



JVET-AD0106

EE1-1.6: IN-LOOP FILTER WITH WIDE ACTIVATION AND LARGE RECEPTIVE FIELD

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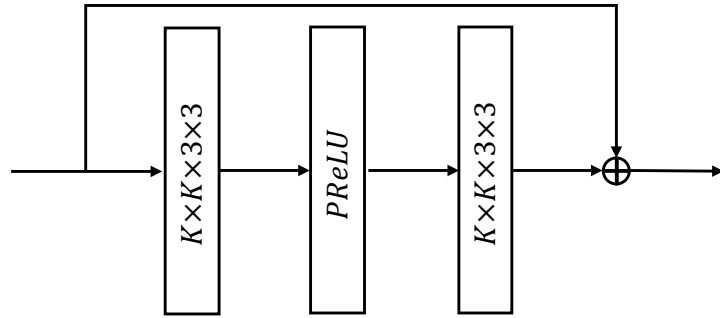
Samuel Eadie, Yun Li, Dmytro Rusanovsky, Marta Karczewicz (Qualcomm)



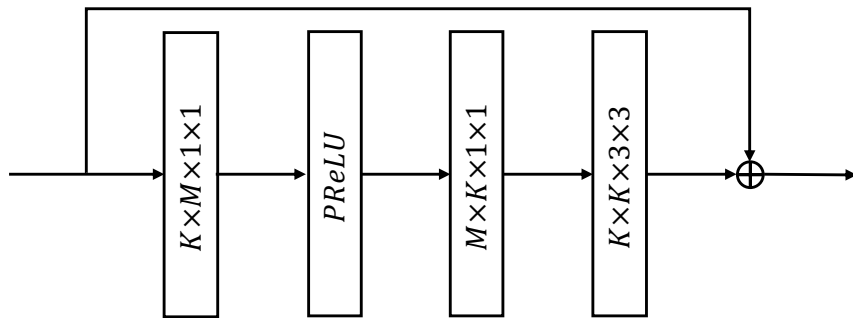
Overview

- EE1-1.6.1: combine strengths of residual blocks in filter set #0 and filter set #1, process intra and inter with unified models, aggressively simplify the chroma model
 - *Compared with current filter set #1*
 - 16% kMAC/pixel reduction, 34% model memory reduction
 - RA: -1.52%, -2.65%, -0.95%, LDB: -2.91%, -4.45%, -3.60%, AI: -0.99%, -0.20%, 1.55%
 - *Compared with NNVC-4.0 anchor*
 - RA: -11.04%, -22.99%, -22.26%, LDB: -11.02%, -23.29%, -23.67%, AI: -8.37%, -18.59%, -18.84%
- EE1-1.6.2: take bs as extra input on top of EE1-1.6.1
 - *Compared with current filter set #1*
 - 16% kMAC/pixel reduction, 34% model memory reduction
 - RA: -1.65%, -3.39%, -0.86%, LDB: -2.72%, -5.05%, -1.51%, AI: -1.04%, -0.92%, 0.56%
 - *Compared with NNVC-4.0 anchor*
 - RA: -11.18%, -23.51%, -22.17%, LDB: -10.84%, -23.85%, -21.98%, AI: -8.46%, -18.99%, -19.46%

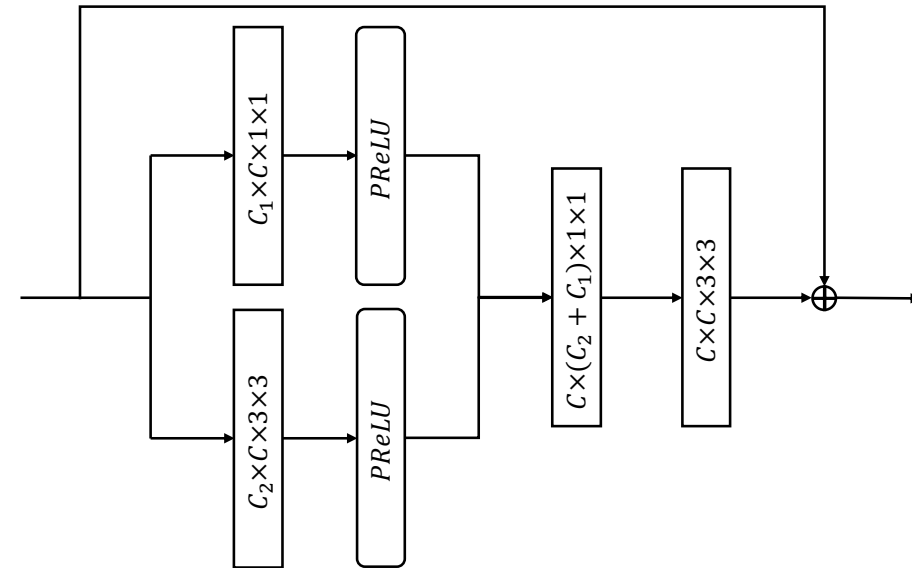
Proposed residual block



(a) Residual block in filter set #1: large receptive field but no wide activation



