Non-RCE3: Implicit derivation for adaptively turning filtering off in intra prediction

JCTVC-D0181

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Introduction

- Screen content and non-camera generated videos contain sharp edges
  - Filters used in HEVC intra prediction may be undesirable

- RCE3 A.3 proposes the use of nearest-neighbor interpolation instead of bilinear interpolation of intra reference samples

- Proposal
  - Extend the concept to all other filters used in angular intra prediction modes
    - MDIS, gradient filtering, strong filtering for 32×32 blocks
  - Two implicit derivation methods to turn filtering off for a TU for angular intra prediction modes

Method 1

- Filtering is disabled when
  - The transform skip (or transquant bypass) flag 1 AND
  - [1, -2, 1] FIR filter applied to the reference samples provides a filtered value greater than a threshold (dependent on bit-depth).

M = N = 4 in this figure
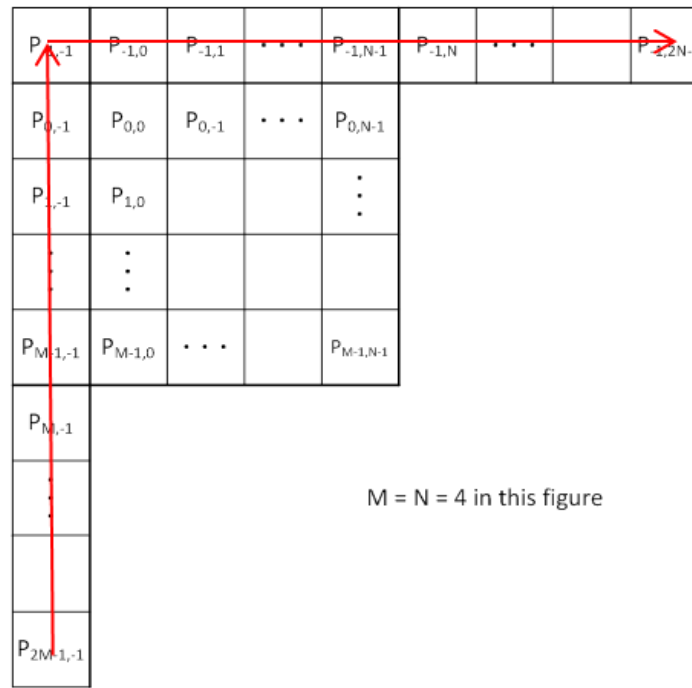
Method 2

- Filtering is disabled when
  - The transform skip flag is 1

- Not applied to lossless coding
  - Since all blocks are coded in transquant bypass mode, the transquant bypass flag is not a good decision criterion.

Results Method 1 (Lossy – All Intra) (4×4 blocks)

	All Intra HE Main-tier			All Intra HE High-tier			All Intra HE Super-High-tier		
	Y	U	V	Y	U	V	Y	U	V
Class F	-0.5%	-0.4%	-0.5%	-0.5%	-0.4%	-0.4%	-0.5%	-0.4%	-0.5%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC RGB 444	-1.4%	-1.0%	-1.1%	-1.5%	-1.1%	-1.1%	-1.5%	-1.1%	-1.1%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-1.0%	-0.4%	-0.4%	-0.9%	-0.4%	-0.5%	-0.9%	-0.4%	-0.5%
Animation YUV 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RangeExt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC(444) GBR Optional	-3.9%	-3.6%	-3.5%	-4.3%	-3.8%	-3.7%	-4.4%	-3.8%	-3.8%
SC(444) YUV Optional	-2.7%	-2.0%	-1.8%	-2.8%	-2.0%	-1.9%	-2.8%	-2.2%	-2.2%
Enc Time[%]	100%			101%			100%		
Dec Time[%]	100%			100%			101%		

Results Method 1 (Lossy – RA and LB) (4×4 blocks)

	Random Access HE Main-tier			Random Access HE High-tier		
	Y	U	V	Y	U	V
Class F	-0.4%	-0.2%	-0.2%	-0.3%	-0.2%	-0.1%
Class B	0.0%	0.1%	-0.1%	0.0%	0.0%	0.0%
SC RGB 444	-1.2%	-0.9%	-1.0%	-1.4%	-1.1%	-1.1%
Animation RGB 444	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
SC YUV 444	-0.9%	-0.4%	-0.4%	-0.8%	-0.4%	-0.3%
Animation YUV 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RangeExt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC(444) GBR Optional	-3.5%	-3.0%	-2.9%	-3.9%	-3.4%	-3.2%
SC(444) YUV Optional	-2.4%	-1.4%	-1.5%	-2.7%	-1.8%	-1.6%
Enc Time[%]	100%			100%		
Dec Time[%]	100%			100%		

