

MEDIATEK

JCTVC-U0065: CE2-related: Intra block copy searching constraints for reducing worst case bandwidth

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Overview Summary

- Proposed two IntraBC encoder searching constraints to reduce the worst case bandwidth in SCC in mono-color
- An current picture is divided into 8x8 blocks
- Method-1:
 - Restrict to access the 8x8 block that in 8x8 bi-pred, 4x8/8x4 uni-pred, or 16x16 AMP bi-predblocks
 - Allow to access the 8x8 block that is IntraBC coded block, within current or left CTU, or the use_integer_mv_flag is 1
- Method-2:
 - Method-1 + allow to access the 8x8 block that one of the MV is integer MV

Lossy YUV, TGM and mixed content	AI	RA	LB
Method-1	0.0%	0.5-0.6%	0.7-1.0%
Method-2	0.0%	0.3-0.4%	0.2-0.6%

Problem Definition

- In IntraBC, the unfiltered reconstructed pixels (before deblocking) of the current picture are used to predict the current PU
- In full-frame IntraBC configuration, the unfiltered reconstructed pixels need to be outputted to DRAM which increases the worst case memory bandwidth in SCC
- The bandwidth per pixel is calculated by

$$P = \frac{\left\lceil \frac{m-1+M+L-1}{m} \right\rceil \cdot \left\lceil \frac{n-1+N+L-1}{n} \right\rceil \cdot m \cdot n}{M \cdot N}$$

Bandwidth Analysis of HEVC Motion Compensation

- 8x8 bi-pred block and 4x8 uni-pred block are the bandwidth bottleneck in HEVC Luma MC

Memory configuration	8x8 bi-pred.	8x4 uni-pred.	4x8 uni-pred.	16x16 bi-pred.	16x4 bi-pred. + 16x12 bi-pred.	4x16 bi-pred. + 12x16 bi-pred.
4x1	9.375	6.875	7.5	5.03125	6.5625	7.1875
4x2	10	7.5	8	5.25	7	7.5
8x1	11.25	8.25	11.25	5.75	7.5	10.0625
8x2	12	9	12	6	8	10.5
16x1	15	11	15	8.625	11.25	14.375

Bandwidth Analysis with Write Data

Bandwidth

- $P = 1$ for outputting filtered and unfiltered pixels
- 8x8 bi-pred block, 4x8 uni-pred block, and 4x16+12x16 bi-pred block are the bandwidth bottleneck in mono-color SCC

Memory configuration	With outputting filtered pixels (bandwidth in HEVC)			With outputting filtered and unfiltered pixels (bandwidth in HEVC-SCC)		
	8x8 bi-pred.	4x8 uni-pred.	4x16 bi-pred. + 12x16 bi-pred.	8x8 bi-pred.	4x8 uni-pred.	4x16 bi-pred. + 12x16 bi-pred.
4x1	10.375	8.5	9.1875	11.375	9.5	10.1875
4x2	11	9	8.5	12	10	9.5
8x1	12.25	12.25	11.0625	13.25	13.25	12.0625
8x2	13	13	11.5	14	14	12.5
16x1	16	16	15.375	17	17	16.375

Proposed IntraBC Encoder Searching Constraints

- An current picture is divided into 8x8 blocks
- Method-1:
 - Restrict to access the 8x8 block that in 8x8 bi-pred, 4x8/8x4 uni-pred, or 16x16 AMP bi-predblocks
 - 16x16 AMP bi-pred block:
4x16 bi-pred block + 12x16 bi-pred block, or
16x4 bi-pred block + 16x12 bi-pred block
 - Allow to access the 8x8 block that is IntraBC coded block, within current or left CTU, or the use_integer_mv_flag is 1
- Method-2:
 - Method-1 + allow to access 8x8 block that one of the MV is integer MV

Lossy Coding Result – Method 1

- Anchor: SCM-4.0, Full-frame IBC
- Test: Proposed Method-1

	All Intra			Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.6%	0.6%	0.6%	0.8%	0.8%	0.8%
RGB, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.6%	0.6%	0.6%	1.0%	1.0%	0.9%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.1%
YUV, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.5%	0.5%	0.5%	0.7%	0.6%	0.6%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.6%	0.6%	0.5%	1.0%	1.0%	1.0%
YUV, Animation, 720p	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	-0.1%	0.0%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%

Thanks Qualcomm for cross-checking

Lossy Coding Result – Method 2

- Anchor: SCM-4.0, Full-frame IBC
- Test: Proposed Method-2

	All Intra			Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%
RGB, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.3%	0.4%	0.4%	0.5%	0.6%	0.5%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	-0.1%	0.0%	0.1%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.3%	0.2%	0.3%	0.2%	0.1%	0.2%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.4%	0.4%	0.4%	0.6%	0.7%	0.8%
YUV, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.1%	0.1%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%

