

CE2-related: Improved method for entropy coding MVD/BVD

Shih-Ta Hsiang, Shawmin Lei

20th JCT-VC Meeting : Geneva, CH
10–18 Feb. 2015

Overall Summary

■ Problem

- Our former method (JCTVC-S0162) 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

■ Average lossy BD rate saving for YUV, text & graphics with motion, 1080p & 720p under SCC CTCs

- 0.8%, 1.5%, and 1.8% for AI, RA, LB, respectively, using up to 1 regular bin/comp for BVD, 2 regular bins/comp for MVD
- 1.1%, 1.9%, and 2.2% for AI, RA, LB, respectively, using up to 4 regular bins/comp

Former Proposed Method (JCTVC-S0162)

- Represent the absolute value of each BVD component in binary 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 part indicates the MSB index plus one (**msb_plus_one**) of a binary symbol value x with

$$\text{msb_plus_one} = \begin{cases} \text{Floor}(\text{Log}_2(x)) + 1, & \text{if } (x > 0); \\ 0, & \text{otherwise.} \end{cases}$$

- Prefix bin string representing msb_plus_one in a unary code
- Suffix bin string representing refinement value in a fixed-length binary code
- The decoded syntax value x is given by

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

- Same binarization as that of HEVC MVD coding in version 1
- Fully unified for BVD/MVD coding
 - Same binarization & context model set
- SPS flag to turn on/off the new BVD/MVD coding tool

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

Context Modeling

- Three contexts for `msb_idx_p1_gr0_flag[0]` & `msb_idx_p1_gr0_flag[1]`
 - 1 context dedicated to `msb_idx_p1_gr0_flag[0]`
 - `msb_idx_p1_gr0_flag[1]` conditioned on the value of `msb_idx_p1_gr0_flag[0]`
 - Similar method independently developed but applied to BVD only in JCTVC-T0114
- `msb_idx_p1_grT_flag` is coded in either the bypass mode or the CABAC mode
- Each sub-prefix bin string is coded in the CABAC mode if the current bin index is less than a pre-determined threshold value, in the bypass mode, otherwise.
- Separate context sets are allocated for coding MVD and BVD

Experimental Results

- Lossy coding under SCC CTCs
 - Anchor: SCM-3.0
 - Test: **SCM-3.0 + proposal using up to 1 regular bin for BVD, 2 regular bins for MVD per vector component**
- **Thank Sharp for cross check (JCTVC-T0197)**

	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	-0.8%	-0.7%	-0.7%	-1.3%	-1.3%	-1.3%	-1.8%	-1.6%	-1.6%
RGB, mixed content, 1440p & 1080p	-0.2%	-0.2%	-0.2%	-0.1%	-0.2%	-0.1%	-0.2%	0.0%	-0.4%
RGB, Animation, 720p	-0.1%	-0.1%	-0.1%	-0.2%	-0.1%	-0.2%	-0.2%	-0.1%	-0.2%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	-0.2%	-0.1%	-0.1%	-0.2%	-0.1%	-0.1%
YUV, text & graphics with motion, 1080p & 720p	-0.8%	-0.8%	-0.7%	-1.5%	-1.5%	-1.6%	-1.8%	-1.7%	-1.8%
YUV, mixed content, 1440p & 1080p	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.4%	-0.6%	-0.6%
YUV, Animation, 720p	0.0%	0.0%	0.0%	-0.2%	-0.2%	0.1%	0.0%	0.1%	-0.1%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	-0.2%	-0.1%	-0.3%	-0.2%	-0.1%	-0.1%

Experimental Results

- Lossy coding under SCC CTCs
 - Anchor: SCM-3.0
 - Test: SCM-3.0 + proposal using up to 4 regular bins per vector component
- Thank Sharp for cross check (JCTVC-T0197)

	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%	-0.9%	-0.9%	-1.7%	-1.7%	-1.7%	-2.0%	-1.9%	-1.8%
RGB, mixed content, 1440p & 1080p	-0.3%	-0.3%	-0.3%	-0.3%	-0.4%	-0.2%	-0.5%	-0.4%	-0.4%
RGB, Animation, 720p	-0.1%	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%	-0.2%	-0.3%	-0.3%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	-0.3%	-0.2%	-0.2%	-0.2%	-0.1%	-0.1%
YUV, text & graphics with motion, 1080p & 720p	-1.1%	-1.0%	-1.0%	-1.9%	-1.9%	-1.9%	-2.2%	-2.2%	-2.1%
YUV, mixed content, 1440p & 1080p	-0.4%	-0.4%	-0.3%	-0.4%	-0.3%	-0.4%	-0.5%	-0.8%	-0.5%
YUV, Animation, 720p	-0.1%	-0.1%	0.0%	-0.2%	-0.2%	0.0%	0.0%	0.3%	0.1%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	-0.3%	-0.2%	-0.3%	-0.2%	0.0%	0.1%