	Low delay B HE Main-tier			Low delay B HE High-tier		
	Y	U	V	Y	U	V
Class F	-0.2%	-0.1%	-0.7%	-0.2%	-0.2%	-0.4%
Class B	0.0%	0.0%	0.3%	0.0%	0.0%	0.2%
SC RGB 444	-0.7%	-0.5%	-0.5%	-1.2%	-0.8%	-0.8%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.8%	-0.4%	-0.5%	-0.8%	-0.2%	-0.5%
Animation YUV 444	0.0%	0.1%	0.0%	0.0%	0.0%	-0.1%
RangeExt	0.0%	0.1%	-0.1%	0.0%	0.0%	-0.1%
SC(444) GBR Optional	-4.0%	-3.4%	-3.5%	-4.0%	-3.3%	-3.3%
SC(444) YUV Optional	-3.7%	-2.8%	-3.0%	-3.6%	-2.6%	-2.9%
Enc Time[%]	98%			98%		
Dec Time[%]	101%			101%		

Results Method 1 (Lossless – All Intra) (4×4 blocks)

	AI Main											
	compression ratio (Total)		compression ratio (Average)		compression ratio (min)		compression ratio (max)		Bit-rate saving (Total)	Bit-rate saving (Average)	Bit-rate saving (Min)	Bit-rate saving (Max)
	Ref.	Tested	Ref.	Tested	Ref.	Tested	Ref.	Tested				
Class F	4.57	4.58	5.57	5.58	2.27	2.26	11.14	11.14	0.1%	0.1%	-0.1%	0.4%
Class B	2.24	2.24	2.26	2.26	2.08	2.08	2.44	2.44	0.0%	0.0%	0.0%	0.0%
SC RGB 444	7.88	7.94	9.5	9.66	5.23	5.25	14.73	15.29	0.7%	1.1%	-0.1%	3.6%
Animation RGB 444	2.48	2.48	2.5	2.51	2.15	2.15	3.05	3.05	0.0%	0.0%	0.0%	0.0%
SC YUV 444	11.09	11.12	13.2	13.28	7.87	7.88	19.32	19.59	0.3%	0.4%	-0.1%	1.4%
Animation YUV 444	3.00	3.00	3.2	3.16	2.57	2.57	3.93	3.93	0.0%	0.0%	0.0%	0.0%
RangeExt	1.92	1.92	2.38	2.38	1.46	1.46	4.37	4.37	0.0%	0.0%	-0.1%	0.0%
SC GBR 444 Optional	20.30	21.75	24.82	25.96	9.69	10.72	36.10	37.54	6.7%	5.5%	3.1%	9.6%
SC YUV 444 Optional	31.85	32.98	34.39	35.37	22.30	23.89	51.97	52.83	3.4%	3.3%	1.6%	6.7%
Enc Time[%]	100%											
Dec Time[%]	101%											

Results Method 1 (Lossless – RA and LB) (4×4 blocks)

RA Main								Bit-rate saving (Total)	Bit-rate saving (Average)	Bit-rate saving (Min)	Bit-rate saving (Max)
compression ratio (Total)		compression ratio (Average)		compression ratio (min)		compression ratio (max)					
Ref.	Tested	Ref.	Tested	Ref.	Tested	Ref.	Tested				
8.66	8.66	36.22	36.24	3.01	3.01	90.48	90.61	0.0%	0.0%	-0.2%	0.1%
2.60	2.60	2.60	2.60	2.57	2.57	2.64	2.64	0.0%	0.0%	0.0%	0.0%
53.71	53.83	117.01	118.68	19.48	19.48	225.68	227.40	0.2%	0.8%	0.0%	3.7%
3.58	3.58	3.60	3.60	3.43	3.43	3.70	3.70	0.0%	0.0%	0.0%	0.0%
73.79	73.91	157.08	157.94	24.42	24.42	287.13	291.12	0.2%	0.4%	0.0%	1.4%
3.8	3.84	4.48	4.48	2.75	2.75	5.70	5.70	0.0%	0.0%	0.0%	0.0%
2.1	2.1	2.5	2.5	1.5	1.53	4.41	4.41	0.0%	0.0%	0.0%	0.0%
42.0	45.7	254.1	262.9	11.5	12.52	395.52	408.09	8.1%	5.0%	3.1%	8.5%
101.1	107.4	314.9	320.4	30.5	32.66	531.53	540.07	5.9%	3.3%	1.5%	6.8%
99%											
101%											