(b) Residual block in filter set #0: wide activation ($M > K$) but restricted receptive field



(c) Proposed residual block with wide activation ($C_1 > C$), large receptive field, and multi-scale feature extraction

Proposed network

■ EE1-1.6.1

- Network configuration

- $C_{in} = 4$, i.e. input rec, pred, slice type, and qp
- $S = 2$ to achieve feature down-sampling
- $C = 64$, $C_1 > C$, $C_2 < C$
- $N = 19$

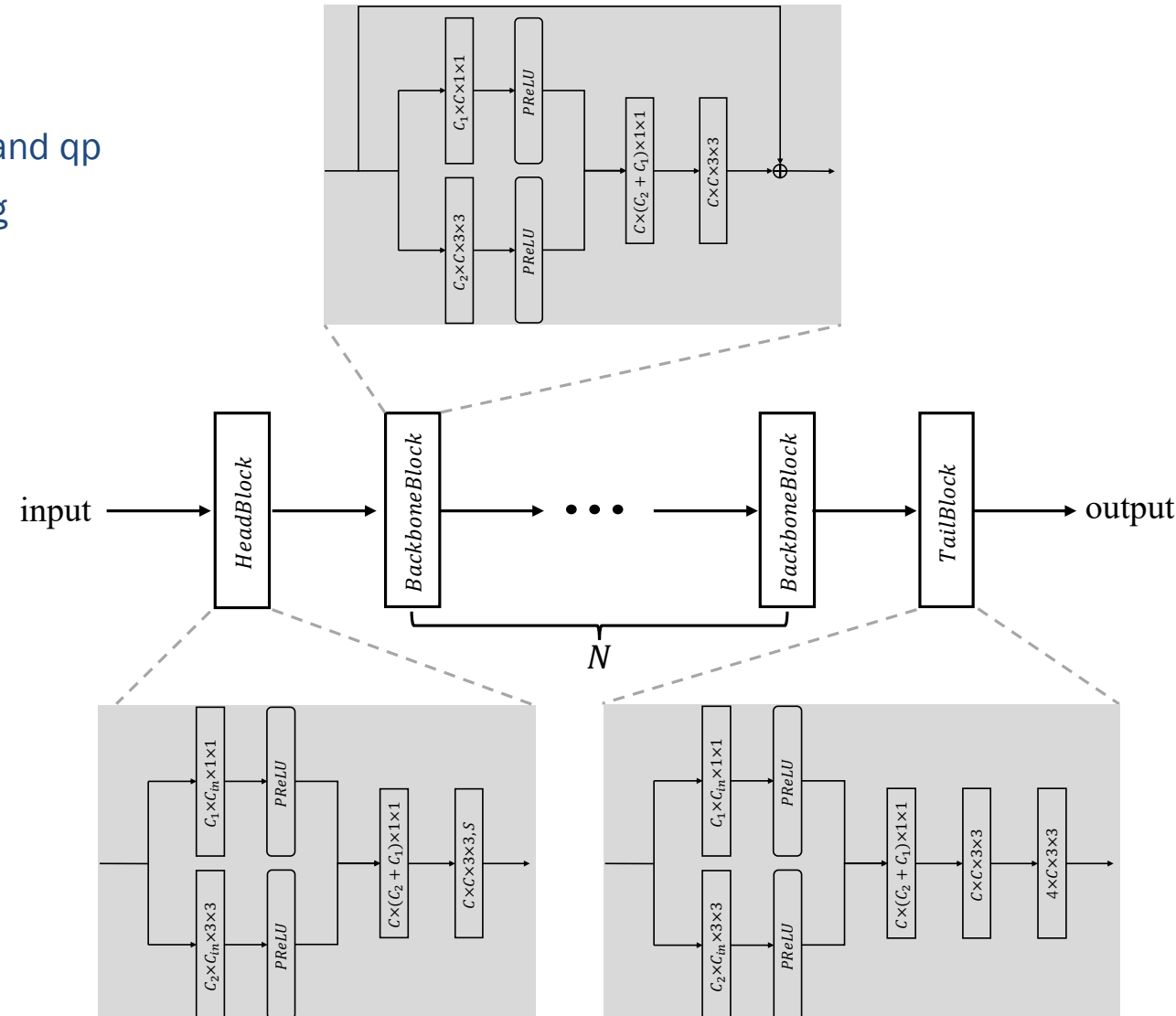
- Simplification

- Unified model for intra and inter
- aggressively simplified chroma model

■ EE1-1.6.2

- Take bs as extra input

- $C_{in} = 5$



Inference

- SADL is used for performing the inference of the proposed CNN filters
- Both weights and internal computations are represented with int16 precision

	kMAC/pixel (frame basis)	kMAC/pixel (block basis)	Total Parameter Number	Total parameter memory (int16)
NNVC-4.0 filter set #1	532	673	3.10M	6.20M
EE1-1.6.1	445.5	563.8	2.054M	4.108M
EE1-1.6.2	446.1	564.6	2.055M	4.110M

