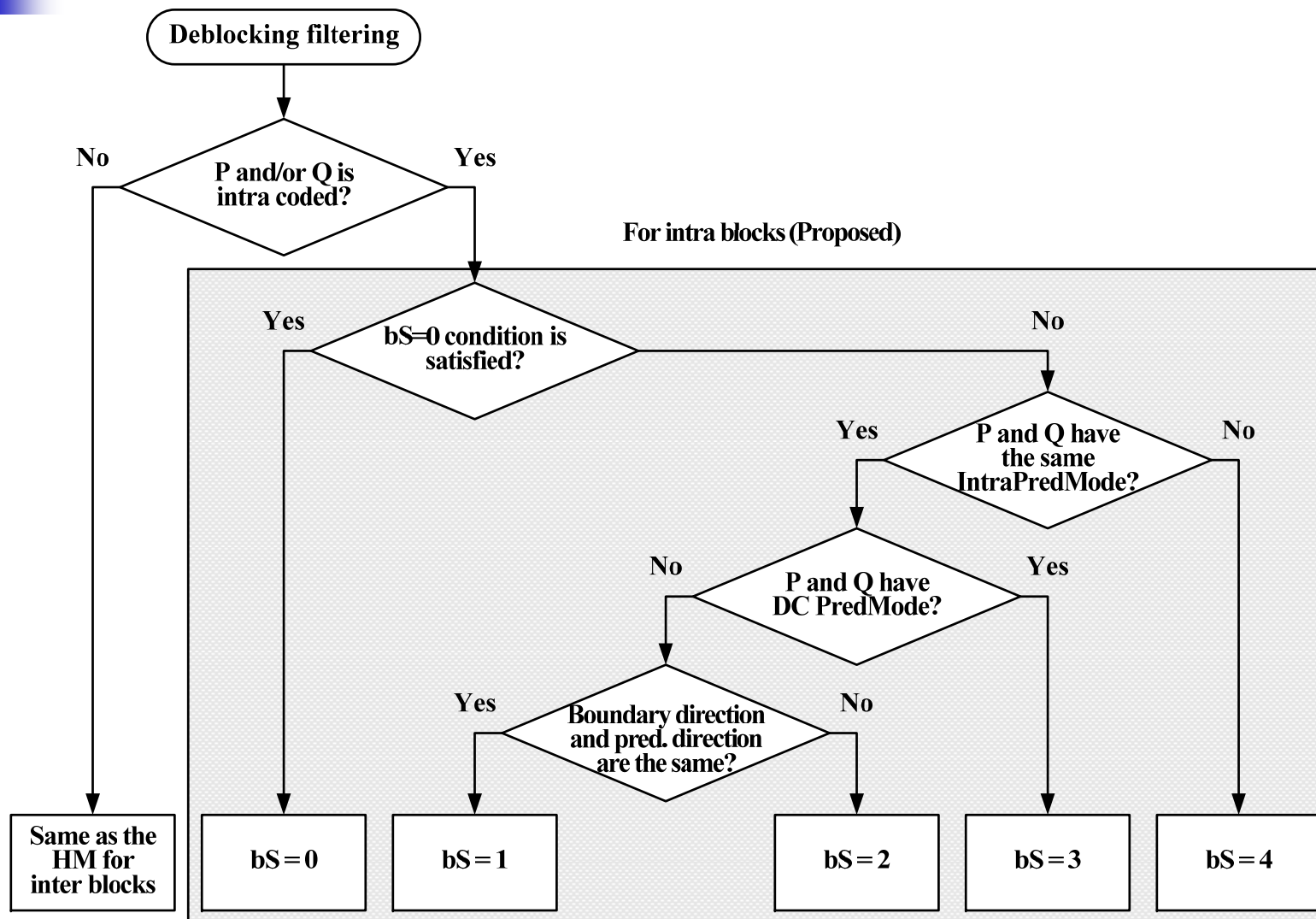
- For intra coded block, bS and tc of **HM2.0**

P and/or Q are intra coded	bS = 3 or 4
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- For intra coded block, bS and tc **of the proposed method**

