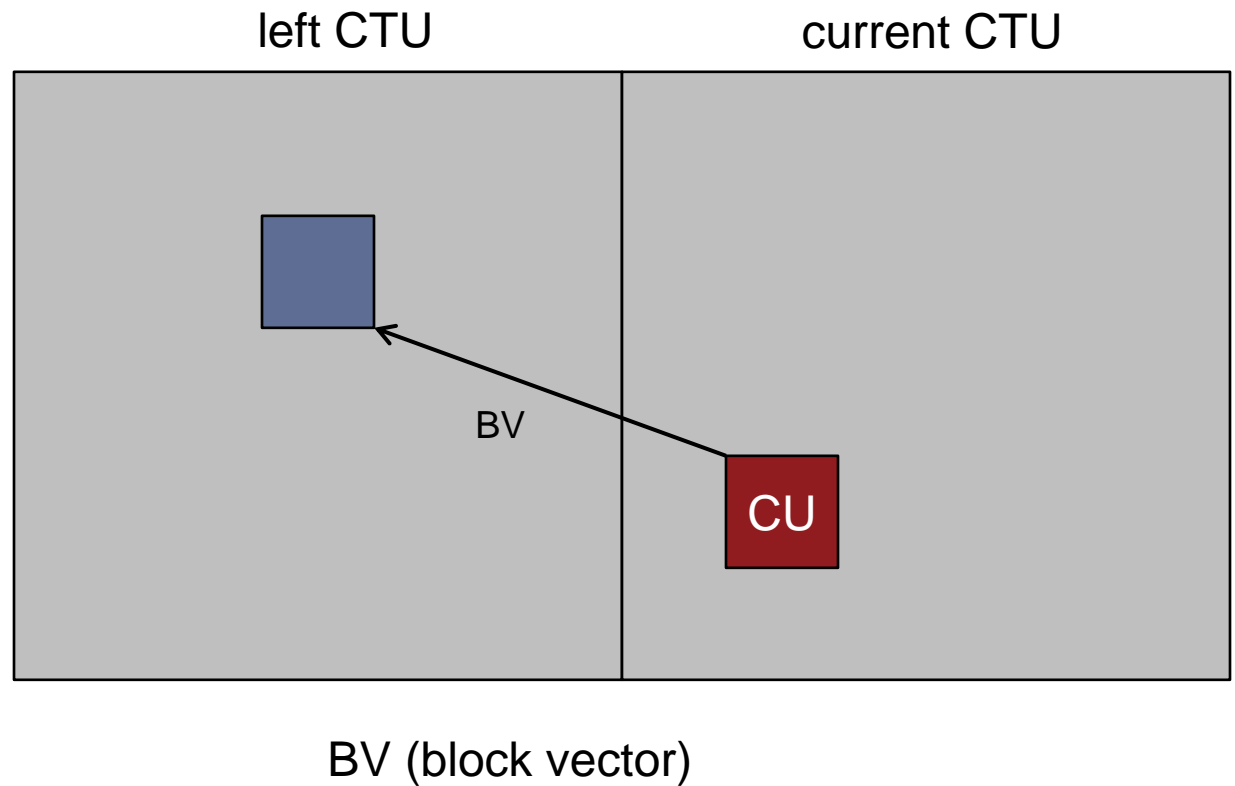# Block vector signaling for intra block copy

JCTVC-P0149

Chao Pang, Joel Sole, Rajan Joshi, Marta Karczewicz

Introduction

- Intra block copy (Intra BC)

  - JCTVC-N0256

left CTU	current CTU

BV (block vector)

Proposed

- To improve the coding efficiency of BV, two methods are proposed:

1. Method 1
   - The left or above BV is selected as predictor, and resulting block vector difference (BVD) is encoded; If one of them is unavailable, (-2*CUwidth, 0) is used instead. If both of them are unavailable, (-2*CUWidth, 0) and (-CUWidth, 0) are used instead.

   - First, one flag indicates whether the difference is zero. When BVD is not zero, expo-Golomb codes with order 3 are used to encode the remaining absolute level of the BVD and a flag is used to code its sign.