Subjective Quality

- The proposed methods are encoder constraints
- The unfiltered reconstructed pixels of the 8x8 blocks that won't be referenced don't need to be outputted. The worst case bandwidth is reduced
- The filtered reconstructed pixels are always outputted
 - No subjective quality loss

Subjective Quality Comparison

- In CE2 Test-2 and Test-3, the DB and SAO might be disabled for some CTUs which will result in subjective visual artifact



CE2 Test-3



Proposed Method-2

WebBrowsing, Frame 1

Subjective Quality Comparison

- In CE2 Test-2 and Test-3, the DB and SAO might be disabled for some CTUs which will result in subjective visual artifact



CE2 Test-3

WebBrowsing, Frame 1

Subjective Quality Comparison

- In CE2 Test-2 and Test-3, the DB and SAO might be disabled for some CTUs which will result in subjective visual artifact



Proposed Method-2

WebBrowsing, Frame 1

Subjective Quality Comparison

- In CE2 Test-2 and Test-3, the DB and SAO might be disabled for some CTUs which will result in subjective visual artifact



CE2 Test-3

recruitin
since 19
universi



Proposed Method-2

recruitin
since 19
universi

WebBrowsing, Frame 93, AI

Subjective Quality Comparison

- In CE2 Test-2 and Test-3, the DB and SAO might be disabled for some CTUs which will result in subjective visual artifact



recruitin
since 19
universi

CE2 Test-3

WebBrowsing, Frame 93, AI

Subjective Quality Comparison

- In CE2 Test-2 and Test-3, the DB and SAO might be disabled for some CTUs which will result in subjective visual artifact



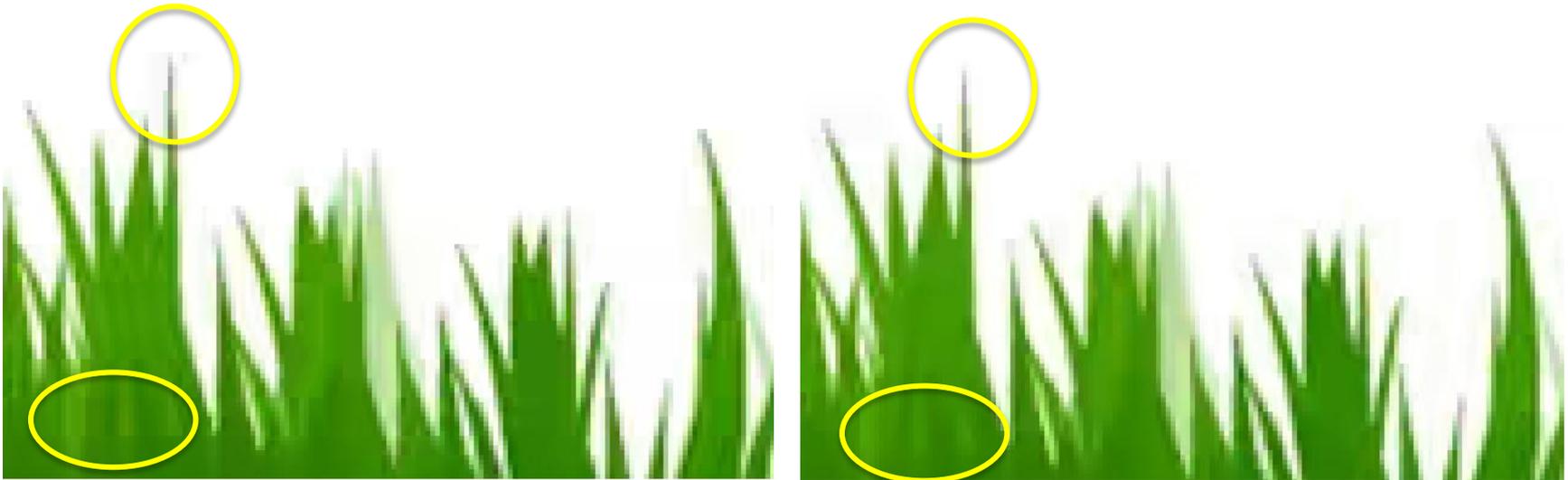
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since 19
universi

Proposed
Method-2

WebBrowsing, Frame 93

Subjective Quality Comparison

- In CE2 Test-2 and Test-3, the DB and SAO might be disabled for some CTUs which will result in subjective visual artifact



CE2 Test-3

Proposed Method-2

SlideShow, Frame 56, AI

Subjective Quality Comparison

- In CE2 Test-2 and Test-3, the DB and SAO might be disabled for some CTUs which will result in subjective visual artifact



CE2 Test-3

SlideShow, Frame 56, AI

Subjective Quality Comparison

- In CE2 Test-2 and Test-3, the DB and SAO might be disabled for some CTUs which will result in subjective visual artifact