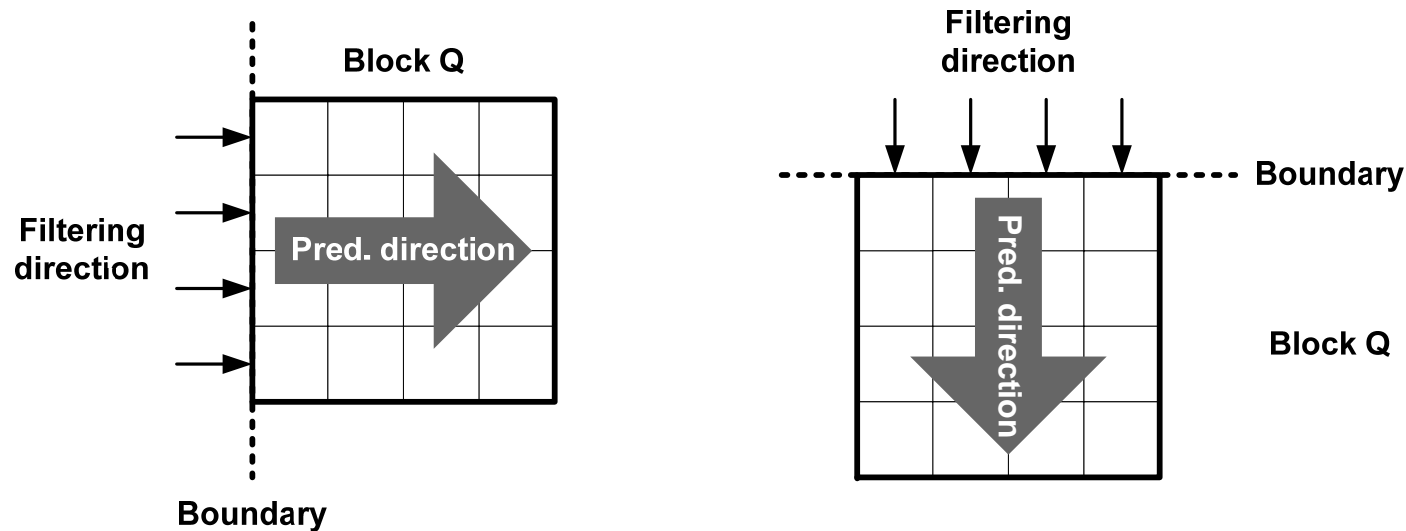
Q is intra coded, <i>and</i> Q is predicted in the same direction as the deblocking filtering, <i>and</i> Q has no coded residual coefficient.	bS = 0
P and Q are intra coded, <i>and</i> P and Q have the same intra prediction direction, <i>and</i> boundary direction & prediction direction are the same.	bS = 1
P and Q are intra coded, <i>and</i> P and Q have the same intra prediction direction, <i>and</i> boundary direction & prediction direction are different.	bS = 2
P and Q are intra coded, <i>and</i> P and Q have DC intra prediction modes.	bS = 3
Otherwise	bS = 4

bS decision (2)



Decision: $bs = 0$

- Q is intra coded and Q is predicted in the same direction as the deblocking filtering → *No blocking artifact caused by intra prediction*

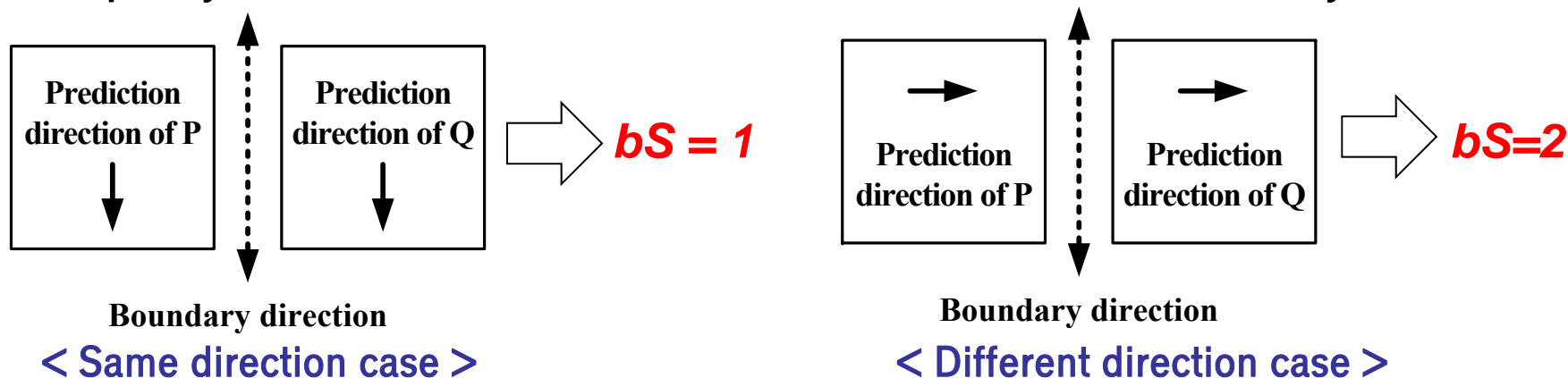


- Additionally Q has no coded residual coefficient → *No blocking artifact caused by intra prediction*