   - To avoid extra line buffer to store the above MV, only the above MV inside current CTU is allowed to be used as the predictor.

2. Method 2
   - The predictor is not changed, but the resulting BVD is coded as in Method 1.

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Experimental results

- We test
  1. Method 1 compared with the anchor;
  2. Method 2 compared with the anchor;
  3. Method 1 with NxN PU Intra BC;
  4. Method 2 with NxN PU Intra BC;

Method 1 compared with the anchor (lossy)

	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%	-0.5%	-0.6%	-0.4%	-0.4%	-0.4%	-0.2%	-0.2%	-0.3%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC RGB 444	-0.6%	-0.6%	-0.7%	-0.4%	-0.5%	-0.5%	-0.3%	-0.4%	-0.3%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.8%	-0.9%	-0.8%	-0.6%	-0.7%	-0.6%	-0.5%	-0.5%	-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	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.4%	-0.1%	-0.1%
SC(444) YUV Optional	-1.3%	-1.3%	-1.3%	-1.1%	-1.1%	-1.2%	-1.0%	-0.9%	-1.0%
Enc Time[%]	98%			98%			98%		
Dec Time[%]	99%			99%			99%		

	Random Access HE Main-tier			Random Access HE High-tier				Low delay B HE Main-tier			Low delay B HE High-tier		
	Y	U	V	Y	U	V		Y	U	V	Y	U	V
Class F	-0.4%	-0.4%	-0.4%	-0.3%	-0.3%	-0.4%	Class F	0.0%	-0.3%	0.1%	-0.1%	-0.3%	0.0%
Class B	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	Class B	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
SC RGB 444	-0.3%	-0.4%	-0.4%	-0.3%	-0.3%	-0.3%	SC RGB 444	-0.5%	-0.5%	-0.5%	-0.5%	-0.3%	-0.4%
Animation RGB 444	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.5%	-0.5%	-0.5%	-0.3%	-0.4%	-0.4%	SC YUV 444	-0.7%	-0.6%	-0.4%	-0.5%	-0.4%	-0.3%
Animation YUV 444	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	Animation YUV 444	0.1%	0.2%	-0.1%	0.0%	0.1%	0.0%
RangeExt	0.0%	0.0%	-0.1%	0.0%	0.0%	-0.1%	RangeExt	0.1%	0.1%	0.2%	0.0%	0.0%	0.1%
SC(444) GBR Optional	-0.7%	-0.7%	-0.7%	-0.8%	-0.7%	-0.8%	SC(444) GBR Optional	-1.6%	-1.7%	-1.7%	-1.2%	-1.2%	-1.3%
SC(444) YUV Optional	-1.2%	-1.1%	-1.3%	-1.0%	-1.0%	-1.1%	SC(444) YUV Optional	-1.8%	-1.6%	-1.5%	-1.3%	-1.1%	-1.1%
Enc Time[%]	98%			98%			Enc Time[%]	97%			97%		
Dec Time[%]	101%			101%			Dec Time[%]	102%			101%		

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Method 1 compared with the anchor (lossless)

Bit-rate saving	AI Main				RA Main				LB Main			
	Total	Average	Min	Max	Total	Average	Min	Max	Total	Average	Min	Max
Class F	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC RGB 444	-0.1%	-0.1%	-0.3%	0.0%	0.0%	-0.1%	-0.3%	0.0%	0.0%	-0.1%	-0.3%	0.0%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.1%	-0.1%	-0.3%	0.0%	0.0%	0.0%	-0.3%	0.4%	0.0%	-0.1%	-0.4%	0.0%
Animation YUV 444	0.0%	0.0%	0.0%	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%	0.0%	0.0%	0.0%
SC GBR 444 Optional	1.2%	1.8%	-0.6%	6.1%	0.2%	1.6%	-0.5%	5.3%	0.1%	0.7%	-1.0%	3.1%
SC YUV 444 Optional	-0.5%	-0.5%	-0.8%	-0.2%	-0.2%	-0.3%	-0.5%	-0.2%	-0.2%	-0.7%	-1.2%	-0.1%
Enc Time[%]	100%				98%				98%			
Dec Time[%]	101%				101%				101%			