Proposed Method-2

SlideShow, Frame 56, AI

Different Block Size for Encoder Constraint in Method-1

	Method-1											
	8x8			16x16			32x32			64x64		
	Random Access			Random Access			Random Access			Random Access		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.6%	0.6%	0.6%	0.9%	0.9%	0.9%	1.6%	1.6%	1.6%	2.4%	2.3%	2.4%
RGB, mixed content, 1440p & 1080p	0.6%	0.6%	0.6%	0.9%	0.9%	1.0%	1.5%	1.5%	1.5%	2.2%	2.2%	2.2%
RGB, Animation, 720p	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.5%	0.5%	0.5%	0.8%	0.8%	0.8%	1.4%	1.3%	1.3%	2.1%	2.0%	2.0%
YUV, mixed content, 1440p & 1080p	0.6%	0.6%	0.5%	0.9%	0.9%	0.8%	1.5%	1.5%	1.5%	2.2%	2.2%	2.1%
YUV, Animation, 720p	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Low delay B			Low delay B			Low delay B			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.8%	0.8%	0.8%	1.3%	1.3%	1.4%	2.0%	2.0%	2.0%	2.7%	2.7%	2.8%
RGB, mixed content, 1440p & 1080p	1.0%	1.0%	0.9%	1.3%	1.3%	1.4%	2.0%	1.9%	2.0%	2.6%	2.5%	2.5%
RGB, Animation, 720p	0.0%	0.1%	0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.1%	-0.1%	0.1%	0.1%
RGB, camera captured, 1080p	-0.1%	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
YUV, text & graphics with motion, 1080p & 720p	0.7%	0.6%	0.6%	1.1%	1.1%	1.1%	1.8%	1.6%	1.9%	2.5%	2.2%	2.5%
YUV, mixed content, 1440p & 1080p	1.0%	1.0%	1.0%	1.4%	1.3%	1.4%	2.0%	1.7%	2.0%	2.5%	2.2%	2.4%
YUV, Animation, 720p	-0.1%	0.0%	0.0%	-0.1%	0.0%	0.1%	-0.1%	0.1%	-0.1%	0.0%	0.3%	0.2%
YUV, camera captured, 1080p	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	118%			119%			123%			127%		
Dec Time[%]	114%			115%			121%			121%		

Different Block Size for Encoder Constraint in Method-2

	Method-2											
	8x8			16x16			32x32			64x64		
	Random Access			Random Access			Random Access			Random Access		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.3%	0.3%	0.3%	0.5%	0.5%	0.5%	0.9%	0.8%	0.8%	1.5%	1.4%	1.4%
RGB, mixed content, 1440p & 1080p	0.3%	0.4%	0.4%	0.6%	0.6%	0.6%	1.0%	1.0%	1.1%	1.6%	1.6%	1.6%
RGB, Animation, 720p	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.3%	0.2%	0.3%	0.4%	0.4%	0.4%	0.7%	0.6%	0.6%	1.2%	1.1%	1.1%
YUV, mixed content, 1440p & 1080p	0.4%	0.4%	0.4%	0.6%	0.6%	0.6%	1.0%	1.0%	1.0%	1.6%	1.5%	1.5%
YUV, Animation, 720p	0.0%	0.0%	0.0%	-0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%
	Low delay B			Low delay B			Low delay B			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.2%	0.2%	0.2%	0.4%	0.4%	0.4%	0.7%	0.7%	0.8%	1.2%	1.3%	1.4%
RGB, mixed content, 1440p & 1080p	0.5%	0.6%	0.5%	0.8%	0.8%	0.7%	1.4%	1.4%	1.3%	1.9%	1.9%	1.9%
RGB, Animation, 720p	-0.1%	0.0%	0.1%	-0.1%	0.0%	0.0%	-0.1%	0.0%	0.1%	-0.1%	-0.1%	0.1%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.2%	0.1%	0.2%	0.3%	0.4%	0.6%	0.7%	0.7%	0.8%	1.1%	1.0%	1.1%
YUV, mixed content, 1440p & 1080p	0.6%	0.7%	0.8%	0.8%	0.7%	0.9%	1.3%	1.3%	1.5%	1.8%	1.7%	1.8%
YUV, Animation, 720p	-0.1%	0.1%	0.1%	0.0%	0.1%	0.0%	-0.1%	0.2%	0.2%	-0.1%	0.2%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.1%	0.0%	-0.1%	0.1%	-0.1%	0.1%	0.1%	0.0%	0.1%	0.0%
Enc Time[%]	123%			126%			122%			125%		
Dec Time[%]	112%			113%			121%			123%		

Conclusion

- Proposed two IntraBC encoder searching constraints to reduce the worst case bandwidth in SCC
 - Restrict to access the 8x8 block that in 8x8 bi-pred, 4x8/8x4 uni-pred, or 16x16 AMP bi-predblocks
 - Allow to access the 8x8 block that is IntraBC coded block, within current or left CTU, or the use_integer_mv_flag is 1
 - Allow to access the 8x8 block that one of the MV is integer MV
- Encoder only constraints that won't generate subjective visual artifact