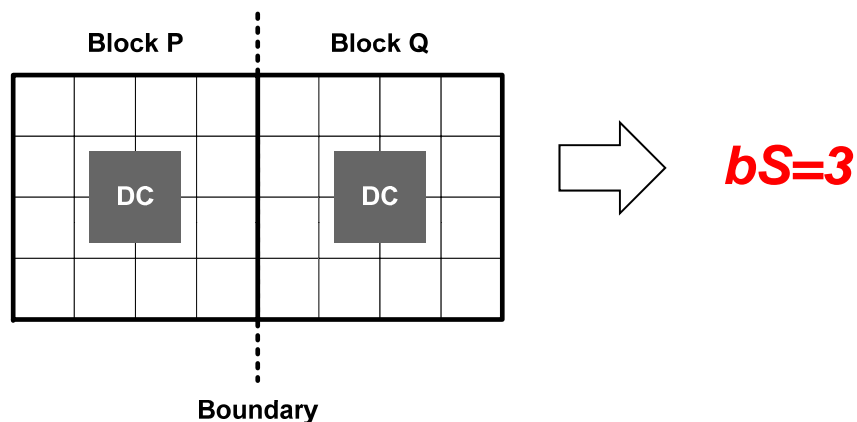
⇒ *No filtering ($bs=0$)*

Decision: $bs = 1 \sim 4$

- Equality check of direction of intraPredMode and block boundary



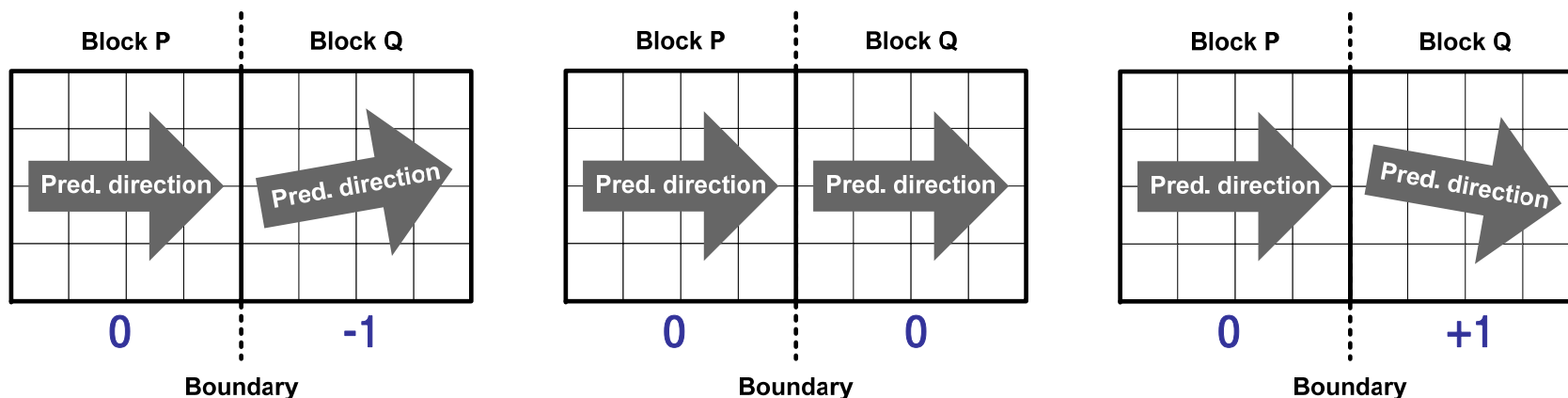
- When P and Q are of both DC intra Prediction Mode



- Otherwise, $bs = 4$

Check direction

- Equality check of IntraPredModes of P and Q



If ($| \text{IntraPredAngleID of } P - \text{IntraPredAngleID of } Q | < 2$) same direction;
else different direction

tc value

- tc value depends on QP and bS
 - For intra: tc value from modified LUT below
 - For inter: tc value from LUT in HM2.0 indexed by QP (**no change from HM2.0)