LB Main								Bit-rate saving (Total)	Bit-rate saving (Average)	Bit-rate saving (Min)	Bit-rate saving (Max)
compression ratio (Total)		compression ratio (Average)		compression ratio (min)		compression ratio (max)					
Ref.	Tested	Ref.	Tested	Ref.	Tested	Ref.	Tested				
8.9	8.9	57.8	57.8	3.0	3.0	169.5	169.5	0.0%	0.0%	0.0%	0.0%
2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	0.0%	0.0%	0.0%	0.0%
62.2	62.3	355.6	365.0	20.5	20.5	1618.0	1679.6	0.1%	0.7%	0.0%	3.7%
3.6	3.6	3.6	3.6	3.4	3.4	3.7	3.7	0.0%	0.0%	0.0%	0.0%
85.1	85.1	469.0	473.4	25.7	25.6	2105.0	2135.0	0.0%	0.2%	-0.2%	1.4%
4	3.9	4.5	4.5	2.8	2.8	5.8	5.8	0.0%	0.0%	0.0%	0.0%
2.1	2.1	2.5	2.5	1.5	1.5	4.4	4.4	0.0%	0.0%	0.0%	0.0%
45	49.0	1010.8	1039.1	11.6	12.7	2253.7	2320.5	8.1%	4.4%	2.2%	8.3%
117.1	124.9	1139.4	1125.8	31.0	33.2	2208.6	2147.3	6.2%	1.8%	-2.9%	6.6%
98%											
98%											

Results Method 2 (Lossy – All Intra) (4×4 blocks)

	All Intra HE Main-tier			All Intra HE High-tier			All Intra HE Super-High-tier		
	Y	U	V	Y	U	V	Y	U	V
Class F	-0.6%	-0.5%	-0.5%	-0.6%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
SC RGB 444	-1.5%	-1.1%	-1.2%	-1.6%	-1.2%	-1.2%	-1.7%	-1.2%	-1.2%
Animation RGB 444	0.1%	0.0%	0.0%	0.2%	0.0%	0.0%	0.2%	0.0%	0.0%
SC YUV 444	-1.2%	-0.7%	-0.7%	-1.2%	-0.8%	-0.8%	-1.3%	-0.9%	-1.0%
Animation YUV 444	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%
RangeExt	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	-0.1%	0.0%
SC(444) GBR Optional	-4.2%	-3.8%	-3.6%	-4.7%	-4.1%	-3.9%	-5.0%	-4.2%	-4.1%
SC(444) YUV Optional	-3.7%	-3.0%	-2.8%	-4.1%	-3.6%	-3.3%	-4.4%	-4.1%	-3.9%
Enc Time[%]	99%			99%			98%		
Dec Time[%]	99%			99%			99%		

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Results Method 1 (Lossy – RA and LB) (4×4 blocks)

	Random Access HE Main-tier			Random Access HE High-tier		
	Y	U	V	Y	U	V
Class F	-0.3%	-0.2%	-0.1%	-0.3%	-0.2%	-0.1%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
SC RGB 444	-1.2%	-0.9%	-1.0%	-1.5%	-1.1%	-1.1%
Animation RGB 444	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%
SC YUV 444	-0.9%	-0.6%	-0.6%	-1.1%	-0.7%	-0.7%
Animation YUV 444	0.0%	-0.1%	0.0%	0.0%	-0.1%	0.0%
RangeExt	0.0%	-0.1%	-0.1%	0.0%	0.0%	-0.1%
SC(444) GBR Optional	-3.5%	-3.0%	-2.9%	-4.2%	-3.5%	-3.3%
SC(444) YUV Optional	-3.4%	-2.5%	-2.5%	-3.8%	-3.0%	-2.8%
Enc Time[%]	96%			96%		
Dec Time[%]	101%			101%		
	Low delay B HE Main-tier			Low delay B HE High-tier		
	Y	U	V	Y	U	V
Class F	-0.2%	0.1%	0.0%	-0.1%	0.0%	0.0%
Class B	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
SC RGB 444	-1.0%	-0.7%	-0.8%	-1.2%	-0.8%	-0.9%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.9%	-0.5%	-0.7%	-0.7%	-0.3%	-0.3%
Animation YUV 444	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
RangeExt	0.1%	0.0%	-0.1%	0.0%	0.0%	0.0%
SC(444) GBR Optional	-3.8%	-3.2%	-3.3%	-4.0%	-3.1%	-3.3%
SC(444) YUV Optional	-3.0%	-2.0%	-2.3%	-3.3%	-2.3%	-2.6%
Enc Time[%]	100%			100%		
Dec Time[%]	100%			100%		

Conclusions

- Implicit derivation methods to switch off filters are proposed.
  - All filtering (MDIS, Interpolation of reference samples, gradient filtering, strong filtering for 32 × 32 blocks) is disabled based on a decision criterion.