Experimental results – EE1-1.6.1

- Compared with NNVC-4.0 filter set #1
 - 16% kMAC/pixel reduction, 34% model memory reduction
 - BD-rate changes shown in the table

Random access Main10					
BD-rate Over NNVC-4.0-NnIntra-NnFilterSet1					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1	-1.63%	-4.16%	-1.41%	100%	103%
Class A2	-1.91%	-2.20%	-2.52%	102%	107%
Class B	-1.55%	-3.64%	-0.61%	103%	110%
Class C	-1.12%	-0.62%	0.16%	99%	107%
Class E					
Overall	-1.52%	-2.65%	-0.95%	101%	107%
Class D	-0.50%	-0.74%	2.99%	103%	114%
Class F	-0.34%	-0.83%	-1.88%	102%	101%

Low delay B Main10					
BD-rate Over NNVC-4.0-NnIntra-NnFilterSet1					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1					
Class A2					
Class B	-2.91%	-4.60%	-1.61%	101%	112%
Class C	-2.56%	-3.34%	-3.05%	101%	110%
Class E	-3.35%	-5.68%	-7.65%	102%	137%
Overall	-2.91%	-4.45%	-3.60%	101%	117%
Class D	-2.24%	-1.31%	-1.17%	99%	108%
Class F	-1.93%	-3.81%	-3.95%	102%	100%

All Intra Main10					
BD-rate Over NNVC-4.0-NnIntra-NnFilterSet1					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1	-0.81%	-1.86%	0.23%	102%	104%
Class A2	-0.80%	-0.03%	-0.28%	99%	103%
Class B	-0.81%	0.77%	3.93%	100%	104%
Class C	-1.28%	0.48%	1.48%	102%	106%
Class E	-1.29%	-1.24%	0.82%	106%	105%
Overall	-0.99%	-0.20%	1.55%	101%	104%
Class D	-1.11%	0.22%	3.14%	99%	114%
Class F	0.36%	2.41%	0.84%	101%	90%

Experimental results – EE1-1.6.1

- Compared with NNVC-4.0 anchor
 - *BD-rate changes shown in the table*

Random access Main10					
BD-rate Over NNVC-4.0-Anchor					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1	-10.29%	-19.66%	-22.01%	183%	33463%
Class A2	-11.64%	-22.02%	-18.25%	175%	33491%
Class B	-10.56%	-25.01%	-23.32%	185%	36806%
Class C	-11.74%	-23.68%	-24.11%	155%	30194%
Class E					
Overall	-11.04%	-22.99%	-22.26%	174%	33614%
Class D	-13.27%	-24.76%	-25.22%	147%	27845%
Class F	-5.81%	-15.12%	-14.04%	237%	14670%

Low delay B Main10					
BD-rate Over NNVC-4.0-Anchor					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1					
Class A2					
Class B	-10.13%	-23.53%	-22.15%	176%	35970%
Class C	-11.55%	-24.22%	-24.64%	158%	32551%
Class E	-11.81%	-21.65%	-24.92%	303%	30645%
Overall	-11.02%	-23.29%	-23.67%	195%	33426%
Class D	-12.99%	-25.67%	-28.26%	144%	27283%
Class F	-7.30%	-17.78%	-14.93%	241%	15833%

All Intra Main10					
BD-rate Over NNVC-4.0-Anchor					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1	-7.39%	-17.74%	-17.63%	175%	23772%
Class A2	-7.51%	-19.41%	-15.76%	145%	20947%
Class B	-7.50%	-17.33%	-18.32%	144%	20222%
Class C	-8.68%	-18.50%	-20.56%	125%	13345%
Class E	-11.26%	-20.84%	-21.72%	146%	21834%
Overall	-8.37%	-18.59%	-18.84%	145%	19298%
Class D	-8.38%	-18.87%	-20.46%	122%	11149%
Class F	-4.88%	-13.64%	-13.34%	114%	12675%

Experimental results – EE1-1.6.2

- Compared with NNVC-4.0 filter set #1
 - 16% kMAC/pixel reduction, 34% model memory reduction
 - BD-rate changes shown in the table