Index	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
bS=1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
bS=2	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
bS=3	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2
bS=4	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2

Index	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
bS=1	1	1	2	2	2	2	3	3	3	4	4	4	5	6	6	7	8	9	10	11	13
bS=2	2	2	2	2	3	3	3	4	4	5	5	6	7	8	8	10	11	12	13	15	17
bS=3	3	3	3	4	4	4	5	6	6	7	8	9	10	11	13	14	16	18	20	23	25
bS=4	3	3	3	4	4	4	5	6	6	7	8	9	10	11	13	14	16	18	20	23	25

※ Proposed method (v1) uses the same tc for intra and inter from the modified LUT, indexed by QP.

Appendix: t_c & β in HM 2.0

- T_c and β value are all zero, when the index is smaller than 10
- β value indexed by QP
- t_c value indexed by QP / QP+4
 - For inter ($bS \leq 2$) \rightarrow index = QP
 - For intra ($bS > 2$) \rightarrow index = QP + 4

Index	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
t_c	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2
β	0	0	0	0	0	0	6	7	8	9	10	11	12	13	14	15	16	17
Index	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
t_c	2	2	2	3	3	3	3	4	4	4	5	5	6	6	7	8	9	9
β	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
Index	46	47	48	49	50	51	52	53	54	55								
t_c	10	10	11	11	12	12	13	13	14	14								
β	54	56	58	60	62	64												

Filtering decision – Luma

- First luma pixels (p0 and q0) from the boundary are always filtered when the filtering decision conditions are satisfied
 - Exactly same as the HM 2.0 design

$(bS > 0) \ \& \ (d < \beta)$ where

$$d = |p_{2,2} - 2 * p_{1,2} + p_{0,2}| + |q_{2,2} - 2 * q_{1,2} + q_{0,2}| + |p_{2,5} - 2 * p_{1,5} + p_{0,5}| + |q_{2,5} - 2 * q_{1,5} + q_{0,5}|$$

- Second luma pixels (p1 and q1) from the boundary are filtered respectively when the additional conditions are satisfied

Filter p1 if $d_p < \beta_p$ where $d_p = |p_{2,2} - 2 * p_{1,2} + p_{0,2}| + |p_{2,5} - 2 * p_{1,5} + p_{0,5}|$

Filter q1 if $d_q < \beta_q$ where $d_q = |q_{2,2} - 2 * q_{1,2} + q_{0,2}| + |q_{2,5} - 2 * q_{1,5} + q_{0,5}|$

- Note that this filtering decision is block-based.



Filtering decision – Chroma

- In HM2.0, the first chroma pixels (p0 and q0) from the boundary are filtered only for $bS > 2$ (i.e., P or Q is intra coded block)
 - No chroma filtering for inter coded block
 - In this proposal, the chroma pixels (p0 and q0) are filtered only for intra coded block (with $bS = 1, 2, 3, 4$)
 - No chroma filtering for inter coded block
- ➔ No change from HM 2.0
- ※ In the proposed method v1, chroma pixels (p0 and q0) were filtered also for inter-coded block (with $bS=1, 2$)
- It turned out “chroma sometimes suffer from deblocking filtering in inter case!”

Filtering

- Strong filter : same as the HM 2.0 design
- (modified) Weak filter
 - The first pixels from the boundary (p_0 and q_0) are modified by the same filter of H.264/AVC deblocking filter
 - To reduce complexity, however, the pixels at the second position from the boundary (p_1 and q_1) are modified by using $\Delta/2$ value

$$\Delta = \text{Clip3}(-t_c, t_c, ((q_0 - p_0) \ll 2) + (q_1 - p_1) + 4) \gg 3$$

$$p_0' = \text{Clip0-255}(p_0 + \Delta)$$

$$q_0' = \text{Clip0-255}(q_0 - \Delta)$$

$$p_1' = \text{Clip0-255}(p_1 + \Delta/2) \text{ when } d_p < \beta_p$$

$$q_1' = \text{Clip0-255}(q_1 - \Delta/2) \text{ when } d_q < \beta_q$$

Simulation Results

- Different tc value for intra (bS=1, 2) and inter (bS=1, 2)
- No chroma filtering for inter (bS=1, 2)

