

JVET-Q0185

AHG16: On merge estimation region (MER) for VVC

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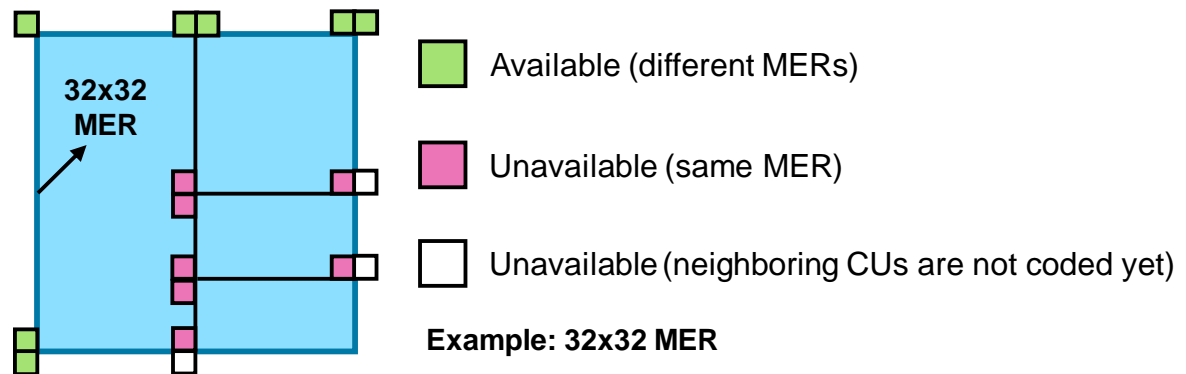
Overall Summary

- Propose to add HEVC-based MER to VVC
 - Achieved with minor normative changes with proper encoder-only non-normative changes

Over VTM7.0 CTC Anchor (%)		Y	Cb	Cr	EncT	DecT	
1	MER = 8x8	RA	1.29	1.73	1.84	80%	98%
		LB	1.67	2.42	2.35	81%	97%
2	MER = 16x16	RA	3.08	3.71	3.92	62%	98%
		LB	3.82	4.92	4.60	63%	98%
3	MER = 32x32	RA	3.23	3.33	3.55	67%	96%
		LB	3.82	4.36	4.25	68%	97%
4	MER = 64x64	RA	3.18	3.01	3.27	101%	95%
		LB	3.82	3.72	3.73	99%	97%

Introduction

- Merge estimation region (MER) in HEVC
 - Estimate costs of merging candidates in parallel for different CUs in one MER at the encoder side
 - MERs are non-overlapping square regions
 - When MER is applied, a spatial merging candidate can be added into merging candidate list only when the current CU and the neighboring CU are in the different MERs

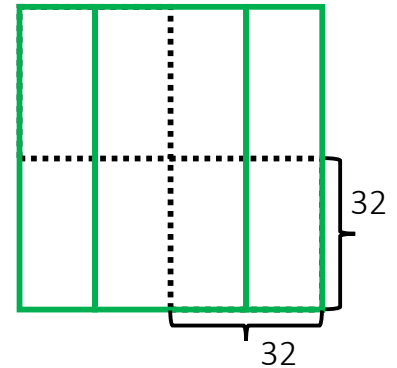


Proposed Method

- Proposed to add the HEVC-based MER to VVC
- Also consider subblock-based merging candidates
 - SbTMVP
 - Inherited affine merging candidates
 - Constructed affine merging candidates

Proposed Method

- Two encoder-only non-normative are needed
 - In order to guarantee parallel processing
- 1. For BT and TT split in inter slice
 - Any CU that is not smaller than MER size has to contain one or multiple complete MERs
 - Any CU that is smaller than MER size has to locate within one MER
 - When (CU width > MER width || CU height > MER height)
 - When (CU height <= MER height) -> disallow horizontal BT split
 - When (CU width <= MER width) -> disallow vertical BT split
 - When (CU height <= 2xMER height) -> disallow horizontal TT split
 - When (CU width <= 2xMER width) -> disallow vertical TT split
- 2. For HMVP merging candidates
 - To break the dependency caused by updating HMVP table
 - For any CU that is contained within one MER, HMVP candidates and merging candidates after HMVP in the merging candidate list are not used
 - Affects four merge modes (inter regular merge mode, MMVD, CIIP, and GEO)



Simulation Results

MER = 8x8

MER = 16x16

	Random access Main10					Random access Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1	0.47%	0.39%	0.65%	84%	97%	1.77%	2.06%	2.74%	64%	96%
Class A2	1.06%	1.68%	1.75%	82%	102%	3.59%	4.93%	4.82%	64%	100%
Class B	1.07%	1.54%	1.54%	80%	97%	2.95%	3.56%	3.62%	63%	97%
Class C	2.38%	3.00%	3.18%	75%	98%	3.86%	4.23%	4.50%	59%	100%
Class E										
Overall	1.29%	1.73%	1.84%	80%	98%	3.08%	3.71%	3.92%	62%	98%
Class D	2.54%	3.41%	3.43%	74%	97%	3.28%	3.38%	3.69%	62%	97%
Class F	1.92%	2.52%	2.62%	84%	102%	2.93%	3.39%	3.58%	73%	101%

