



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*
- 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)

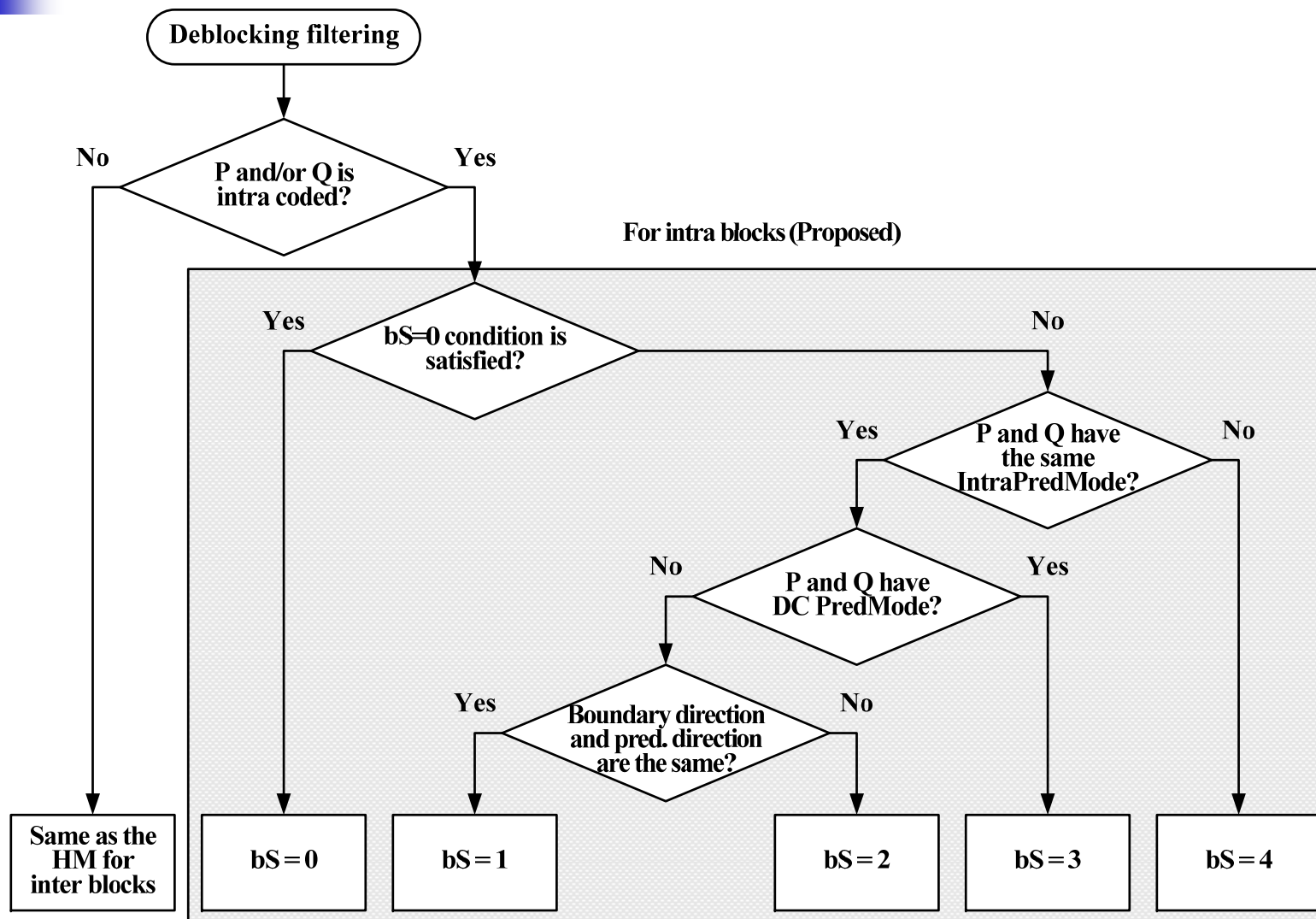
- For intra coded block, bS and tc of **HM2.0**

