



MEDIATEK

JVET-L0100

CE10.1: Combined and multi-hypothesis prediction (CE10.1.1.a, CE10.1.1.b, CE10.1.1.c, CE10.1.1.d)

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Overall Summary

- In CE10, combined prediction is used to improve the inter prediction
- Combined prediction using multi-hypothesis in JVET-L0100 is tested in CE10.1.1.a to CE10.1.1.d

#	Config.	VTM-2.0.1					Supported modes
		Y	U	V	EncT	DecT	
CE10.1.1.a	RA	-0.31%	-0.27%	-0.30%	109%	101%	AMVP (uni-)
	LB	-0.17%	-0.14%	-0.28%	110%	102%	
CE10.1.1.b	RA	-0.55%	-0.62%	-0.73%	106%	104%	skip/merge
	LB	-0.35%	-0.18%	-0.21%	108%	103%	
CE10.1.1.c	RA	-0.51%	-0.41%	-0.50%	108%	103%	merge
	LB	-0.50%	-0.90%	-0.83%	109%	103%	
CE10.1.1.d	RA	-1.05%	-1.20%	-1.17%	115%	105%	skip/merge AMVP (uni-)
	LB	-0.65%	-0.81%	-0.82%	118%	104%	

CE10.1.1.a: Multi-hypothesis Prediction for Improving AMVP Mode

- One flag is signaled for uni-prediction of AMVP mode
- One more merge index is signaled when the flag is true
 - Reuse merge candidate list without sub-CU candidates
- Enabled for CUs with luma CB area larger than or equal to 64 and is only applied to L1 when in low delay B pictures

Random Access Main 10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1	-0.28%	-0.29%	-0.20%	108%	97%
Class A2	-0.21%	-0.28%	-0.26%	109%	103%
Class B	-0.46%	-0.48%	-0.48%	109%	101%
Class C	-0.21%	-0.01%	-0.18%	110%	103%
Class E					
Overall	-0.31%	-0.27%	-0.30%	109%	101%
Class D	-0.23%	-0.32%	-0.29%	110%	103%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

Low delay B Main10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.16%	-0.12%	-0.22%	110%	100%
Class C	-0.11%	-0.23%	-0.35%	110%	102%
Class E	-0.27%	-0.05%	-0.29%	111%	103%
Overall	-0.17%	-0.14%	-0.28%	110%	102%
Class D	-0.08%	0.18%	-0.08%	110%	102%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

CE10.1.1.a: Multi-hypothesis Prediction for Improving AMVP Mode

Random Access Main 10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1	-0.28%	-0.29%	-0.20%	108%	97%
Class A2	-0.21%	-0.28%	-0.26%	109%	103%
Class B	-0.46%	-0.48%	-0.48%	109%	101%
Class C	-0.21%	-0.01%	-0.18%	110%	103%
Class E					
Overall	-0.31%	-0.27%	-0.30%	109%	101%
Class D	-0.23%	-0.32%	-0.29%	110%	103%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

Low delay B Main10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.16%	-0.12%	-0.22%	110%	100%
Class C	-0.11%	-0.23%	-0.35%	110%	102%
Class E	-0.27%	-0.05%	-0.29%	111%	103%
Overall	-0.17%	-0.14%	-0.28%	110%	102%
Class D	-0.08%	0.18%	-0.08%	110%	102%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

CE10.1.1.b: Multi-hypothesis Prediction for Improving Skip or Merge Mode

- One flag is signaled for merge mode
- An extra merge indexed prediction is implicitly derived as the succeeding merge candidate when the flag is true
 - Sub-CU candidates (e.g., affine, ATMVP) are excluded from the candidate list
- For low delay B pictures, multi-hypothesis prediction is not applied to skip mode
- For bandwidth reduction, 2-tap interpolation filter is used in motion compensation for both the original hypothesis and the additional hypothesis

Bandwidth (required access samples per sample) for luma and chroma

W	4	8	8	16	16
H	4	8	16	8	16
normal merge: bi	21.375	10.09375	7.796875	7.796875	6.023438
MH: bi	42.75	20.1875	15.59375	15.59375	12.04688
CE10.1.1.b	10.75	8.1875	7.59375	7.59375	7.046875

CE10.1.1.b: Multi-hypothesis Prediction for Improving Skip or Merge Mode

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Random Access Main 10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1	-0.62%	-0.69%	-0.96%	104%	101%
Class A2	-0.35%	-0.60%	-0.63%	106%	107%
Class B	-0.90%	-0.95%	-0.92%	106%	103%
Class C	-0.21%	-0.18%	-0.38%	108%	106%
Class E					
Overall	-0.55%	-0.62%	-0.73%	106%	104%
Class D	-0.03%	-0.08%	-0.13%	109%	104%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

Low delay B Main10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.52%	-0.39%	-0.17%	108%	101%
Class C	-0.27%	-0.04%	-0.34%	109%	104%
Class E	-0.17%	0.00%	-0.10%	107%	103%
Overall	-0.35%	-0.18%	-0.21%	108%	103%
Class D	-0.02%	0.57%	-0.14%	110%	104%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

CE10.1.1.c: Multi-hypothesis Prediction for Improving Intra Mode

- One flag is signaled for merge mode
- One more intra mode index is signaled when the flag is true
 - For luma, the intra candidate list includes DC, planar, horizontal, and vertical modes
 - For chroma, DM is always applied without extra signaling
- When the CU width is larger than the double of CU height, horizontal mode is removed
- When the CU height is larger than the double of CU width, vertical mode is removed

