



# **JCTVC-M0222**

## **Non-SCE3.4: Simplified Generalized Combined Prediction**

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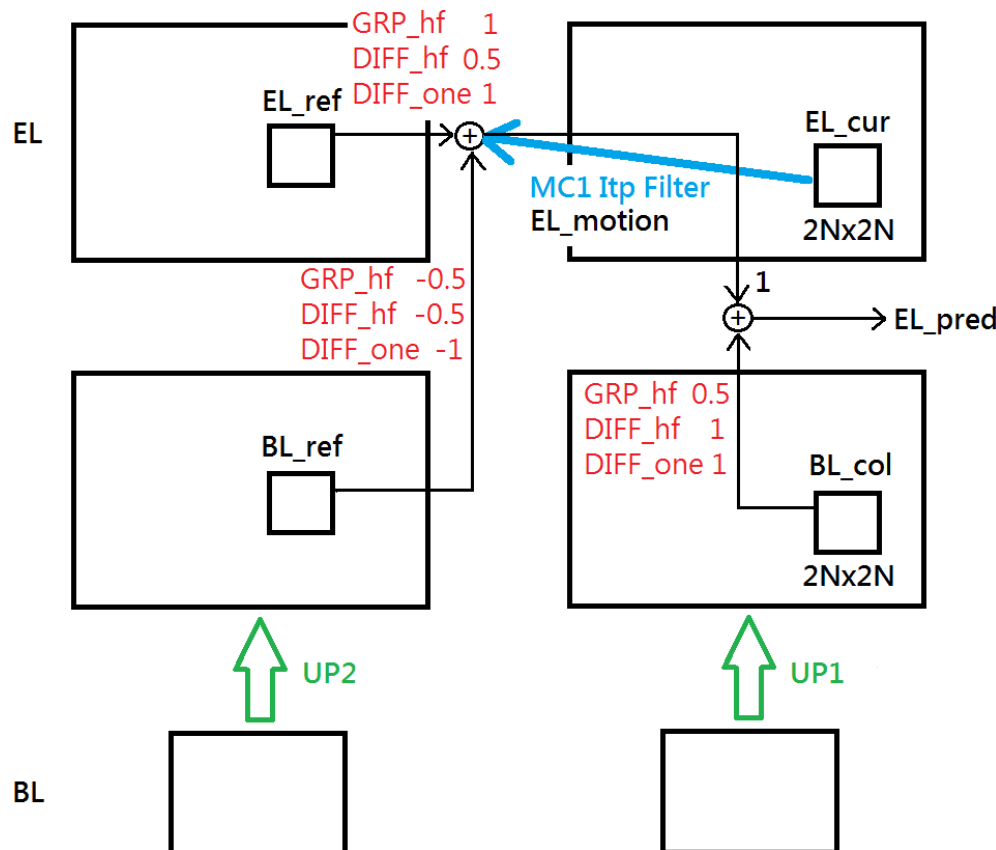
# Overall Summary

- Complexity reduction for SCE3.4 JCTVC-M0221 (GCP)
  - a. Luma-only GCP
  - b. Size limitation for GCP-uni and GCP-bi
  - c. Bilinear MC interpolation for “Luma-only GCP”
- **EL-only** Worst-case “Test 2, with a. + b. + c.” v.s. SHM1.0
  - Mult / Add operations: Both are 112%
  - Memory bandwidth: 87% for 2D-4x2 case, 70% for 2D-8x2 case
- **EL+BL** BD-rate results (Test 2, with a. + b. + c.)

	2x			1.5X			SNR			Average			Enc	Dec
	Y	U	V	Y	U	V	Y	U	V	Y	U	V	Time	Time
RA	-1.4%	-5.4%	-6.5%	-1.7%	-7.4%	-8.4%	-1.7%	-7.2%	-8.8%	-1.6%	-6.6%	-7.9%	126.7%	102.3%
LD-P	-3.8%	-6.8%	-8.3%	-4.1%	-9.9%	-11.3%	-4.9%	-9.9%	-11.8%	-4.2%	-8.9%	-10.5%	130.3%	101.3%
LD-B	-2.5%	-6.3%	-7.5%	-3.0%	-9.6%	-10.6%	-2.7%	-8.1%	-9.8%	-2.7%	-8.0%	-9.3%	122.8%	102.8%