	Low delay B Main10					Low delay B Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1										
Class A2										
Class B	1.19%	1.74%	2.11%	82%	98%	3.34%	4.64%	4.60%	62%	97%
Class C	2.61%	3.43%	3.61%	75%	97%	4.52%	5.53%	5.48%	57%	98%
Class E	1.23%	2.20%	1.07%	89%	98%	3.70%	4.59%	3.41%	75%	98%
Overall	1.67%	2.42%	2.35%	81%	97%	3.82%	4.92%	4.60%	63%	98%
Class D	3.16%	4.85%	4.68%	72%	97%	4.12%	4.85%	5.26%	60%	98%
Class F	3.91%	4.65%	6.48%	81%	98%	5.64%	6.68%	7.71%	69%	100%

Simulation Results

MER = 32x32

MER = 64x64

	Random access Main10					Random access Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1	2.51%	2.74%	3.39%	60%	96%	1.87%	1.51%	2.13%	100%	96%
Class A2	3.81%	4.40%	4.40%	67%	98%	3.10%	3.50%	3.68%	103%	96%
Class B	3.18%	3.12%	3.14%	67%	95%	3.30%	2.73%	2.76%	101%	94%
Class C	3.42%	3.24%	3.54%	72%	96%	4.08%	4.11%	4.47%	100%	95%
Class E										
Overall	3.23%	3.33%	3.55%	67%	96%	3.18%	3.01%	3.27%	101%	95%
Class D	2.99%	2.84%	3.10%	79%	96%	3.83%	3.83%	4.16%	99%	97%
Class F	2.29%	2.41%	2.61%	79%	97%	2.07%	2.28%	2.33%	102%	100%

	Low delay B Main10					Low delay B Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1										
Class A2										
Class B	3.67%	4.28%	4.46%	64%	96%	3.67%	3.09%	3.27%	101%	96%
Class C	3.92%	4.31%	4.55%	72%	97%	4.89%	5.06%	5.51%	99%	97%
Class E	3.93%	4.57%	3.49%	70%	99%	2.66%	3.00%	2.11%	97%	98%
Overall	3.82%	4.36%	4.25%	68%	97%	3.82%	3.72%	3.73%	99%	97%
Class D	3.72%	4.29%	4.39%	79%	97%	4.84%	5.16%	7.05%	98%	96%
Class F	4.00%	4.63%	5.36%	74%	99%	3.21%	3.84%	4.29%	99%	99%

Additional Experiment

- Alternative all encoder-only non-normative design
 - Simply disables inter merge modes in CUs smaller than MER (e.g. CU Area < 32x32)
 - Sequential processing problem in merge mode can also be solved

Additional Experiment Results

Alternative all encoder-only non-normative
(CU Area < (32x32))

MER = 32x32

	Random access Main10					Random access Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1	2.51%	2.74%	3.39%	60%	96%	2.30%	2.07%	2.66%	94%	97%
Class A2	3.81%	4.40%	4.40%	67%	98%	4.14%	4.85%	5.05%	94%	98%
Class B	3.18%	3.12%	3.14%	67%	95%	4.86%	4.12%	4.22%	94%	94%
Class C	3.42%	3.24%	3.54%	72%	96%	6.69%	6.83%	7.18%	90%	97%
Class E										
Overall	3.23%	3.33%	3.55%	67%	96%	4.69%	4.58%	4.86%	93%	96%
Class D	2.99%	2.84%	3.10%	79%	96%	6.67%	6.37%	6.75%	90%	94%
Class F	2.29%	2.41%	2.61%	79%	97%	3.72%	4.27%	4.46%	97%	98%

	Low delay B Main10					Low delay B Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1										
Class A2										
Class B	3.67%	4.28%	4.46%	64%	96%	6.76%	6.31%	6.12%	89%	93%
Class C	3.92%	4.31%	4.55%	72%	97%	8.86%	9.74%	10.53%	83%	96%
Class E	3.93%	4.57%	3.49%	70%	99%	6.98%	6.95%	6.63%	93%	98%
Overall	3.82%	4.36%	4.25%	68%	97%	7.52%	7.61%	7.72%	88%	95%
Class D	3.72%	4.29%	4.39%	79%	97%	8.46%	10.03%	10.63%	86%	97%
Class F	4.00%	4.63%	5.36%	74%	99%	6.30%	7.44%	8.24%	92%	97%

Additional Experiment Results

Alternative all encoder-only non-normative
(CU Area < (64x64))

MER = 64x64

	Random access Main10					Random access Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1	1.87%	1.51%	2.13%	100%	96%	4.97%	4.18%	5.12%	95%	96%
Class A2	3.10%	3.50%	3.68%	103%	96%	6.65%	7.29%	7.61%	97%	97%
Class B	3.30%	2.73%	2.76%	101%	94%	7.19%	6.27%	6.38%	98%	92%
Class C	4.08%	4.11%	4.47%	100%	95%	8.54%	8.85%	9.16%	93%	90%
Class E										
Overall	3.18%	3.01%	3.27%	101%	95%	7.00%	6.74%	7.11%	96%	93%
Class D	3.83%	3.83%	4.16%	99%	97%	9.27%	9.07%	9.58%	94%	90%
Class F	2.07%	2.28%	2.33%	102%	100%	5.24%	6.00%	6.12%	100%	93%

