

Tencent 腾讯 interdigital

JVET-AA0088

EE1-1.5: neural network based in-loop filter
with a single model

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Introduction

- This contribution reports the EE results for the NN based in-loop filter with 1 model.
- In this meeting, three training cross-checking tests were conducted. All the cross-checking tests have been finished successfully with **a maximum 0.04% difference** to the target performance.
- Meanwhile, base on the previous proposal, the model is further fine-tuned and model quantization is studied.
- In addition to two sub-tests in EE1-1.5, another optimized implementation is designed to reduce the running time or refine the trade-off. The PixelShuffle module and the skip connection from the input to the output and are revised to be conducted by C code instead of SADL.
 - The modification of PixelShuffle module is to reduce the running time by removing the redundant calculation.
 - The modification of skip connection may be helpful to finish the model quantization more easily on SADL.

Result

Test 1.5.2: Optimize the float SADL implementation based on JVET-Z0091.

EE1-1.5.2
float

		All Intra Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		-8.51%	-6.11%	-14.20%	-17.27%	247%	76923%
Class A2		-7.92%	-5.74%	-15.94%	-12.97%	180%	61888%
Class B		-8.46%	-5.92%	-14.97%	-17.20%	169%	60875%
Class C		-9.05%	-6.37%	-16.30%	-17.94%	140%	45995%
Class E		-10.55%	-8.78%	-15.31%	-16.40%	182%	71264%
Overall		-8.86%	-6.50%	-15.35%	-16.54%	177%	61224%
Class D		-9.05%	-6.41%	-15.43%	-18.52%	136%	49787%
Class F		-5.98%	-4.04%	-11.92%	-11.72%	134%	53680%

		Random access Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		-11.15%	-9.31%	-14.86%	-18.51%	178%	113825%
Class A2		-11.44%	-9.56%	-19.63%	-14.53%	171%	108569%
Class B		-11.41%	-8.51%	-19.42%	-20.80%	179%	115788%
Class C		-11.40%	-8.36%	-20.57%	-20.45%	156%	101829%
Class E							
Overall		-11.36%	-8.84%	-18.86%	-18.99%	171%	110080%
Class D		-12.14%	-9.53%	-19.62%	-20.32%	159%	109075%
Class F		-5.79%	-3.78%	-12.25%	-11.38%	228%	49417%

EE1-1.5.2
Addition
float

		All Intra Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class A2		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class B		-8.57%	-5.93%	-15.56%	-17.45%	164%	56043%
Class C		-9.11%	-6.38%	-16.47%	-18.12%	134%	38899%
Class E		-10.56%	-8.81%	-15.27%	-16.32%	176%	65033%
Overall		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class D		-9.06%	-6.40%	-15.48%	-18.58%	127%	36448%
Class F		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!

		Random access Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class A2		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class B		-11.48%	-8.59%	-19.48%	-20.83%	173%	106725%
Class C		-11.51%	-8.50%	-20.61%	-20.51%	147%	86818%
Class E							
Overall		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class D		-12.29%	-9.68%	-19.86%	-20.39%	143%	80331%
Class F		-5.84%	-3.85%	-12.18%	-11.45%	216%	45043%

The running time drops obviously, especially for the decoder.

Result

Test 1.5.3: Optimize the integer SADL implementation based on JVET-Z0091.

EE1-1.5.3
int16

		All Intra Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		-8.36%	-5.98%	-14.23%	-16.76%	248%	77028%
Class A2		-7.92%	-5.72%	-15.91%	-13.17%	180%	61837%
Class B		-8.45%	-5.91%	-15.19%	-16.99%	168%	60971%
Class C		-9.03%	-6.53%	-15.12%	-17.90%	140%	46114%
Class E		-10.54%	-8.88%	-14.81%	-16.26%	182%	71589%
Overall		-8.83%	-6.52%	-15.07%	-16.40%	177%	61338%
Class D		-8.74%	-6.56%	-13.32%	-17.23%	135%	49828%
Class F		-6.17%	-4.24%	-11.83%	-12.11%	134%	52423%