- Method 1: Filtering is disabled based on transform skip (or transquant bypass) flag and intra reference samples
  - Decision complexity comparable to performing MDIS

- Method 2: Filtering is disabled based on transform skip flag
  - Simple decision criterion
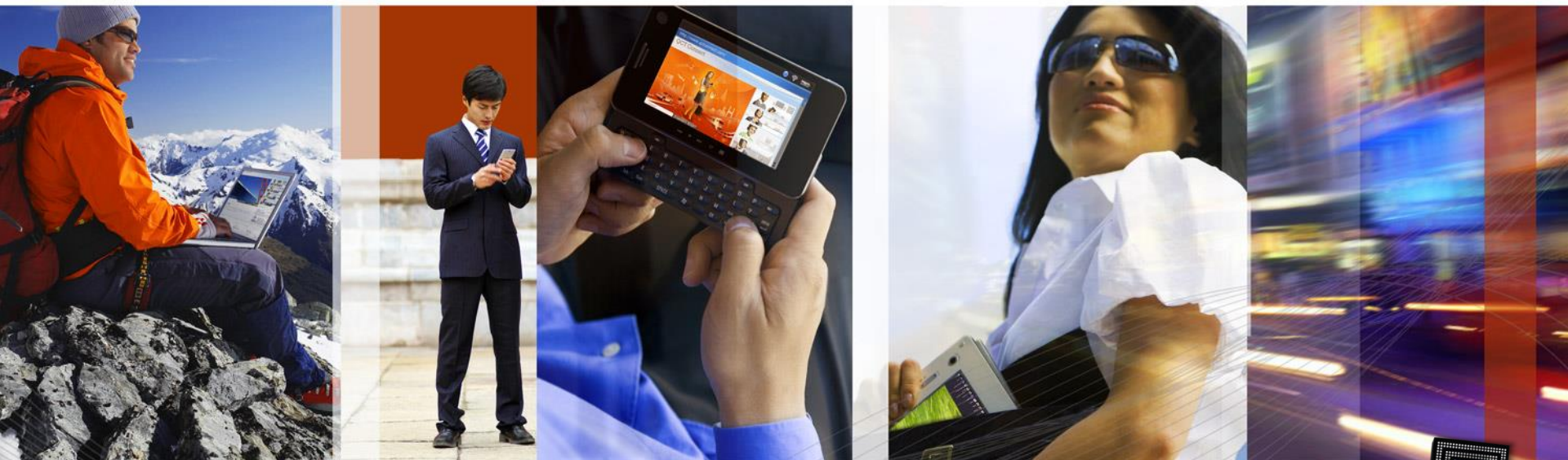
Non-RCE3: Implicit derivation for adaptively turning filtering off in intra prediction

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RCE3 A.3 results

- Implicit derivation (4×4 blocks)

		AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
	Class F	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	0.0%	-0.1%
	Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
A.3.4 (Samsung)	SC RGB 444	-0.6%	-0.6%	-0.6%	-0.7%	-0.8%	-0.1%	-0.4%
NN Interpolation	Animation RGB 444	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Lossy	SC YUV 444	-0.5%	-0.5%	-0.4%	-0.3%	-0.3%	-0.4%	-0.3%
Threshold Based	Animation YUV 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Only 4x4	RangeExt	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%
	SC(444) GBR Optional	-4.5%	-4.3%	-4.3%	-4.2%	-4.3%	-3.9%	-4.4%
	SC(444) YUV Optional	-2.3%	-2.2%	-2.0%	-2.5%	-2.5%	-3.5%	-2.9%
	Enc Time[%]	101%	101%	101%	101%	101%	101%	101%
	Dec Time[%]	102%	102%	102%	101%	102%	101%	101%

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RCE3 A.3 results

- Explicit (4×4 blocks)

		AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
	Class F	-0.9%	-0.9%	-0.8%	-0.6%	-0.7%	-0.4%	-0.4%
	Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
A.3.3 (Samsung)	SC RGB 444	-2.0%	-2.0%	-2.1%	-2.0%	-2.0%	-1.2%	-1.6%
NN Interpolation	Animation RGB 444	-0.1%	-0.1%	-0.2%	0.0%	-0.1%	0.0%	0.0%
Lossy	SC YUV 444	-1.6%	-1.7%	-1.8%	-1.4%	-1.6%	-0.9%	-0.9%
RD Based	Animation YUV 444	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.1%	0.0%
Only 4x4	RangeExt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SC(444) GBR Optional	-8.2%	-8.8%	-9.1%	-6.9%	-7.5%	-7.0%	-7.2%
	SC(444) YUV Optional	-7.3%	-8.0%	-8.5%	-6.3%	-7.1%	-6.8%	-7.2%
	Enc Time[%]	108%	109%	109%	100%	100%	100%	100%
	Dec Time[%]	100%	100%	100%	98%	99%	99%	100%