	Low delay B Main10					Low delay B Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1										
Class A2										
Class B	3.67%	3.09%	3.27%	101%	96%	9.16%	9.04%	8.85%	91%	95%
Class C	4.89%	5.06%	5.51%	99%	97%	10.18%	11.50%	12.23%	83%	95%
Class E	2.66%	3.00%	2.11%	97%	98%	13.33%	13.72%	13.09%	97%	98%
Overall	3.82%	3.72%	3.73%	99%	97%	10.55%	11.03%	11.04%	90%	96%
Class D	4.84%	5.16%	7.05%	98%	96%	9.79%	11.01%	13.24%	85%	96%
Class F	3.21%	3.84%	4.29%	99%	99%	8.83%	9.98%	11.30%	93%	98%

Conclusion

- Propose to add the HEVC-based MER to VVC
 - With proper encoder-only non-normative changes, parallel merge at the encoder side can be guaranteed
 - Real-time encoder is less challenging with MER
 - More BD-rate savings compared with alternative all encoder-only non-normative design
- MER is a commonly used tool for a commercial real-time hardware encoder
 - In our survey of HEVC hardware encoders from major mobile device providers, MER is activated in most cases
- Thanks to Huawei for cross-checking

Alternative all encoder-only non-normative
+ BT/TT encoder constraint same as MER
(CU Area < (32x32))

MER = 32x32

	Random access Main10					Random access Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1	2.51%	2.74%	3.39%	60%	96%	3.89%	4.05%	4.91%	59%	101%
Class A2	3.81%	4.40%	4.40%	67%	98%	6.54%	7.58%	7.72%	63%	98%
Class B	3.18%	3.12%	3.14%	67%	95%	6.32%	5.87%	5.84%	64%	94%
Class C	3.42%	3.24%	3.54%	72%	96%	7.66%	7.79%	8.16%	65%	98%
Class E										
Overall	3.23%	3.33%	3.55%	67%	96%	6.24%	6.36%	6.65%	63%	97%
Class D	2.99%	2.84%	3.10%	79%	96%	7.25%	6.92%	7.18%	71%	94%
Class F	2.29%	2.41%	2.61%	79%	97%	4.91%	5.54%	5.74%	77%	99%

	Low delay B Main10					Low delay B Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1										
Class A2										
Class B	3.67%	4.28%	4.46%	64%	96%	8.72%	9.51%	8.95%	57%	95%
Class C	3.92%	4.31%	4.55%	72%	97%	9.97%	11.04%	12.09%	61%	99%
Class E	3.93%	4.57%	3.49%	70%	99%	10.24%	10.55%	9.66%	67%	98%
Overall	3.82%	4.36%	4.25%	68%	97%	9.52%	10.28%	10.17%	61%	97%
Class D	3.72%	4.29%	4.39%	79%	97%	9.23%	10.29%	11.78%	67%	96%
Class F	4.00%	4.63%	5.36%	74%	99%	8.77%	10.48%	11.42%	69%	98%

Alternative all encoder-only non-normative
+ BT/TT encoder constraint same as MER
(CU Area < (64x64))

MER = 64x64

	Random access Main10					Random access Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1	1.87%	1.51%	2.13%	100%	96%	4.97%	4.18%	5.12%	95%	96%
Class A2	3.10%	3.50%	3.68%	103%	96%	6.65%	7.29%	7.61%	97%	97%
Class B	3.30%	2.73%	2.76%	101%	94%	7.19%	6.27%	6.38%	98%	92%
Class C	4.08%	4.11%	4.47%	100%	95%	8.54%	8.85%	9.16%	93%	90%
Class E										
Overall	3.18%	3.01%	3.27%	101%	95%	7.00%	6.74%	7.11%	96%	93%
Class D	3.83%	3.83%	4.16%	99%	97%	9.27%	9.07%	9.58%	94%	90%
Class F	2.07%	2.28%	2.33%	102%	100%	5.24%	6.00%	6.12%	100%	93%

	Low delay B Main10					Low delay B Main10				
	Over VTM-7.0					Over VTM-7.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1										
Class A2										
Class B	3.67%	3.09%	3.27%	101%	96%	9.16%	9.04%	8.85%	91%	95%
Class C	4.89%	5.06%	5.51%	99%	97%	10.18%	11.50%	12.23%	83%	95%
Class E	2.66%	3.00%	2.11%	97%	98%	13.33%	13.72%	13.09%	97%	98%
Overall	3.82%	3.72%	3.73%	99%	97%	10.55%	11.03%	11.04%	90%	96%
Class D	4.84%	5.16%	7.05%	98%	96%	9.79%	11.01%	13.24%	85%	96%
Class F	3.21%	3.84%	4.29%	99%	99%	8.83%	9.98%	11.30%	93%	98%