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Method 2 compared with the anchor (lossy)

	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	-0.4%	-0.4%	-0.4%	-0.3%	-0.3%	-0.3%	-0.2%	-0.2%	-0.2%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC RGB 444	-0.4%	-0.4%	-0.5%	-0.3%	-0.3%	-0.4%	-0.3%	-0.2%	-0.3%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.6%	-0.6%	-0.5%	-0.4%	-0.4%	-0.4%	-0.3%	-0.3%	-0.3%
Animation YUV 444	0.0%	0.0%	-0.1%	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	-0.5%	-0.5%	-0.4%	-0.5%	-0.5%	-0.4%	-0.5%	-0.5%	-0.4%
SC(444) YUV Optional	-0.8%	-0.7%	-0.8%	-0.7%	-0.6%	-0.7%	-0.6%	-0.6%	-0.6%
Enc Time[%]	101%			100%			100%		
Dec Time[%]	100%			102%			102%		

	Random Access HE Main-tier			Random Access HE High-tier		
	Y	U	V	Y	U	V
Class F	-0.3%	-0.3%	-0.3%	-0.2%	-0.2%	-0.3%
Class B	0.0%	0.1%	-0.1%	0.0%	0.0%	-0.1%
SC RGB 444	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.1%	-0.1%	-0.2%	0.0%	0.0%	-0.1%
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%	-0.1%
SC(444) GBR Optional	-0.5%	-0.4%	-0.5%	-0.5%	-0.4%	-0.5%
SC(444) YUV Optional	-0.6%	-0.7%	-0.7%	-0.6%	-0.6%	-0.6%
Enc Time[%]	101%			102%		
Dec Time[%]	99%			100%		

	Low delay B HE Main-tier			Low delay B HE High-tier		
	Y	U	V	Y	U	V
Class F	-0.1%	-0.8%	-0.1%	-0.1%	-0.4%	-0.2%
Class B	0.0%	-0.1%	-0.2%	0.0%	0.0%	-0.1%
SC RGB 444	-0.4%	-0.4%	-0.4%	-0.3%	-0.2%	-0.2%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.5%	-0.3%	-0.5%	-0.3%	-0.2%	-0.3%
Animation YUV 444	0.0%	-0.1%	-0.1%	0.0%	0.0%	-0.1%
RangeExt	0.0%	-0.1%	0.0%	0.0%	-0.1%	0.0%
SC(444) GBR Optional	-0.6%	-0.5%	-0.6%	-0.6%	-0.5%	-0.5%
SC(444) YUV Optional	-0.9%	-0.8%	-0.6%	-0.8%	-1.0%	-0.8%
Enc Time[%]	101%			101%		
Dec Time[%]	99%			100%		

Method 2 compared with the anchor (lossless)

Bit-rate saving	AI Main				RA Main				LB Main			
	Total	Average	Min	Max	Total	Average	Min	Max	Total	Average	Min	Max
Class F	-0.1%	-0.1%	-0.2%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	-0.1%	0.0%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC RGB 444	-0.1%	-0.1%	-0.2%	0.0%	0.1%	0.1%	-0.2%	1.0%	0.0%	-0.1%	-0.2%	0.0%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.1%	-0.1%	-0.2%	0.0%	0.1%	0.1%	-0.2%	1.2%	0.0%	-0.1%	-0.4%	0.0%
Animation YUV 444	0.0%	0.0%	0.0%	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%	0.0%	0.0%	0.0%
SC GBR 444 Optional	-0.2%	-0.3%	-0.5%	0.0%	-0.1%	-0.3%	-0.5%	-0.1%	0.0%	-0.4%	-0.9%	0.0%
SC YUV 444 Optional	-0.4%	-0.4%	-0.6%	-0.2%	-0.2%	-0.4%	-0.5%	-0.2%	-0.2%	-0.5%	-0.8%	-0.2%
Enc Time[%]	100%				99%				99%			
Dec Time[%]	93%				99%				107%			

Method 1 with NxN PU Intra BC (lossy)