# Generalized Combined Prediction

- $EL\_pred' = (1-a) EL\_ref + a BL\_col + (b) ( BL\_col - BL\_ref )$
- Upsampling process is intact



- **GRP\_hf**  
 $0.5 \text{ UP1}(BL\_col) + \text{MC}(EL\_ref - 0.5 \text{ UP2}(BL\_ref))$
- **Diff\_hf**  
 $\text{UP1}(BL\_col) + 0.5 \text{ MC}(EL\_ref - \text{UP2}(BL\_ref))$
- **GRP\_one = Diff\_one**  
 $\text{UP1}(BL\_col) + \text{MC}(EL\_ref - \text{UP2}(BL\_ref))$

# Simplification Methods

## a. Luma-only GCP:

- Only require luma BL\_ref (reduce memory BW, UP filter process)
- Chroma is normal Inter
- By forcing luma-only: 0.2%~0.4% luma loss with 2%~4% chroma gain  
→ GCP-chroma is just bit-shifting!!

## b. Size limitation:

- GCP-uni, PU H and W  $\geq 8$  (No 8x4, 4x8)
- GCP-bi, PU H and W  $\geq 16$  (No 8x8, 16x8, 8x16, 32x8, 8x32)

## c. Bilinear MC interpolation for “Luma-only GCP”

- Luma: bilinear 2-tap  $\times$  4-phase = 8 LUT size
- Chroma: Just normal Inter, no new filters

# Worst-case (Test 1 , with a. + b.)

		MC at EL resolution				Combined Pred Uni			Combined Pred Bi			Cascaded UpS and IPF		Add. Subtraction for {EL_ref-BL_ref}	
Target	Component	Filter description	# Tap	Mult	Adds	nb MC EL Uni	nb ILPred	nb MC EL Bi	nb ILPred						
Anchor	Luma	{-1, 4, -11, 40, 40, -11}	8	8	7	0	0	0	0	0	0				
	Chroma	{-6, 46, 28, -4 },	4	4	3	0	0	0	0						
Tested	Luma	{-1, 4, -11, 40, 40, -11}	8	8	7	1	2	1	3	1	1				
	Chroma	{-6, 46, 28, -4 },	4	4	3	1	0	1	0						
		HEVC Tested				SM	Tested	SM	Tested	Worst case Uni/Bi					
										Anchor Tested					
se		Mult	74	74	100%	0	167	INF	0	163	INF	74	167	226%	
		Adds	63	63	100%	0	147	INF	0	143	INF	63	147	233%	
se		MemBand(2D:4x2)	18	18	100%	0	29	INF	0	21	INF	18	29	158%	
		MemBand(2D:8x2)	27	27	100%	0	33	INF	0	24	INF	27	33	122%	
		Number of Ref Frames										5	9	180%	
		Tables Size										192	192	100%	
		Minimum uni-pred MC PU				Minimum Combined Uni block			Minimum Combined Bi block						
	Anchor					Anchor	4	8	Anchor	8	8				
	Test					Test	8	8	Test	16	16				

## Worst-case (Test 2 , with a. + b. + c.)

		MC at EL resolution				Combined Pred Uni			Combined Pred Bi			Cascaded UpS and IPF		Add. Subtraction for {EL_ref-BL_ref}			
Target	Component	Filter description	# Tap	Mult	Adds	nb MC EL Uni	nb ILPred	nb MC EL Bi	nb ILPred								
Anchor	Luma	{-1, 4, -11, 40, 40, -11}	8	8	7	0	0	0	0	0	0						
	Chroma	{-6, 46, 28, -4},	4	4	3	0	0	0	0								
Tested	Luma	{-1, 4, -11, 40, 40, -11}	2	2	1	1	2	1	3	1	1						
	Chroma	{-6, 46, 28, -4},	4	4	3	1	0	1	0								
														Worst case Uni/Bi			
														Anchor		Tested	
use		Mult	74	23	31%	0	66	INF	0	83	INF		74	83	112%		
		Adds	63	15	24%	0	57	INF	0	70	INF		63	70	112%		
use		MemBand(2D:4x2)	18	11	58%	0	16	INF	0	14	INF		18	16	87%		
		MemBand(2D:8x2)	27	18	67%	0	19	INF	0	16	INF		27	19	70%		
		Number of Ref Frames											5	9	180%		
		Tables Size											192	200	104%		
Minimum uni-pred MC PU						Minimum Combined Uni block			Minimum Combined Bi block								
		Anchor	4	8		Anchor	4	8	Anchor	0	0						
		Test	4	8		Test	8	8	Test	16	16						