		High Efficiency			Low Complexity		
		Y	U	V	Y	U	V
Intra Only	BD-rate	-1.2	-0.6	-0.6	-1.1	-0.5	-0.4
	Enc Time[%]	99%			100%		
	Dec Time[%]	101%			101%		
Random Access	BD-rate	-1.0	-0.6	-0.6	-0.9	-0.7	-0.6
	Enc Time[%]	105%			110%		
	Dec Time[%]	100%			101%		
Low Delay	BD-rate	-1.4	-0.4	-0.3	-1.0	-0.3	-0.1
	Enc Time[%]	103%			106%		
	Dec Time[%]	99%			99%		

Visual Comparison

BQMall_IOLC_QP37 – 146th frame



Anchor



Proposed

Visual Comparison

BQMall_IOLC_QP37 – 11st frame



Anchor



Proposed

Visual Comparison

BQMall_IOLC_QP37 – 308th frame



Anchor



Proposed

Visual Comparison

PartyScene_IOLC_QP37 – 4th frame



Anchor



Proposed

❖ Simulation Results (v1)

- Same tc value for intra (bS=1, 2) and inter (bS=1, 2)
- Chroma filtering for inter (bS=1, 2)

	Intra			Intra LoCo		
	Y	U	V	Y	U	V
Class A	-1.6	-0.4	-0.5	-1.5	-0.5	-0.5
Class B	-1.2	-0.6	-0.5	-1.1	-0.5	-0.4
Class C	-0.9	-0.7	-0.6	-0.9	-0.6	-0.5
Class D	-0.8	-0.6	-0.7	-0.8	-0.5	-0.5
Class E	-1.3	0.0	-0.1	-1.0	0.2	0.1
All	-1.2	-0.5	-0.5	-1.1	-0.4	-0.4
Enc [%]	101%			100%		
Dec [%]	100%			101%		

	Random access			Random access LoCo		
	Y	U	V	Y	U	V
Class A	-1.1	2.6	2.8	-0.6	5.3	5.7
Class B	-1.0	1.3	1.1	-0.6	1.3	1.3
Class C	-0.7	0.9	0.7	-0.5	1.2	0.8
Class D	-0.6	1.1	1.1	-0.4	1.4	1.5
Class E						
All	-0.9	1.5	1.4	-0.5	2.2	2.2
Enc [%]	106%			101%		
Dec [%]	100%			101%		

	Low delay			Low delay LoCo		
	Y	U	V	Y	U	V
Class A						
Class B	-1.2	1.2	0.9	-0.5	1.6	2.3
Class C	-0.8	1.6	1.9	-0.2	2.7	2.1
Class D	-0.8	2.6	3.2	-0.2	3.9	4.6
Class E	-2.7	-3.4	-2.7	-1.9	-6.4	-3.7
All	-1.3	0.8	1.0	-0.6	0.9	1.7
Enc [%]	103%			100%		
Dec [%]	98%			101%		

Conclusion Remarks

- This contribution proposed a deblocking filter modified from HM2.0 with more attention to intra coded blocks.
- According to the test condition agreed by CE12, it is reported that the proposed filter has BDBR gain of 1.2% (HE_IO) and 1.1% (LC_IO) with approximately the same encoding and decoding time compared to HM 2.0.
 - The subjective quality of the proposed method is also reported to be similar to that of the HM2.0 anchor.
- Main contribution of this proposal is to show BDBR gains by having finer assignment of bS values for intra blocks.
 - This simple extension of bS decision for intra blocks is relatively orthogonal to subsequent filters. Therefore, **the proposed method is easy to combine with other deblocking filtering methods.**
- *It is recommended to employ this simple mechanism in coming HM design.*



Report on Combination



Combination tests

- Combination 1:
 - Luma filtering (Ericsson, E276) + Chroma filtering (MediaTek, E079)

- Combination 2:
 - BS decision (v1) (SKKU/SKT, E417) + Luma filtering (Ericsson, E276)
 - ※ Due to faulty code (v1), less meaningful

- Combination 3:
 - BS decision (v2) (SKKU/SKT, E417) + Luma filtering (Ericsson, E276) + Chroma filtering (MediaTek, E079)

Combination 3

- BS decision (v2) (SKKU/SKT, E417) + Luma filtering (Ericsson, E276) + Chroma filtering (MediaTek, E079) ~ Cross-verified by KAIST & ETRI (JCTVC-E500)