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**

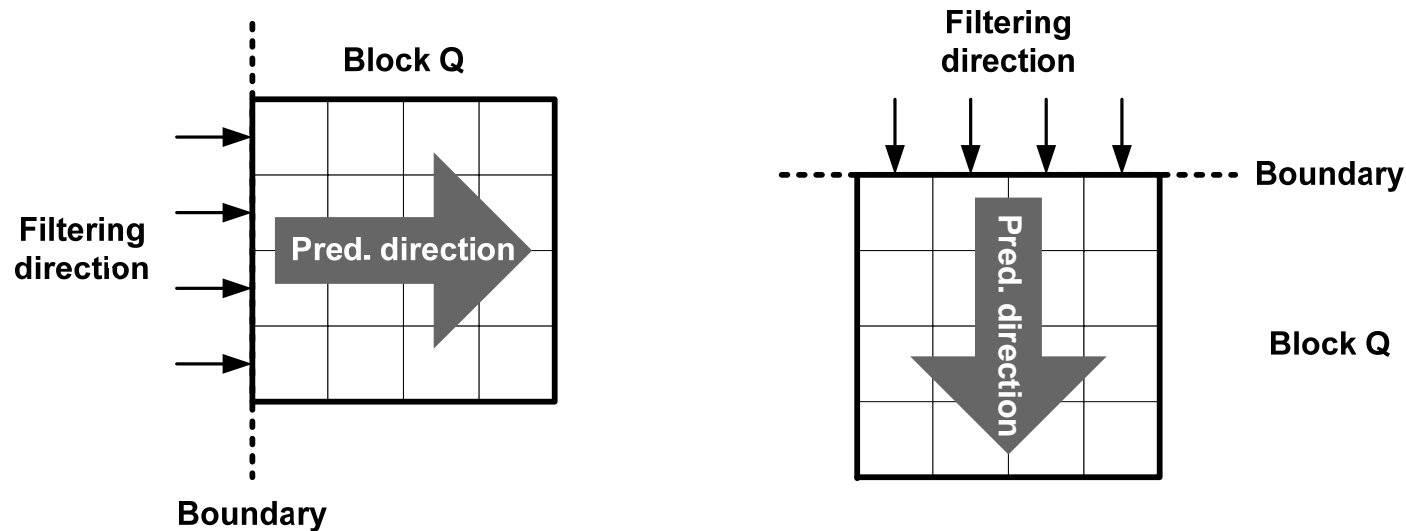
Q is intra coded, <i>and</i> Q is predicted in the same direction as the deblocking filtering, <i>and</i> Q has no coded residual coefficient.	bS = 0
P and Q are intra coded, <i>and</i> P and Q have the same intra prediction direction, <i>and</i> boundary direction & prediction direction are the same.	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*

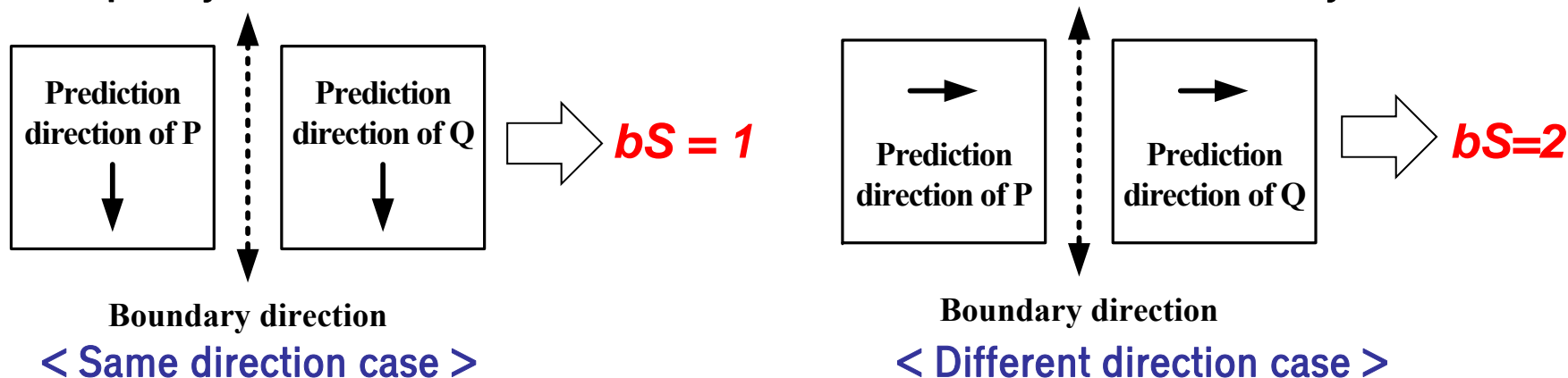


- Additionally Q has no coded residual coefficient → *No blocking artifact caused by intra prediction*