# BD-rate Results (Test 1, with a. + b.)

	RA HEVC 2x			RA HEVC 1.5x			RA HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-1.6%	-6.0%	-7.6%				-1.1%	-5.2%	-7.0%
Class B	-1.6%	-5.1%	-6.0%				-2.0%	-7.6%	-9.1%
Overall (Test vs Ref)	-1.6%	-5.4%	-6.4%	-2.2%	-7.7%	-8.8%	-1.7%	-6.9%	-8.5%
Overall (Test vs single layer)	17.4%	24.7%	24.3%	13.9%	18.2%	19.2%	12.9%	19.1%	20.4%
EL only (Test vs Ref)	-3.0%	-6.9%	-8.0%	-5.4%	-11.3%	-12.5%	-2.9%	-8.5%	-10.2%
Enc Time[%]		131.9%			122.9%			124.9%	
Dec Time[%]		103.8%			104.7%			103.4%	
Enc Mem[%]		#DIV/0!			#DIV/0!			#DIV/0!	
BL Match		Matched			Matched			Matched	
	LD-P HEVC 2x			LD-P HEVC 1.5x			LD-P HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-3.5%	-8.0%	-9.3%				-3.2%	-6.9%	-8.6%
Class B	-3.6%	-6.1%	-7.6%	-4.8%	-10.3%	-11.6%	-4.6%	-10.1%	-12.1%
Overall (Test vs Ref)	-3.6%	-6.6%	-8.1%	-4.8%	-10.3%	-11.6%	-4.2%	-9.2%	-11.1%
Overall (Test vs single layer)	21.5%	27.1%	26.8%	16.5%	19.0%	19.9%	17.2%	21.3%	22.7%
EL only (Test vs Ref)	-5.9%	-9.0%	-10.4%	-10.0%	-15.6%	-17.0%	-6.4%	-11.6%	-13.6%
Enc Time[%]		136.4%			124.7%			128.7%	
Dec Time[%]		103.7%			103.2%			103.4%	
Enc Mem[%]		#DIV/0!			#DIV/0!			#DIV/0!	
BL Match		Matched			Matched			Matched	
	LD-B HEVC 2x			LD-B HEVC 1.5x			LD-B HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-2.9%	-7.8%	-9.1%				-2.4%	-6.4%	-8.1%
Class B	-3.2%	-6.4%	-7.5%	-4.4%	-10.8%	-11.9%	-3.4%	-9.1%	-10.7%
Overall (Test vs Ref)	-3.2%	-6.8%	-8.0%	-4.4%	-10.8%	-11.9%	-3.1%	-8.3%	-9.9%
Overall (Test vs single layer)	24.1%	27.8%	27.3%	19.1%	18.3%	18.8%	19.9%	21.8%	22.6%
EL only (Test vs Ref)	-5.5%	-9.1%	-10.4%	-10.3%	-16.7%	-17.8%	-5.1%	-10.6%	-12.3%
Enc Time[%]		127.5%			118.8%			121.7%	
Dec Time[%]		104.1%			105.9%			104.6%	
Enc Mem[%]		#DIV/0!			#DIV/0!			#DIV/0!	
BL Match		Matched			Matched			Matched	

