MEDIATEK

JVET-K0255
CE9.5.2: BIO with simplified gradient calculation, adaptive BIO granularity, and applying BIO to chroma components

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Overall Summary

- BIO with simplified gradient calculation is proposed
  - Apply 3-tap filter, [-1, 0, 1] to MC results to derive gradients instead of using one set of gradient filters and one set of 6-tap interpolation filters
  - No memory bandwidth increase by applying padding
  - Division is replaced by shift operations only
- Experimental results

	VTM-1.0-RA			BMS-1.0-RA		
	Y	U	V	Y	U	V
BD-rate	-2.86%	-0.94%	-0.65%	-1.28%	-0.49%	-0.46%
Run Time	EncT: 108%; DecT: 146%			EncT: 104%; DecT: 118%		

Proposed Method: Simplified Gradient Calculation

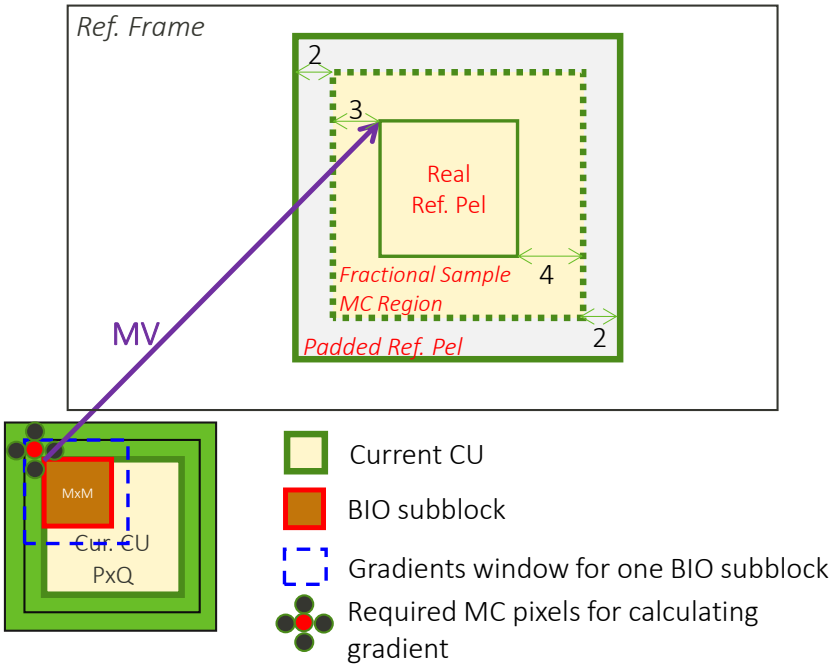
- BIO refines the bi-prediction predictor by using sample gradients and the derived displacement vector (v_x, v_y)

$$P_{\mathrm{BIO}}[i,j] = (P^{(0)}[i,j] + P^{(1)}[i,j] + v_x[i,j]\left(I_x^{(0)}[i,j] - I_x^{(1)}[i,j]\right)/2 + v_y[i,j]\left(I_y^{(0)}[i,j] - I_y^{(1)}[i,j]\right)/2 + 1) >> 1$$

- In JEM version, one motion-phase-dependent gradient filter set and 6-tap interpolation filters are used to derive gradients, (I_x , I_y).
- Proposed method
  - Apply 3-tap filter [-1, 0, 1] on MC results directly to generate gradients instead of motion-phase-dependent gradient and interpolation filters
  - One MxN BIO block needs (1+M+1)x(1+N+1) gradients, so the required size of MC results is increased to (2+M+2)x(2+N+2)

Proposed Methods: Memory Bandwidth Reduction

- Need the reference pixels of size (3+2+M+2+4)x(3+2+N+2+4) because of MC results of size (2+M+2)x(2+N+2)
  - Generate the required reference pixels of size (3+2+M+2+4)x(3+2+N+2+4) by using padding from the reference pixels of size (3+M+4)x(3+N+4)
  - Bandwidth is reduced to that without BIO
- Division used to derive the displacement vector is replaced by shift operation only



Simulation Results

- Implemented on top of BMS1.0
- Compared to JEM version
  - Remove one set of gradient filters and one set of 6-tap interpolation filters
  - Division-free operations
  - Only half encoding time and decoding time increases are required with 0.02% and 0.17% BD-rate loss for VTM-1.0-RA and BMS-1.0-RA.

