



华中科技大学

Densely Connected Unit based Loop Filter for Short Video Coding

Reporter: Shengwei Wang

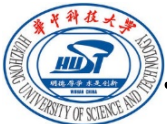
Authors: Shengwei Wang, Peidi Yi, Hongkui
Wang, Li Yu

Background

- ❑ VVC is the new video standard, which has the best performance
- ❑ Block based compression and quantization introduce distortion
- ❑ Loop-filter eliminate distortion, but not perfect
- CNN shows good performance in image recover

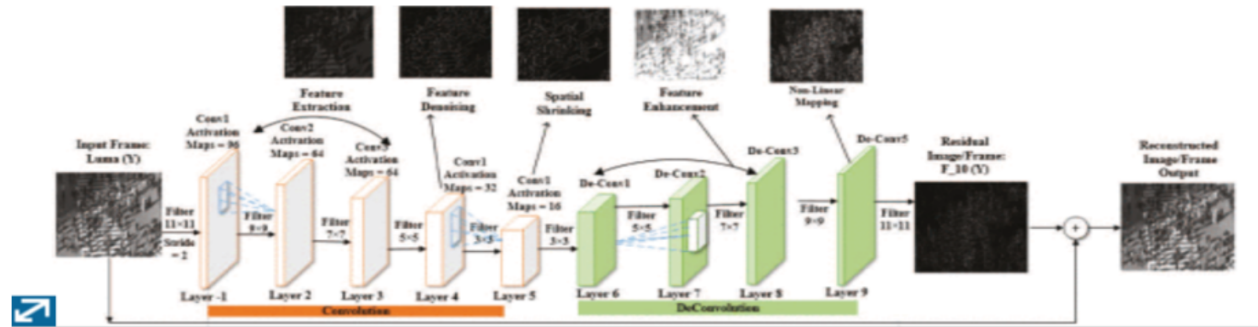


We propose a CNN based filter for VVC



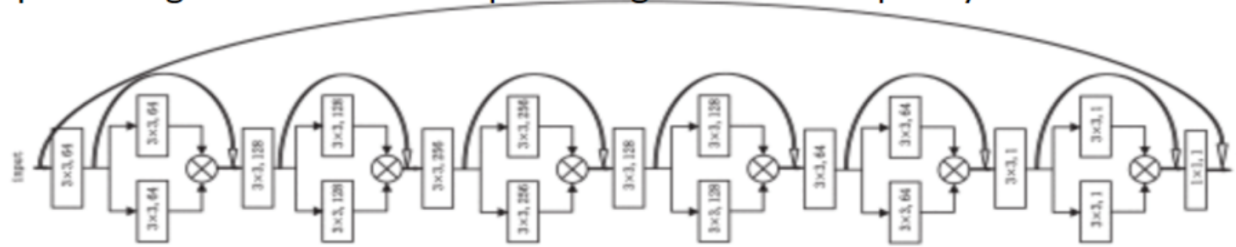
Literature review

MRCNN



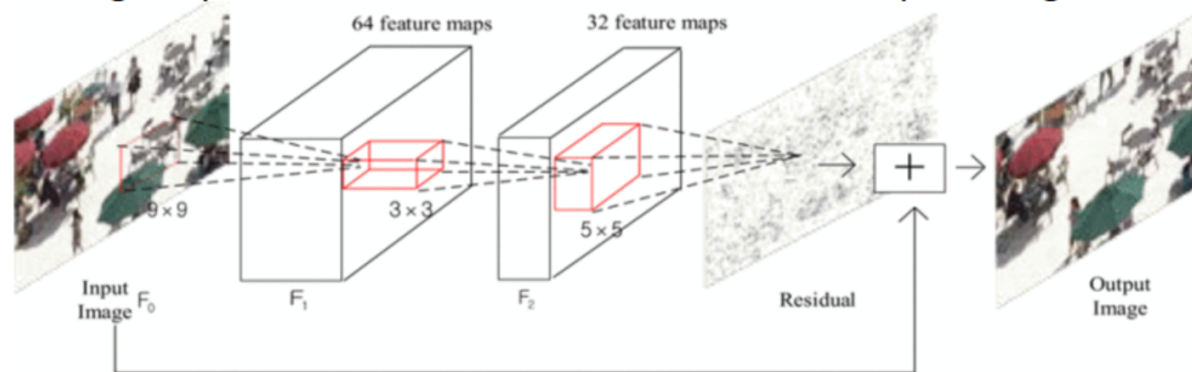
Deep learning based hevcc in-loop filtering for decoder quality enhancement