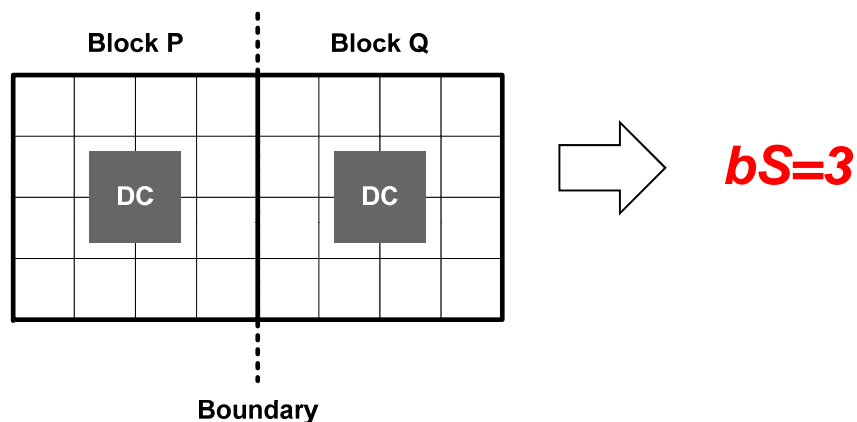
⇒ *No filtering ($bs=0$)*

Decision: $bs = 1 \sim 4$

- Equality check of direction of intraPredMode and block boundary



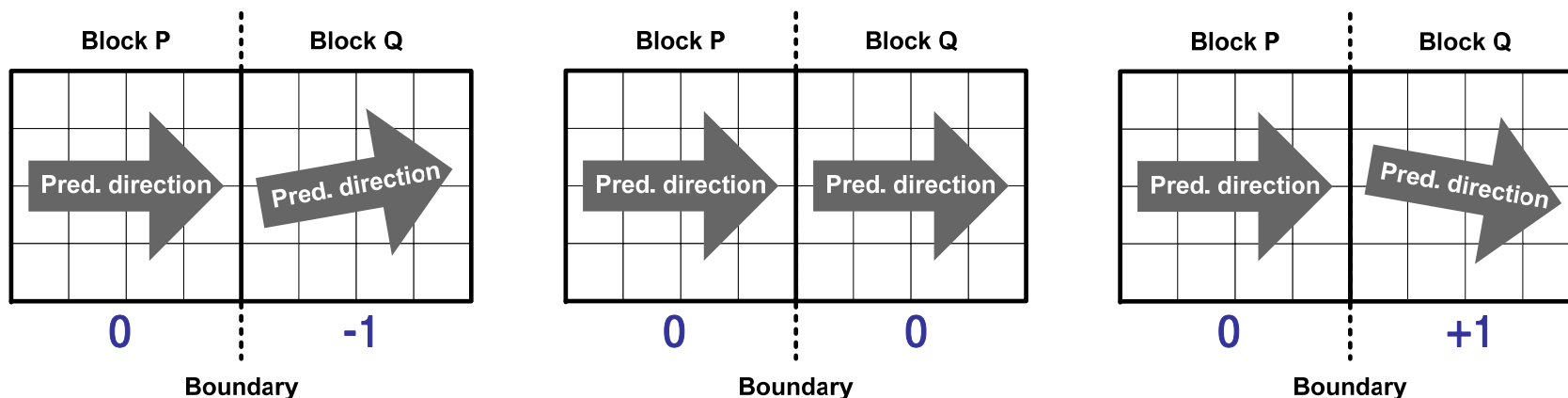
- When P and Q are of both DC intra Prediction Mode



- Otherwise, $bs = 4$

Check direction

- Equality check of IntraPredModes of P and Q



If ($|IntraPredAngleID \text{ of } P - IntraPredAngleID \text{ of } Q| < 2$) 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[%]						
Random Access	BD-rate	-1.0	-0.6	-0.6	-0.9	-0.7	-0.6
	Enc Time[%]	105%			110%		
	Dec Time[%]						
Low Delay	BD-rate	-1.4	-0.4	-0.3	-1.0	-0.3	-0.1
	Enc Time[%]	103%			106%		
	Dec Time[%]						

❖ 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.*