Random access Main10					
BD-rate Over NNVC-4.0-NnIntra-NnFilterSet1					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1	-1.77%	-4.72%	-1.05%	100%	100%
Class A2	-2.04%	-2.62%	-3.23%	100%	104%
Class B	-1.67%	-4.73%	-0.82%	101%	106%
Class C	-1.25%	-1.31%	1.01%	99%	107%
Class E					
Overall	-1.65%	-3.39%	-0.86%	100%	105%
Class D	-0.33%	-1.13%	3.90%	103%	112%
Class F	-0.44%	-2.22%	-2.75%	101%	100%

Low delay B Main10					
BD-rate Over NNVC-4.0-NnIntra-NnFilterSet1					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1					
Class A2					
Class B	-2.70%	-4.71%	0.46%	100%	108%
Class C	-2.57%	-4.55%	-0.16%	99%	108%
Class E	-2.95%	-6.28%	-6.57%	103%	133%
Overall	-2.72%	-5.05%	-1.51%	100%	114%
Class D	-2.29%	-1.72%	3.07%	101%	110%
Class F	-1.85%	-2.33%	-2.97%	104%	98%

All Intra Main10					
BD-rate Over NNVC-4.0-NnIntra-NnFilterSet1					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1	-0.86%	-2.60%	-0.87%	101%	101%
Class A2	-0.80%	-0.21%	-0.72%	98%	100%
Class B	-0.84%	-0.94%	1.84%	103%	98%
Class C	-1.36%	0.02%	1.52%	104%	101%
Class E	-1.34%	-1.14%	-0.16%	102%	104%
Overall	-1.04%	-0.92%	0.56%	102%	101%
Class D	-1.17%	-0.58%	2.88%	99%	103%
Class F	0.72%	2.45%	0.74%	97%	83%

Experimental results – EE1-1.6.2

- Compared with NNVC-4.0 anchor
 - *BD-rate changes shown in the table*

Random access Main10					
BD-rate Over NNVC-4.0-Anchor					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1	-10.43%	-20.07%	-21.83%	183%	33243%
Class A2	-11.77%	-22.19%	-18.67%	174%	32755%
Class B	-10.72%	-25.77%	-23.41%	183%	36066%
Class C	-11.87%	-24.27%	-23.49%	154%	29520%
Class E					
Overall	-11.18%	-23.51%	-22.17%	173%	32996%
Class D	-13.16%	-25.07%	-24.44%	149%	27305%
Class F	-5.92%	-16.23%	-14.72%	235%	14280%

Low delay B Main10					
BD-rate Over NNVC-4.0-Anchor					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1					
Class A2					
Class B	-9.92%	-23.62%	-20.11%	173%	34481%
Class C	-11.61%	-25.13%	-22.50%	155%	31563%
Class E	-11.34%	-22.52%	-24.39%	304%	29737%
Overall	-10.84%	-23.85%	-21.98%	192%	32263%
Class D	-13.04%	-26.35%	-24.83%	144%	26071%
Class F	-7.21%	-15.77%	-13.82%	237%	15486%

All Intra Main10					
BD-rate Over NNVC-4.0-Anchor					
	Y-PSNR	U-PSNR	V-PSNR	EncT	DecT CPU
Class A1	-7.48%	-18.24%	-18.60%	171%	23226%
Class A2	-7.56%	-19.45%	-15.68%	145%	20524%
Class B	-7.58%	-18.13%	-19.61%	138%	19175%
Class C	-8.80%	-18.88%	-20.60%	125%	13422%
Class E	-11.38%	-20.86%	-22.37%	142%	20767%
Overall	-8.46%	-18.99%	-19.46%	142%	18745%
Class D	-8.46%	-19.43%	-20.67%	124%	10862%
Class F	-4.57%	-13.51%	-13.46%	115%	11075%

Conclusions


■ EE1-1.6.1

- *Compared with current filter set #1*
 - 16% kMAC/pixel reduction, 34% model memory reduction
 - RA: -1.52%, -2.65%, -0.95%, LDB: -2.91%, -4.45%, -3.60%, AI: -0.99%, -0.20%, 1.55%
- *Compared with NNVC-4.0 anchor*
 - RA: -11.04%, -22.99%, -22.26%, LDB: -11.02%, -23.29%, -23.67%, AI: -8.37%, -18.59%, -18.84%

■ EE1-1.6.2

- *Compared with current filter set #1*
 - 16% kMAC/pixel reduction, 34% model memory reduction
 - RA: -1.65%, -3.39%, -0.86%, LDB: -2.72%, -5.05%, -1.51%, AI: -1.04%, -0.92%, 0.56%
- *Compared with NNVC-4.0 anchor*
 - RA: -11.18%, -23.51%, -22.17%, LDB: -10.84%, -23.85%, -21.98%, AI: -8.46%, -18.99%, -19.46%

This contribution presents a NN-based in loop filter with improved performance and reduced complexity

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Thank
Vivo, Dolby, and Tencent
for crosschecking!