

CE3-related: Improved method for entropy coding offset vectors of 2-D matching

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Overall Summary

■ Problem

- Our former method (CE3 Test B.5, JCTVC-T0128) uses a relatively large number of regular bins, increasing the worst-case number of the regular bins per CU

■ Proposal

- Modified method for coding the prefix part with reduced number of regular bins & improved coding efficiency

- Average lossy BD rate saving for YUV, text & graphics with motion, 1080p & 720p under SCC CTCs
 - Test condition 1 : bitrate savings 0.4%, 0.2%, and 0% for AI, RA, LB, respectively
 - Test condition 2 : bitrate savings 0.7%, 0.4%, and 0.1% for AI, RA, LB, respectively

Former Method

- Represent the absolute value of each component of 2D offset vector (**dictionary_pred_offsetX, dictionary_pred_offsetY**) by signaling its most significant bit (MSB) index followed by its refinement bits
- Binarization
 - A concatenation of a prefix bin string and a suffix bin string
 - The prefix string represents the MSB index plus one, or **msb_id_plus1**, of symbol x with

$$\text{msb_id_plus1} = \begin{cases} \text{Floor} (\text{Log2}(x)) + 1, & \text{if } x > 0; \\ 0, & \text{otherwise.} \end{cases}$$

- Prefix part representing **msb_plus_one** in a unary code
- Suffix part representing **refinement_bits** by a fixed-length binary code
- The decoded syntax value x is given by

$$x = \begin{cases} (1 \ll (\text{msb_id_plus1}-1)) + \text{refinement_bits}, & \text{if } \text{msb_id_plus1} > 1; \\ \text{msb_id_plus1}, & \text{otherwise.} \end{cases}$$

Coding Prefix with reduced regular bins

- Code a syntax flag **msb_idx_p1_gr0_flag** to indicate if **msb_plus_one** is greater than 0
- If **msb_idx_p1_gr0_flag** is true, code a syntax flag **msb_idx_p1_grT_flag** to indicate if **msb_plus_one** is greater than a threshold value **msb_idx_thre**
- If **msb_idx_p1_grT_flag** is true, then code $(\text{msb_plus_one} - 1 - \text{msb_idx_thre})$ in unary code
- Otherwise, encode $(\text{msb_idx_thre} - \text{msb_plus_one})$ in truncated unary code
- The threshold value, **msb_idx_thre**, is coded in the slice header for each vector component

Redundancy removal

- Starting position of the reference string should be always located at the reconstructed picture region
- (`msb_idx_p1_gr0_flag[0]`, `msb_idx_p1_gr0_flag[1]`) jointly coded using a syntax element **`msb_idx_p1_gr0_flag_xy`** with the value equal to 0, 1, or 2
 - (`msb_idx_p1_gr0_flag[0] = 0`, `msb_idx_p1_gr0_flag[1] = 0`) never occurs
- Sign coding
 - The signs of the two offset vector components are coded only if (`msb_idx_p1_gr0_flag[0] == 1 && msb_idx_p1_gr0_flag[1] == 1`).
 - Otherwise, the signs are inferred to be positive.
 - Use a new syntax element **`dictionary_pred_offset_sign_xy`** with the value equal to 0, 1, or 2
 - (`dictionary_pred_offsetX < 0`, `dictionary_pred_offsetY < 0`) never occur

Lossy Results, TC1

- Test condition 1
 - Anchor: SCM-3.0, 2-CTU nonHash-based IBC, FF hash-based IBC
 - Tests
 - top: ISC SW with 2-CTU ISC search + TC 1 anchor IBC settings
 - bottom: proposal + ISC SW with 2-CTU ISC search + TC 1 anchor IBC settings (up to 2 regular bins/comp for coding 2 syntax flags, 388 per 8x8 CU)

	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	-0.3%	-0.4%	-0.3%	-0.1%	-0.2%	-0.1%	0.0%	-0.1%	0.0%
RGB, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%
YUV, text & graphics with motion, 1080p & 720p	-0.3%	-0.4%	-0.3%	-0.1%	-0.2%	-0.3%	0.0%	-0.2%	-0.3%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.1%	0.1%	0.2%	0.1%	0.0%	-0.1%	0.0%
YUV, Animation, 720p	0.1%	0.1%	0.0%	0.1%	0.0%	0.3%	0.3%	0.0%	0.3%
YUV, camera captured, 1080p	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%

Test Condition 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	-0.5%	-0.5%	-0.5%	-0.3%	-0.3%	-0.3%	-0.2%	-0.1%	-0.1%
RGB, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%	0.1%	0.1%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.1%
YUV, text & graphics with motion, 1080p & 720p	-0.4%	-0.4%	-0.4%	-0.2%	-0.3%	-0.4%	0.0%	0.0%	0.0%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.1%	0.1%	0.0%	0.2%	0.0%	-0.1%	-0.1%
YUV, Animation, 720p	0.1%	0.1%	0.0%	0.1%	0.0%	0.3%	0.3%	0.1%	0.4%
YUV, camera captured, 1080p	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%

Lossy Results , TC2

- Test condition 2
 - Anchor: SCM-3.0, 4-CTU nonHash-based IBC, 4-CTU hash-based IBC
 - Tests
 - top: ISC SW with 4-CTU ISC search + TC 2 anchor IBC settings
 - bottom: proposal + ISC SW with 4-CTU ISC search + TC 2 anchor IBC settings