	Proposed	VTM-1.0-RA			BMS-1.0-RA		
		Y	U	V	Y	U	V
Proposed	BD-rate	-2.86%	-0.94%	-0.65%	-1.28%	-0.49%	-0.46%
	Run Time	EncT: 108%; DecT: 146%			EncT: 104%; DecT: 118%		
JEM BIO	BD-rate	-2.88%	-1.06%	-0.76%	-1.45%	-0.58%	-0.48%
	Run Time	EncT: 116%; DecT: 190%			EncT: 106%; DecT: 136%		

Conclusions

- Proposed simplified gradient calculation in BIO
  - Apply 3-tap filter, [-1, 0, 1] to MC results to derive gradients instead of using one set of gradient filters and one set of 6-tap interpolation filters
  - Memory bandwidth of accessing reference samples during BIO MC is kept the same as that for non-BIO MC by applying padding
  - Division is replaced by shift operations only
- Experimental results
  - VTM-1.0-RA: 2.86% BD-rate saving with 8% encoding time increase and 46% decoding time increase
  - BMS-1.0-RA: 1.28% BD-rate saving with 4% encoding time increase and 18% decoding time increase
- Thanks Qualcomm for cross-checking

Thank you

Proposed Method: Adaptive BIO Granularity

- The block size in BIO is 4x4 for high resolution videos
- If the number of luma samples in one picture is smaller than or equal to 921600 (i.e., 1280x720), the BIO block size is reduced to 2x2
- Additional 0.24% and 0.14% BD-rate gains can be achieved for Class D in VTM-1.0-RA and BMS-1.0-RA.

	Random Access Main 10									
	Over VTM-1.0					Over BMS-1.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1	-1.69%	-0.82%	-0.44%	108%	152%	-0.80%	-0.29%	-0.19%	104%	119%
Class A2	-4.45%	-0.89%	-0.41%	108%	157%	-1.84%	-0.56%	-0.47%	104%	119%
Class B	-2.87%	-0.93%	-0.70%	110%	152%	-1.21%	-0.50%	-0.40%	105%	120%
Class C	-2.49%	-0.99%	-0.94%	116%	163%	-1.29%	-0.54%	-0.53%	106%	130%
Class E										
Overall	-2.85%	-0.92%	-0.66%	111%	156%	-1.28%	-0.48%	-0.41%	105%	122%
Class D	-4.29%	-1.86%	-1.76%	117%	165%	-2.05%	-1.04%	-0.95%	106%	128%
Class F (optional)	0.29%	0.08%	0.07%	117%	164%	0.01%	0.01%	0.09%	105%	134%

Proposed Method: Applying BIO to Chroma Components

- Extend BIO to chroma components by reusing the luma displacement vector
  - Change the gradient filter from 3-tap filter to 2-tap filter at chroma CU boundaries
- Additional 1.47% and 0.75% chroma BD-rate gains can be achieved in VTM-1.0-RA and BMS-1.0-RA.

	Random Access Main 10									
	Over VTM-1.0					Over BMS-1.0				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
Class A1	-1.69%	-1.28%	-1.49%	109%	157%	-0.82%	-0.76%	-1.00%	104%	120%
Class A2	-4.66%	-3.46%	-3.68%	108%	163%	-1.98%	-1.71%	-1.82%	105%	122%
Class B	-2.87%	-2.09%	-2.09%	111%	157%	-1.20%	-1.03%	-1.04%	105%	124%
Class C	-2.54%	-2.20%	-2.14%	112%	147%	-1.33%	-1.16%	-1.28%	105%	122%
Class E										
Overall	-2.90%	-2.23%	-2.30%	110%	155%	-1.31%	-1.15%	-1.25%	105%	122%
Class D	-4.04%	-3.13%	-3.35%	112%	150%	-1.91%	-1.71%	-1.73%	105%	120%
Class F (optional)	0.14%	-0.31%	-0.32%	113%	149%	-0.05%	-0.11%	-0.15%	105%	127%