	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	-0.9%	-0.9%	-0.8%	-0.7%	-0.7%	-0.7%	-0.6%	-0.6%	-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	-1.3%	-1.3%	-1.5%	-1.1%	-1.2%	-1.2%	-0.9%	-1.0%	-0.9%
Animation RGB 444	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
SC YUV 444	-1.6%	-1.8%	-1.7%	-1.4%	-1.4%	-1.5%	-1.1%	-1.1%	-1.1%
Animation YUV 444	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
RangeExt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC(444) GBR Optional	-1.6%	-1.6%	-1.7%	-1.7%	-1.7%	-1.7%	-1.3%	-1.0%	-0.8%
SC(444) YUV Optional	-1.8%	-1.8%	-1.9%	-1.6%	-1.7%	-1.7%	-1.5%	-1.4%	-1.4%
Enc Time[%]	99%			99%			99%		
Dec Time[%]	98%			99%			99%		

	Random Access HE Main-tier			Random Access HE High-tier		
	Y	U	V	Y	U	V
Class F	-0.7%	-0.8%	-0.7%	-0.6%	-0.7%	-0.7%
Class B	0.0%	-0.1%	-0.1%	0.0%	-0.1%	0.0%
SC RGB 444	-1.0%	-1.0%	-1.1%	-0.9%	-1.0%	-1.0%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-1.2%	-1.1%	-1.2%	-1.0%	-1.0%	-1.1%
Animation YUV 444	0.0%	-0.1%	0.1%	0.0%	0.0%	0.1%
RangeExt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC(444) GBR Optional	-1.4%	-1.4%	-1.4%	-1.3%	-1.4%	-1.5%
SC(444) YUV Optional	-1.7%	-1.7%	-1.6%	-1.5%	-1.5%	-1.4%
Enc Time[%]	101%			101%		
Dec Time[%]	101%			100%		

	Low delay B HE Main-tier			Low delay B HE High-tier		
	Y	U	V	Y	U	V
Class F	-0.6%	-1.0%	-0.6%	-0.6%	-0.6%	-0.4%
Class B	0.0%	0.1%	-0.2%	0.0%	0.0%	-0.1%
SC RGB 444	-0.8%	-0.9%	-0.9%	-0.7%	-0.8%	-0.8%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-1.2%	-1.1%	-1.1%	-1.1%	-1.0%	-1.1%
Animation YUV 444	0.0%	-0.2%	-0.1%	0.0%	-0.1%	0.1%
RangeExt	0.0%	0.1%	-0.1%	0.0%	0.1%	0.0%
SC(444) GBR Optional	-1.4%	-1.3%	-1.3%	-1.2%	-1.2%	-1.3%
SC(444) YUV Optional	-1.8%	-1.8%	-1.8%	-2.3%	-2.3%	-2.2%
Enc Time[%]	99%			99%		
Dec Time[%]	99%			99%		

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Method 1 with NxN PU Intra BC (lossless)

Bit-rate saving	AI Main				RA Main				LB Main			
	Total	Average	Min	Max	Total	Average	Min	Max	Total	Average	Min	Max
Class F	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.3%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC RGB 444	-0.1%	-0.1%	-0.3%	0.1%	0.2%	0.2%	-0.5%	1.7%	0.0%	-0.1%	-0.4%	0.1%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.1%	-0.2%	-0.4%	0.1%	0.0%	-0.1%	-0.6%	0.1%	0.0%	-0.1%	-0.5%	0.1%
Animation YUV 444	0.0%	0.0%	0.0%	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%	0.0%	0.0%	0.0%
SC GBR 444 Optional	1.6%	2.2%	-0.5%	6.8%	0.6%	1.9%	-0.5%	5.9%	0.4%	0.8%	-1.5%	3.4%
SC YUV 444 Optional	-0.2%	-0.3%	-0.8%	0.4%	0.3%	-0.3%	-0.8%	0.5%	0.5%	-0.3%	-1.2%	0.6%
Enc Time[%]	99%				100%				101%			
Dec Time[%]	99%				101%				98%			

Method 2 with NxN PU Intra BC (lossy)