	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	-0.6%	-0.6%	-0.6%	-0.3%	-0.4%	-0.4%	-0.1%	0.0%	0.0%
RGB, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	-0.1%	-0.1%	0.0%	0.1%	0.2%	0.1%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	-0.5%	-0.5%	-0.5%	-0.3%	-0.4%	-0.4%	0.0%	-0.1%	0.1%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	-0.4%	0.0%
YUV, Animation, 720p	0.1%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.3%	0.2%
YUV, camera captured, 1080p	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%	0.1%

Test Condition 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	-0.9%	-1.0%	-1.0%	-0.6%	-0.7%	-0.7%	-0.3%	-0.3%	-0.2%
RGB, mixed content, 1440p & 1080p	0.0%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.2%	0.2%	0.1%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	0.0%	0.1%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	-0.7%	-0.8%	-0.8%	-0.4%	-0.5%	-0.6%	-0.1%	-0.1%	0.1%
YUV, mixed content, 1440p & 1080p	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.2%	-0.3%
YUV, Animation, 720p	0.1%	0.1%	0.0%	0.0%	0.3%	0.1%	0.1%	0.2%	0.2%
YUV, camera captured, 1080p	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%

Lossless Results, TC1

- Test condition 1
 - Anchor: SCM-3.0, 2-CTU nonHash-based IBC, FF hash-based IBC
 - Tests
 - top: ISC SW with 2-CTU ISC search + TC 1 anchor IBC settings
 - bottom: proposal + ISC SW with 2-CTU ISC search + TC 1 anchor IBC settings

	All Intra				Random Access				Low Delay B			
	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)
RGB, text & graphics with motion, 1080p & 720p	-2.1%	-2.3%	-6.5%	0.0%	-0.7%	-1.2%	-3.8%	0.0%	-0.7%	-0.8%	-2.2%	0.1%
RGB, mixed content, 1440p & 1080p	-0.2%	-0.3%	-0.5%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	-2.0%	-2.1%	-6.4%	-0.1%	-0.7%	-1.1%	-3.7%	0.0%	-0.6%	-0.7%	-1.9%	0.0%
YUV, mixed content, 1440p & 1080p	-0.2%	-0.2%	-0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, Animation, 720p	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, 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%

	All Intra				Random Access				Low Delay B			
	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)
RGB, text & graphics with motion, 1080p & 720p	-2.7%	-3.1%	-8.5%	-0.2%	-1.0%	-1.6%	-5.1%	-0.1%	-0.9%	-1.1%	-3.1%	0.1%
RGB, mixed content, 1440p & 1080p	-0.4%	-0.4%	-0.7%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	-0.1%	0.0%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	-2.6%	-2.9%	-8.4%	-0.2%	-0.9%	-1.5%	-5.0%	-0.1%	-0.8%	-1.0%	-2.8%	0.0%
YUV, mixed content, 1440p & 1080p	-0.3%	-0.4%	-0.7%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, Animation, 720p	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, 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%

Lossless Results, TC2

- Test condition 2
 - Anchor: SCM-3.0, 4-CTU nonHash-based IBC, 4-CTU hash-based IBC
 - Tests
 - top: ISC SW with 4-CTU ISC search + TC 2 anchor IBC settings
 - bottom: proposal + ISC SW with 4-CTU ISC search + TC 2 anchor IBC settings

	All Intra				Random Access				Low Delay B			
	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)
RGB, text & graphics with motion, 1080p & 720p	-3.2%	-3.3%	-8.0%	-0.1%	-1.6%	-1.8%	-4.9%	-0.1%	-1.6%	-1.3%	-3.5%	0.0%
RGB, mixed content, 1440p & 1080p	-0.5%	-0.5%	-0.8%	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	-0.1%	0.0%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	-3.1%	-3.2%	-8.1%	-0.1%	-1.4%	-1.7%	-5.0%	-0.1%	-1.3%	-1.2%	-3.2%	-0.1%
YUV, mixed content, 1440p & 1080p	-0.5%	-0.5%	-0.8%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, Animation, 720p	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, 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%

	All Intra				Random Access				Low Delay B			
	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)	Bit-rate change (Total)	Bit-rate change (Average)	Bit-rate change (Min)	Bit-rate change (Max)
RGB, text & graphics with motion, 1080p & 720p	-4.2%	-4.5%	-10.7%	-0.2%	-2.2%	-2.5%	-6.6%	-0.1%	-2.2%	-1.8%	-4.7%	-0.1%
RGB, mixed content, 1440p & 1080p	-0.7%	-0.8%	-1.2%	-0.3%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	-4.2%	-4.4%	-10.9%	-0.2%	-1.9%	-2.4%	-6.7%	-0.1%	-1.8%	-1.7%	-4.7%	-0.1%
YUV, mixed content, 1440p & 1080p	-0.7%	-0.8%	-1.2%	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%
YUV, Animation, 720p	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, 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%

Conclusion

- Further improve our method in Test B.5 for coding the offset vectors of 2D matching with reduced number of regular bins
- Improved coding efficiency experimentally
- Universal entropy coding method, useful for coding other syntax elements
- Recommend to adopt the proposal into the ISC reference SW