	Intra			Intra LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-1.6	-1.2	-1.4	-1.5	-2.3	-2.2
Class B	-1.1	-1.8	-2.1	-1.0	-2.9	-2.9
Class C	-0.9	-2.5	-2.5	-0.9	-3.4	-3.8
Class D	-0.8	-2.3	-2.6	-0.8	-3.7	-3.9
Class E	-1.3	-0.2	-0.4	-1.0	-2.1	-2.8
All	-1.1	-1.7	-1.9	-1.1	-2.9	-3.1
Enc Time[%]	100%			100%		
Dec Time[%]	101%			102%		

Combination 3

	Low delay			Low delay LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-1.5	-2.5	-2.7	-1.2	-2.4	-1.3
Class C	-1.1	-2.4	-2.5	-0.9	-2.3	-2.7
Class D	-1.0	-2.2	-2.2	-0.7	-2.0	-1.7
Class E	-3.3	-3.5	-3.9	-2.6	-6.4	-5.4
All	-1.6	-2.6	-2.8	-1.3	-3.0	-2.5
Enc Time[%]	99%			105%		
Dec Time[%]	99%			101%		

Combination 3

	Random access			Random access LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-1.4	-1.8	-1.8	-1.2	-2.2	-2.0
Class B	-1.2	-2.5	-2.5	-1.1	-2.6	-2.2
Class C	-1.0	-3.3	-3.1	-0.9	-3.3	-3.5
Class D	-0.7	-2.9	-3.2	-0.6	-2.9	-3.0
Class E						
All	-1.1	-2.6	-2.7	-1.0	-2.7	-2.6
Enc Time[%]	104%			100%		
Dec Time[%]	100%			101%		

Comparison

Technology		Comb1 (E+M)			Comb3 (E+M+Sv2)			Comb2 (E+Sv1)			E079 MTK (luma&chroma)			E079 MTK (chroma)			E417 SKT /SKKU (v2)			E276 Ericsson		
Test case		IO	LD	RA	IO	LD	RA	IO	LD	RA	IO	LD	RA	IO	LD	RA	IO	LD	RA	IO	LD	RA
Y	LoCo	-0.9	-1.3	-1.0	-1.1	-1.3	-1.0	-1.1	-0.8	-0.6	-1.5	-1.2	-1.1	0.0	0.0	0.0	-1.1	-1.0	-0.9	-0.9	-1.2	-0.9
	HE	-0.7	-1.5	-0.9	-1.1	-1.6	-1.1	-1.1	-1.4	-0.9	-1.3	-0.9	-0.9	0.0	-0.1	0.0	-1.2	-1.4	-1.0	-0.7	-1.5	-0.9
Cb	LoCo	-2.9	-3.1	-2.6	-2.9	-3.0	-2.7	0.6	-1.4	-0.6	-3.0	-1.8	-1.8	-2.9	-1.1	-2.2	-0.5	-0.3	-0.7	0.0	-1.0	0.2
	HE	-1.5	-2.7	-2.5	-1.7	-2.6	-2.6	-0.3	-1.3	-0.6	-1.4	-0.7	-1.8	-1.5	-0.6	-1.8	-0.6	-0.4	-0.6	0.0	-1.4	-0.2
Cr	LoCo	-3.2	-2.7	-2.5	-3.1	-2.5	-2.6	0.6	-0.4	-0.4	-3.4	-1.9	-1.9	-3.2	-1.0	-2.2	-0.4	-0.1	-0.6	0.0	-0.7	0.2
	HE	-1.8	-2.9	-2.5	-1.9	-2.8	-2.7	-0.2	-0.7	-0.5	-1.6	-0.9	-0.7	-1.8	-0.8	-2.0	-0.6	-0.3	-0.6	0.0	-1.4	-0.2
Decode T(%)	LoCo				102	101	101	100	98	98	100	100	101	100	99	100	101	99	101	100	101	101
	HE				101	99	100	100	100	99	99	99	100	99	100	100	101	99	100	100	98	100

- Comb 1: Luma filtering (Ericsson, E276) + Chroma filtering (MediaTek, E079)
- Comb 2: BS decision (v1) (SKKU/SKT, E417) + Luma filtering (Ericsson, E276) ※ Due to faulty code (v1), less meaningful
- Comb 3: BS decision (v2) (SKKU/SKT, E417) + Luma filtering (Ericsson, E276) + Chroma filtering (MediaTek, E079)