# BD-rate Results (Test 2, with a. + b. + c.)

	RA HEVC 2x			RA HEVC 1.5x			RA HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-1.3%	-5.9%	-7.5%				-0.9%	-5.3%	-7.2%
Class B	-1.5%	-5.2%	-6.1%	-1.7%	-7.4%	-8.4%	-2.1%	-7.9%	-9.5%
Overall (Test vs Ref)	-1.4%	-5.4%	-6.5%	-1.7%	-7.4%	-8.4%	-1.7%	-7.2%	-8.8%
Overall (Test vs single layer)	17.6%	24.6%	24.1%	14.6%	18.6%	19.5%	12.8%	18.5%	19.6%
EL only (Test vs Ref)	-2.6%	-6.8%	-8.0%	-4.0%	-10.3%	-11.5%	-2.8%	-8.6%	-10.5%
Enc Time[%]	131.8%			123.4%			124.8%		
Dec Time[%]	103.6%			101.6%			101.7%		
Enc Mem[%]	#DIV/0!			#DIV/0!			#DIV/0!		
BL Match	Matched			Matched			Matched		
	LD-P HEVC 2x			LD-P HEVC 1.5x			LD-P HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-3.2%	-8.0%	-9.5%				-3.8%	-7.4%	-9.1%
Class B	-4.1%	-6.3%	-7.8%	-4.1%	-9.9%	-11.3%	-5.3%	-10.9%	-12.9%
Overall (Test vs Ref)	-3.8%	-6.8%	-8.3%	-4.1%	-9.9%	-11.3%	-4.9%	-9.9%	-11.8%
Overall (Test vs single layer)	21.2%	26.9%	26.5%	17.5%	19.4%	20.1%	16.4%	20.1%	21.1%
EL only (Test vs Ref)	-5.8%	-8.8%	-10.3%	-7.8%	-13.8%	-15.3%	-6.7%	-12.0%	-14.1%
Enc Time[%]	136.9%			125.0%			128.9%		
Dec Time[%]	101.0%			101.2%			101.5%		
Enc Mem[%]	#DIV/0!			#DIV/0!			#DIV/0!		
BL Match	Matched			Matched			Matched		
	LD-B HEVC 2x			LD-B HEVC 1.5x			LD-B HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-2.2%	-7.2%	-8.5%				-1.9%	-6.1%	-8.0%
Class B	-2.7%	-6.0%	-7.1%	-3.0%	-9.6%	-10.6%	-3.0%	-8.8%	-10.5%
Overall (Test vs Ref)	-2.5%	-6.3%	-7.5%	-3.0%	-9.6%	-10.6%	-2.7%	-8.1%	-9.8%
Overall (Test vs single layer)	25.0%	28.4%	27.9%	20.9%	19.9%	20.5%	20.4%	21.9%	22.5%
EL only (Test vs Ref)	-4.4%	-8.3%	-9.5%	-7.1%	-13.9%	-15.0%	-4.3%	-9.9%	-11.8%
Enc Time[%]	127.6%			119.1%			121.7%		
Dec Time[%]	103.0%			102.4%			102.8%		
Enc Mem[%]	#DIV/0!			#DIV/0!			#DIV/0!		
BL Match	Matched			Matched			Matched		



# Conclusions

- a. Luma-only GCP
- b. Size limitation for GCP-uni (8) and GCP-bi (16)
- c. Bilinear MC interpolation for “Luma-only GCP”
- **EL-only** Worst-case “Test 2, with a. + b. + c.” v.s. SHM1.0
  - Mult / Add operations: Both are 112%
  - Memory bandwidth: 87% for 2D-4x2 case, 70% for 2D-8x2 case
  - Only add bilinear 2-tap × 4-phase = 8 LUT size
- **EL+BL** BD-rate results (Test 2, with a. + b. + c.)

	2x			1.5X			SNR			Average			Enc	Dec
	Y	U	V	Y	U	V	Y	U	V	Y	U	V	Time	Time
RA	-1.4%	-5.4%	-6.5%	-1.7%	-7.4%	-8.4%	-1.7%	-7.2%	-8.8%	-1.6%	-6.6%	-7.9%	126.7%	102.3%
LD-P	-3.8%	-6.8%	-8.3%	-4.1%	-9.9%	-11.3%	-4.9%	-9.9%	-11.8%	-4.2%	-8.9%	-10.5%	130.3%	101.3%
LD-B	-2.5%	-6.3%	-7.5%	-3.0%	-9.6%	-10.6%	-2.7%	-8.1%	-9.8%	-2.7%	-8.0%	-9.3%	122.8%	102.8%

- **Thank Qualcomm and Vidyo for cross-checking!**

# CE Plans

- **Still keep upsampling intact**
- **Adjust constraints (e.g., size limitations)**
  - Complexity-gain trade-off
  - According to potentially new complexity assessment methodology
- **Reduction of number of GCP modes**
  - Interaction between GCP modes and MC-filter
  - Interaction between GCP modes and partition size