CE10.1.1.c: Multi-hypothesis Prediction for Improving Intra Mode

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Random Access Main 10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1	-0.45%	-0.29%	-0.30%	107%	102%
Class A2	-0.44%	-0.46%	-0.65%	109%	103%
Class B	-0.57%	-0.49%	-0.46%	108%	103%
Class C	-0.53%	-0.37%	-0.60%	110%	105%
Class E					
Overall	-0.51%	-0.41%	-0.50%	108%	103%
Class D	-0.33%	-0.23%	-0.48%	110%	103%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

Low delay B Main10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.53%	-1.06%	-0.83%	108%	100%
Class C	-0.56%	-0.69%	-1.08%	110%	105%
Class E	-0.37%	-0.91%	-0.51%	107%	105%
Overall	-0.50%	-0.90%	-0.83%	109%	103%
Class D	-0.37%	-0.97%	-1.43%	110%	104%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

CE10.1.1.c for CU size ≥ 64 luma samples

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Random Access Main 10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1	-0.48%	-0.27%	-0.42%	107%	98%
Class A2	-0.44%	-0.41%	-0.57%	108%	106%
Class B	-0.56%	-0.54%	-0.52%	108%	109%
Class C	-0.49%	-0.32%	-0.42%	109%	104%
Class E					
Overall	-0.50%	-0.40%	-0.48%	108%	105%
Class D	-0.26%	-0.28%	-0.21%	109%	102%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

Low delay B Main10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.52%	-1.01%	-1.00%	107%	99%
Class C	-0.50%	-0.51%	-1.01%	109%	104%
Class E	-0.35%	-0.91%	-0.89%	107%	106%
Overall	-0.47%	-0.82%	-0.98%	108%	102%
Class D	-0.33%	-0.28%	-1.18%	109%	105%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

CE10.1.1.d: Combined Test

CE10.1.1.d + CE4.4.12

- In CE10.1.1.d, CE10.1.1.a, CE10.1.1.b, and CE10.1.1.c are combined
 - Enabled for CBs with the CB area larger than or equal to 64
- CE10.1.1.d and CE4.4.12 are jointly tested with merge list size as 6
 - The candidates for multi-hypothesis are from the merge list where HEVC combined candidates are replaced with pairwise average candidates

CE10.1.1.d	Random Access Main 10				
	Over VTM-2.0.1				
	Y	U	V	EncT	
Class A1	-1.08%	-1.24%	-1.40%	113%	101%
Class A2	-0.77%	-1.12%	-1.08%	116%	106%
Class B	-1.50%	-1.70%	-1.41%	115%	106%
Class C	-0.66%	-0.62%	-0.75%	117%	106%
Class E					
Overall	-1.05%	-1.20%	-1.17%	115%	105%
Class D	-0.34%	-0.32%	-0.29%	119%	105%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

	Low delay B Main10				
	Over VTM-2.0.1				
	Y	U	V	EncT	
Class A1					
Class A2					
Class B	-0.94%	-1.23%	-0.90%	118%	102%
Class C	-0.59%	-0.49%	-0.85%	118%	105%
Class E	-0.26%	-0.54%	-0.64%	117%	105%
Overall	-0.65%	-0.81%	-0.82%	118%	104%
Class D	-0.31%	-0.16%	-1.00%	119%	104%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

CE10.1.1.d + CE4.4.12	Random Access Main 10				
	Over VTM-2.0.1				
	Y	U	V	EncT	
Class A1	-1.33%	-1.50%	-1.55%	113%	105%
Class A2	-1.02%	-1.19%	-1.26%	116%	107%
Class B	-1.73%	-1.81%	-1.62%	115%	104%
Class C	-0.92%	-0.83%	-0.97%	117%	106%
Class E					
Overall	-1.29%	-1.36%	-1.36%	116%	105%
Class D	-0.64%	-0.70%	-0.61%	118%	104%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

	Low delay B Main10				
	Over VTM-2.0.1				
	Y	U	V	EncT	
Class A1					
Class A2					
Class B	-0.96%	-1.14%	-1.25%	118%	102%
Class C	-0.69%	-0.64%	-0.85%	119%	105%
Class E	-0.26%	-0.54%	-0.55%	117%	105%
Overall	-0.70%	-0.82%	-0.94%	118% ¹⁰	104%
Class D	-0.29%	-0.17%	-0.83%	119%	104%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

CE10.1.1.b + CE10.1.1.c

- CE10.1.1.b and CE10.1.1.c are combined.

Random Access Main 10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1	-0.80%	-0.88%	-1.07%	105%	106%
Class A2	-0.57%	-0.76%	-0.74%	107%	106%
Class B	-1.15%	-1.28%	-1.14%	106%	107%
Class C	-0.46%	-0.43%	-0.58%	108%	108%
Class E					
Overall	-0.78%	-0.87%	-0.90%	106%	107%
Class D	-0.18%	-0.09%	-0.03%	109%	104%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

Low delay B Main10					
Over VTM-2.0.1					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.75%	-0.92%	-1.07%	108%	102%
Class C	-0.43%	-0.51%	-0.70%	108%	105%
Class E	-0.19%	-0.27%	-0.74%	107%	105%
Overall	-0.50%	-0.62%	-0.86%	108%	104%
Class D	-0.18%	-0.39%	-0.63%	108%	104%
Class F (optional)	#VALUE!	#VALUE!	#VALUE!	100%	100%

Conclusions

- In this contribution, multi-hypothesis prediction is used to improve uni-prediction of AMVP mode, skip or merge mode, and intra mode
 - Only require weighted averaging on existing modes without complex search operations on the decoder side
 - Provide additive gain when combining with other proposal related to merge mode
 - The worst case bandwidth for multi-hypothesis prediction is half of the original worst case bandwidth
 - On top of VTM-2.0.1, it can achieve -1.05% and -0.65% luma BD-rates for RA and LB, respectively
- It is suggested to consider combined prediction using multi-hypothesis into the test model.