	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%	-0.5%	-0.4%	-0.4%	-0.5%	-0.3%	-0.4%	-0.4%	-0.3%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC RGB 444	-0.6%	-0.6%	-0.6%	-0.5%	-0.6%	-0.6%	-0.5%	-0.5%	-0.5%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.7%	-0.9%	-0.7%	-0.7%	-0.8%	-0.7%	-0.6%	-0.6%	-0.6%
Animation YUV 444	0.0%	0.0%	-0.1%	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	-0.5%	-0.5%	-0.5%	-0.6%	-0.7%	-0.6%	-0.7%	-0.7%	-0.6%
SC(444) YUV Optional	-0.8%	-0.8%	-0.7%	-0.9%	-1.0%	-0.9%	-1.0%	-1.0%	-1.0%
Enc Time[%]	100%			100%			99%		
Dec Time[%]	101%			101%			100%		

	Random Access HE Main-tier			Random Access HE High-tier		
	Y	U	V	Y	U	V
Class F	-0.3%	-0.3%	-0.3%	-0.3%	-0.2%	-0.3%
Class B	0.0%	-0.1%	0.0%	0.0%	-0.1%	0.1%
SC RGB 444	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.3%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.5%	-0.6%	-0.7%	-0.6%	-0.6%	-0.7%
Animation YUV 444	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%
RangeExt	0.0%	0.0%	-0.1%	0.0%	0.0%	-0.1%
SC(444) GBR Optional	-0.4%	-0.4%	-0.4%	-0.5%	-0.4%	-0.5%
SC(444) YUV Optional	-0.7%	-0.8%	-0.7%	-0.7%	-0.8%	-0.6%
Enc Time[%]	98%			99%		
Dec Time[%]	101%			102%		

	Low delay B HE Main-tier			Low delay B HE High-tier		
	Y	U	V	Y	U	V
Class F	-0.3%	-0.1%	-0.3%	-0.3%	-0.1%	-0.4%
Class B	0.0%	0.2%	-0.2%	0.0%	0.0%	-0.1%
SC RGB 444	-0.5%	-0.5%	-0.5%	-0.5%	-0.4%	-0.4%
Animation RGB 444	-0.1%	0.0%	-0.1%	-0.1%	0.0%	-0.1%
SC YUV 444	-0.8%	-0.7%	-0.6%	-0.7%	-0.6%	-0.6%
Animation YUV 444	0.0%	-0.2%	-0.1%	0.0%	-0.1%	0.1%
RangeExt	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%
SC(444) GBR Optional	-0.7%	-0.7%	-0.5%	-0.9%	-0.9%	-0.7%
SC(444) YUV Optional	-1.7%	-1.6%	-1.5%	-1.5%	-1.6%	-1.4%
Enc Time[%]	102%			102%		
Dec Time[%]	100%			101%		

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Method 2 with NxN PU Intra BC (lossless)

Bit-rate saving	AI Main				RA Main				LB Main			
	Total	Average	Min	Max	Total	Average	Min	Max	Total	Average	Min	Max
Class F	-0.1%	-0.2%	-0.5%	0.0%	0.0%	-0.1%	-0.2%	0.0%	0.0%	-0.1%	-0.2%	0.0%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC RGB 444	-0.2%	-0.3%	-0.6%	0.0%	-0.1%	-0.3%	-0.6%	0.0%	-0.1%	-0.3%	-0.7%	0.0%
Animation RGB 444	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SC YUV 444	-0.3%	-0.4%	-0.6%	-0.1%	-0.1%	-0.3%	-0.6%	0.0%	-0.1%	-0.3%	-0.7%	0.0%
Animation YUV 444	0.0%	0.0%	0.0%	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%	0.0%	0.0%	0.0%
SC GBR 444 Optional	-0.5%	-0.6%	-1.1%	-0.2%	-0.2%	-0.5%	-1.1%	-0.1%	-0.1%	-0.8%	-1.7%	-0.1%
SC YUV 444 Optional	-0.9%	-0.9%	-1.3%	-0.4%	-0.5%	-0.9%	-1.3%	-0.3%	-0.4%	-1.0%	-1.5%	-0.3%
Enc Time[%]	100%				100%				98%			
Dec Time[%]	95%				99%				106%			

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