		Random access Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		-11.42%	-9.33%	-16.11%	-19.27%	178%	114212%
Class A2		-11.57%	-9.72%	-19.34%	-14.92%	172%	108495%
Class B		-11.30%	-8.55%	-18.66%	-20.50%	179%	115502%
Class C		-11.48%	-8.59%	-19.56%	-20.76%	156%	101751%
Class E							
Overall		-11.43%	-8.95%	-18.52%	-19.21%	171%	110026%
Class D		-12.21%	-9.78%	-18.84%	-20.16%	159%	109821%
Class F		-6.00%	-4.04%	-11.50%	-12.23%	229%	47213%

EE1-1.5.3
Addition
Real-int16

		All Intra Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class A2		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class B		-8.57%	-5.93%	-15.54%	-17.46%	142%	36131%
Class C		-9.13%	-6.41%	-16.42%	-18.17%	124%	25192%
Class E		-10.54%	-8.83%	-15.25%	-16.12%	150%	41937%
Overall		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class D		-9.04%	-6.41%	-15.30%	-18.56%	117%	23357%
Class F		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!

		Random access Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class A2		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class B		-11.45%	-8.59%	-19.23%	-20.83%	147%	68860%
Class C		-11.56%	-8.50%	-20.77%	-20.72%	130%	55951%
Class E							
Overall		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class D		-12.36%	-9.78%	-19.80%	-20.45%	127%	51976%
Class F		-5.79%	-3.81%	-12.15%	-11.31%	176%	28989%

Result

EE1-1.5.2
Addition
float

		All Intra Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class A2		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class B		-8.57%	-5.93%	-15.56%	-17.45%	164%	56043%
Class C		-9.11%	-6.38%	-16.47%	-18.12%	134%	38899%
Class E		-10.56%	-8.81%	-15.27%	-16.32%	176%	65033%
Overall		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class D		-9.06%	-6.40%	-15.48%	-18.58%	127%	36448%
Class F		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!

		Random access Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class A2		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class B		-11.48%	-8.59%	-19.48%	-20.83%	173%	106725%
Class C		-11.51%	-8.50%	-20.61%	-20.51%	147%	86818%
Class E							
Overall		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class D		-12.29%	-9.68%	-19.86%	-20.39%	143%	80331%
Class F		-5.84%	-3.85%	-12.18%	-11.45%	216%	45043%

EE1-1.5.3
Addition
Real-int16

		All Intra Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class A2		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class B		-8.57%	-5.93%	-15.54%	-17.46%	142%	36131%
Class C		-9.13%	-6.41%	-16.42%	-18.17%	124%	25192%
Class E		-10.54%	-8.83%	-15.25%	-16.12%	150%	41937%
Overall		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class D		-9.04%	-6.41%	-15.30%	-18.56%	117%	23357%
Class F		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!

		Random access Main10					
		BD-rate Over VTM-11.0_nnvc-1.0					
		YUV-PSNR	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class A2		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class B		-11.45%	-8.59%	-19.23%	-20.83%	147%	68860%
Class C		-11.56%	-8.50%	-20.77%	-20.72%	130%	55951%
Class E							
Overall		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#NUM!	#NUM!
Class D		-12.36%	-9.78%	-19.80%	-20.45%	127%	51976%
Class F		-5.79%	-3.81%	-12.15%	-11.31%	176%	28989%

Compared with the results of the float implementation, the performance can be nearly maintained when using the real-int16 implementation. Meanwhile, the running time drops obviously.

Conclusion

- By further fine-tuning the model, an up to 8.8% (RA-Y) BD-rate saving can be achieved by the NN based in-loop filter with 1 model.
- The trade-off between performance and memory size can be further optimized by model quantization.
 - The performance is nearly maintained, meanwhile the memory size is reduced by half and running time is also decreased.
- Recommend to adopt the real-int16 implementation into the common base software.

Thank  HUAWEI  OPPO  Qualcomm for crosschecking.



Thanks