



JVET-AE0044

AHG12: Dynamic Scaling of Bilateral Filter (BIF)

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Enhancement of Bilateral Filter (BIF)



BIF is a part of in-loop filtering in ECM-9.0 [JVET-V0094, JVET-X0067].

For [AI/RA](#), the contribution reports BD-rate PSNR impact

[-0.14%/-0.11%](#) (for Luma)

with the average decoding run time

[100.5%/99.8%](#)

Summary of modifications:

1. The TU scale factor depends on the TU shape size.
2. The TU scale factor depends on the mean absolute difference (MAD) of the TU.
3. The BIF LUTs are interpolated.

TU Shape and Mean Absolute Difference (MAD)



In ECM-9.0, 5x5-start filtering shape is used, BIF's offset equals a scaled sum of 12 offsets:

$$\delta_{BIF} = (C_{TU} \cdot [\sum \text{sign}(S_{i,j} - S_{0,0}) \cdot F_{BIF,i,j,QP}(|S_{i,j} - S_{0,0}|)] + 16) \gg 5, \quad (1)$$

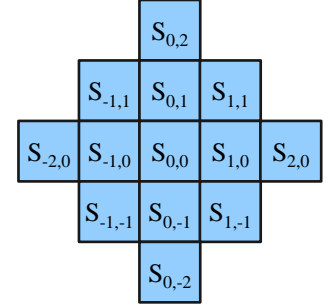
This proposal modifies calculation of C_{TU} and $F_{BIF,i,j,QP}(d)$, and the term is right shifted by 8 (not 5).

For C_{TU} , it is proposed to use a sum of a TU shape-based factor and a MAD-based factor:

$$C_{TU} = C_{w,h}^{TU} + C_{MAD}^{TU},$$

$C_{w,h}^{TU}$ is defined by 2D LUT with width and height as entries.

C_{MAD}^{TU} is defined by 1D LUT with MAD as entry.



$C_{w,h}^{TU}$ depends on $\min(w, h)$

w\h	1	2	4	8	16	32	64	128
1	3	3	3	3	3	3	3	0
2	3	3	3	3	3	3	3	0
4	3	3	3	3	3	3	3	0
8	3	3	3	2	2	2	2	0
16	3	3	3	2	1	1	1	0
32	3	3	3	2	1	1	1	0
64	3	3	3	2	1	1	1	0
128	0	0	0	0	0	0	0	0

This proposal

$C_{w,h}^{TU}$ depends on (w, h)

w\h	1	2	4	8	16	32	64	128
1	12	12	12	11	9	9	5	3
2	12	12	12	11	9	7	5	3
4	12	12	12	10	9	7	5	3
8	11	11	10	8	7	6	5	3
16	9	9	9	7	5	5	5	3
32	9	7	7	6	5	5	4	3
64	5	5	5	5	5	4	4	2
128	3	3	3	3	3	3	2	2

$C_{MAD}^{TU} = 0$

↓ This proposal

MAD _{TU} >> 4	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C_{MAD}^{TU}	0	0	0	1	2	3	4	5	6	6	6	6	7	7	7	7

$$MAD = \frac{1}{hw} \sum_{i=1}^h \sum_{j=1}^w |s_{i,j} - \frac{1}{hw} \sum_{i=1}^h \sum_{j=1}^w s_{i,j}|$$

Bilateral Filtering Function

In ECM-9.0, $F_{\text{BIF},i,j,\text{QP}}(d)$ is defined by 26×16 LUT:

$$F_{\text{BIF},i,j,\text{QP}}(d) = \text{LUT}_{\text{base}}((d + 4) \gg 3) \gg B_{i,j}, \quad (2)$$

where $B_{i,j}$ is 0 or 1 depending on (i, j) .

For $F_{\text{BIF},i,j,\text{QP}}$, it is proposed to precompute three base LUTs for three sample distances:

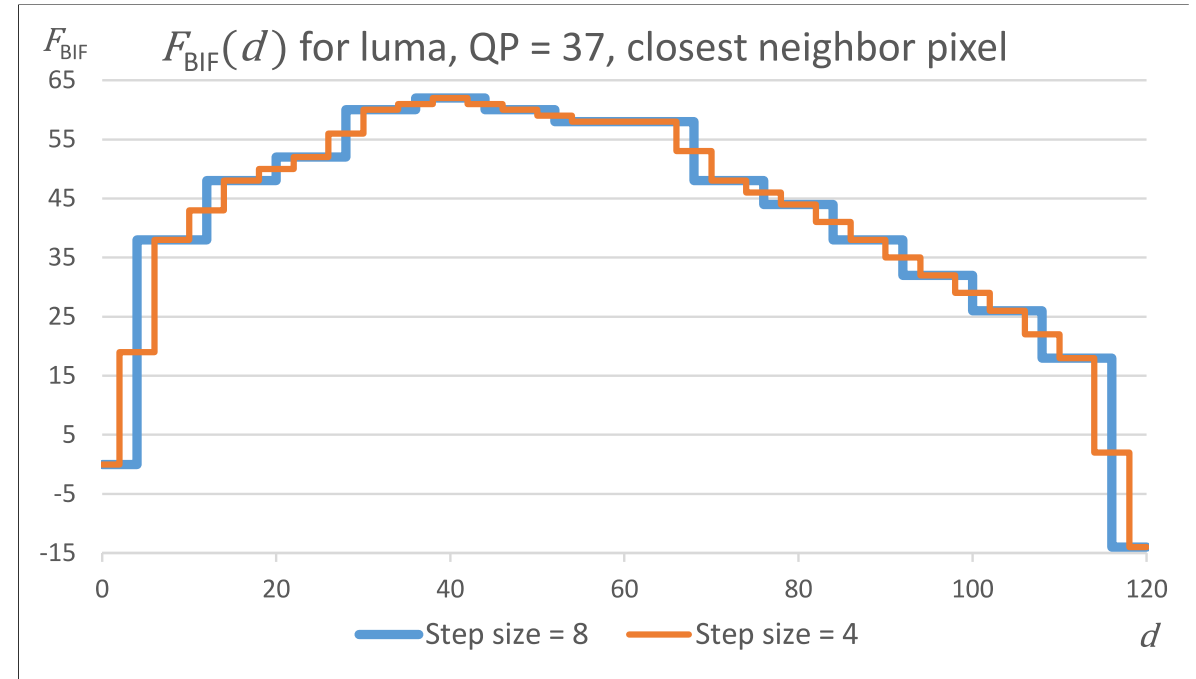
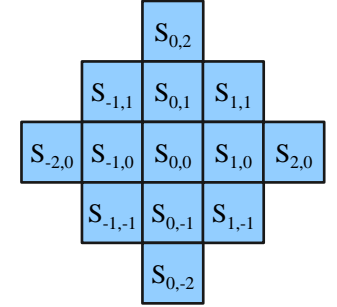
$$\text{LUT}_{i,j,\text{QP}}(k) = (C_{i,j} \cdot \text{LUT}_{\text{base},\text{QP}}(k) + 4) \gg 3, \quad (3)$$

and calculate $F_{\text{BIF},i,j,\text{QP}}(d)$ on the fly using an interpolation:

$$F_{\text{BIF},i,j,\text{QP}}(d) = (v_1 + v_2 + 1) \gg 1, \quad (4)$$

where v_1 and v_2 are successive entries of $\text{LUT}_{i,j,\text{QP}}$.

	Luma	Chroma		Luma	Chroma
LUT entries	16	16	This proposal →	LUT entries	16
LUT step size	8	8		LUT step size	8
F_{BIF} step size	8	8		F_{BIF} step size	4
					2



Results



All Intra Main 10						Low delay B Main 10					
Over ECM-9.0						Over ECM-9.0					
	Y	U	V	EncT	DecT		Y	U	V	EncT	DecT
Class A1	-0.15%	-0.07%	-0.21%	101.4%	101.0%	Class A1					
Class A2	-0.15%	-0.04%	-0.21%	100.8%	100.6%	Class A2					
Class B	-0.09%	-0.20%	-0.17%	101.8%	100.8%	Class B	-0.04%*	0.03%*	0.15%*	?	?
Class C	-0.16%	-0.18%	-0.21%	101.3%	100.0%	Class C	-0.02%	-0.82%	-0.57%	100.5%	100.0%
Class E	-0.15%	-0.23%	0.09%	101.3%	100.1%	Class E	-0.07%	-1.75%	0.16%	99.1%	100.4%
Overall	-0.14%	-0.15%	-0.15%	101.4%	100.5%	Overall	-0.04%*	-0.70%*	-0.09%*	?	?
Class D	-0.07%	-0.18%	-0.20%	101.5%	100.0%	Class D	-0.13%	0.20%	-0.52%	99.1%	98.7%
Class F	-0.14%	-0.21%	-0.25%	100.8%	100.5%	Class F	-0.20%	-0.30%	-0.39%	?	99.4%

*two QP22 results are taken from the anchor

Random Access Main 10					
Over ECM-9.0					
	Y	U	V	EncT	DecT
Class A1	-0.10%	-0.23%	-0.18%	?	100.2%
Class A2	-0.15%	-0.24%	-0.28%	?	99.4%
Class B	-0.12%	-0.16%	-0.09%	100.5%	100.0%
Class C	-0.08%	-0.39%	-0.24%	100.5%	99.8%
Class E					
Overall	-0.11%	-0.25%	-0.19%	?	99.8%
Class D	-0.08%	-0.53%	-0.13%	100.6%	100.1%
Class F	-0.10%	-0.45%	-0.36%	100.5%	99.9%

BIF version	Bit width (maximal)	Summations (per sample)	Multiplications (per sample)	LUT lookups (per sample)	LUTs memory (bytes)
ECM 9.0	12	18	0	6	832
Proposed	15	25	1	12	2816



Thank you!