Comparison of Lossy Results

	CE2 Test 5.1 (JCTVC-T0089)			1 & 2 regular bins/comp			2 regular bins/comp, bpT = 0		
	AI	RA	LB	AI	RA	LB	AI	RA	LB
RGB, text & graphics with motion, 1080p & 720p	-0.2%	-1.1%	-1.6%	-0.8%	-1.3%	-1.8%	-0.9%	-1.5%	-1.7%
RGB, mixed content, 1440p & 1080p	-0.1%	0.0%	-0.3%	-0.2%	-0.1%	-0.2%	-0.2%	-0.2%	-0.2%
RGB, Animation, 720p	0.0%	0.0%	-0.1%	-0.1%	-0.2%	-0.2%	-0.1%	-0.1%	-0.1%
RGB, camera captured, 1080p	0.0%	0.0%	0.1%	0.0%	-0.2%	-0.2%	0.0%	-0.2%	-0.2%
YUV, text & graphics with motion, 1080p & 720p	-0.3%	-1.3%	-1.8%	-0.8%	-1.5%	-1.8%	-0.9%	-1.6%	-1.7%
YUV, mixed content, 1440p & 1080p	-0.1%	-0.1%	-0.3%	-0.2%	-0.2%	-0.4%	-0.3%	-0.3%	-0.3%
YUV, Animation, 720p	0.0%	-0.1%	-0.1%	0.0%	-0.2%	0.0%	0.0%	-0.1%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.1%	0.0%	-0.2%	-0.2%	0.0%	-0.2%	-0.1%
# of context-coded bins per vector	4			2 for BVD & 4 for MVD			4		
total # of contexts for BVD & MVD	8			8			10		

	JCTVC-S0162			3 regular bins/comp, bpT = 1			4 regular bins/comp, bpT = 2		
	AI	RA	LB	AI	RA	LB	AI	RA	LB
RGB, text & graphics with motion, 1080p & 720p	-0.6%	-1.2%	-1.7%	-0.9%	-1.6%	-2.0%	-0.9%	-1.7%	-2.0%
RGB, mixed content, 1440p & 1080p	-0.1%	-0.1%	-0.2%	-0.3%	-0.3%	-0.6%	-0.3%	-0.3%	-0.5%
RGB, Animation, 720p	0.0%	-0.2%	-0.1%	-0.1%	-0.2%	-0.2%	-0.1%	-0.1%	-0.2%
RGB, camera captured, 1080p	0.0%	-0.2%	-0.2%	0.0%	-0.3%	-0.2%	0.0%	-0.3%	-0.2%
YUV, text & graphics with motion, 1080p & 720p	-0.6%	-1.5%	-1.8%	-1.0%	-1.9%	-2.0%	-1.1%	-1.9%	-2.2%
YUV, mixed content, 1440p & 1080p	-0.2%	-0.1%	-0.2%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.5%
YUV, Animation, 720p	0.0%	-0.2%	-0.1%	-0.1%	-0.2%	0.0%	-0.1%	-0.2%	0.0%
YUV, camera captured, 1080p	0.0%	-0.2%	-0.2%	0.0%	-0.3%	-0.2%	0.0%	-0.3%	-0.2%
# of context-coded bins per vector	14			6			8		
total # of contexts for BVD & MVD	6			18			26		

Constraint on the max number of context-coded bins

- Strasburg's meeting resolution requests that the new proposal needs to meet the criterion of not increasing worst-case number of regular bins compared to HEVC version 2
 - 1 bin/comp for BV and 2 bins/comp for MVD
- GJS's comments
 - Only one MVD/BVD per PU
 - Worst case rarely happens
 - Constraint limits flexibility & efficiency in syntax design
- Application concerned about the throughput rate over some processing units
- Constraint enforced by encoder
 - Count the number of the context-coded bins
 - During RD test, select the CU configuration with the lowest RD cost while meeting the constraint on the number of the context-coded bins
 - If no CU configuration is selected at the end of RD mode decision stage, set the CU mode to the 2Nx2N intra mode

Experimental Results

- Anchor: Proposal using 4 context-coded per component
- Test: Proposal using 4 context-coded per component with the constraint on max # of context-coded bins

	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	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
RGB, mixed content, 1440p & 1080p	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
RGB, Animation, 720p	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
RGB, camera captured, 1080p	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
YUV, text & graphics with motion, 1080p & 720p	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
YUV, mixed content, 1440p & 1080p	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
YUV, Animation, 720p	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
YUV, camera captured, 1080p	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%

	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	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
RGB, mixed content, 1440p & 1080p	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
RGB, Animation, 720p	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
RGB, camera captured, 1080p	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
YUV, text & graphics with motion, 1080p & 720p	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
YUV, mixed content, 1440p & 1080p	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
YUV, Animation, 720p	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
YUV, camera captured, 1080p	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%

Conclusion

- Proposed an unified method for coding BVD/MVD
- Improved BD rate savings

	CE2 Test 5.1 (JCTVC-T0089)			1 & 2 regular bins/comp			2 regular bins/comp, bpT = 0		
	AI	RA	LB	AI	RA	LB	AI	RA	LB
RGB, text & graphics with motion, 1080p & 720p	-0.2%	-1.1%	-1.6%	-0.8%	-1.3%	-1.8%	-0.9%	-1.5%	-1.7%
YUV, text & graphics with motion, 1080p & 720p	-0.3%	-1.3%	-1.8%	-0.8%	-1.5%	-1.8%	-0.9%	-1.6%	-1.7%
	JCTVC-S0162			3 regular bins/comp, bpT = 1			4 regular bins/comp, bpT = 2		
	AI	RA	LB	AI	RA	LB	AI	RA	LB
RGB, text & graphics with motion, 1080p & 720p	-0.6%	-1.2%	-1.7%	-0.9%	-1.6%	-2.0%	-0.9%	-1.7%	-2.0%
YUV, text & graphics with motion, 1080p & 720p	-0.6%	-1.5%	-1.8%	-1.0%	-1.9%	-2.0%	-1.1%	-1.9%	-2.2%

- Universal entropy coding, useful for coding other SCC syntax elements
- New MVD/BVD tool can be turned on/off by a SPS flag
- Recommendation
 - Adopt the proposed method or further study in CE
 - Further study the useful worst-case constraint on the number of context-coded bins without sacrifice on efficiency