RHCNN



Residual highway convolutional neural networks for in-loop filtering in HEVC

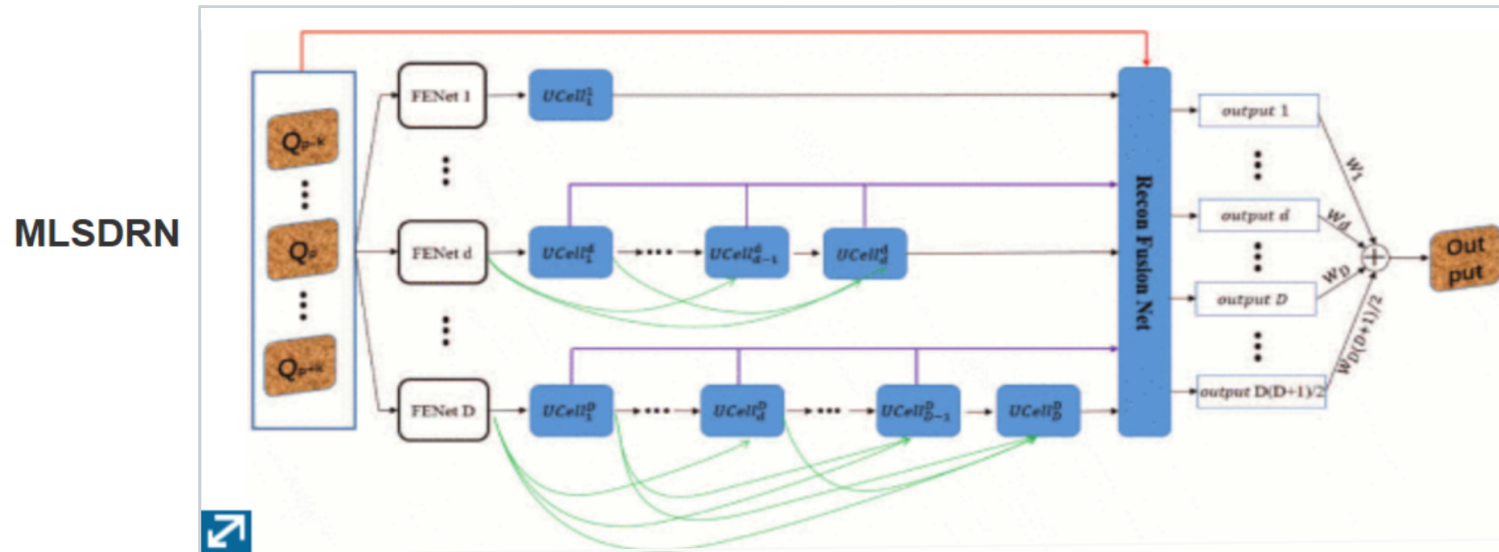
CNNF



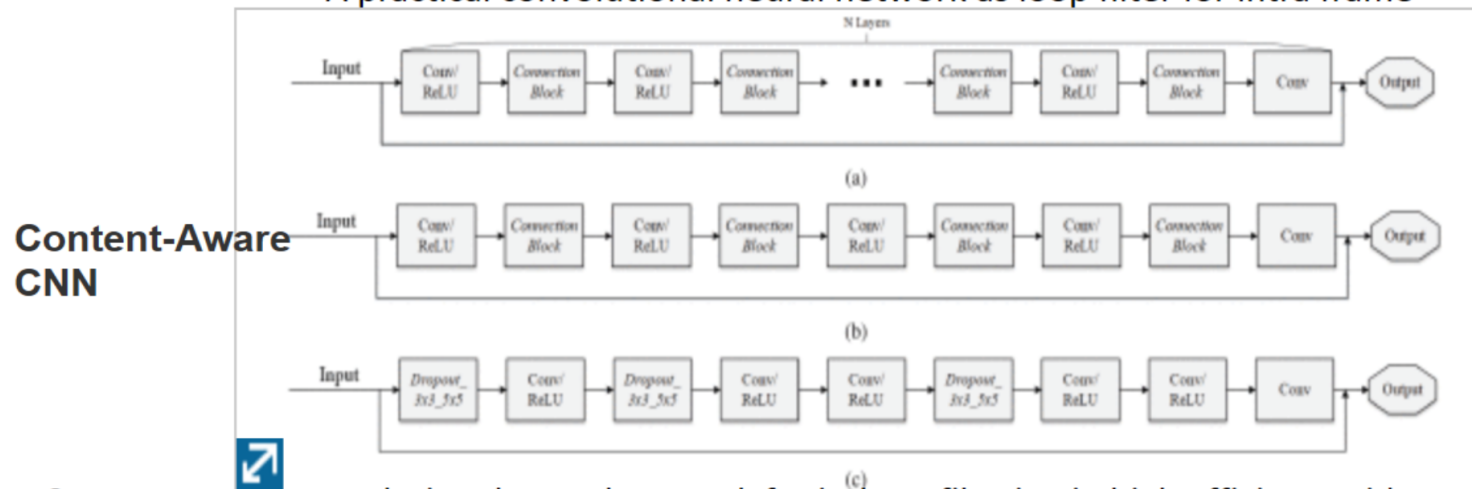
CNN-based in-loop filtering for coding efficiency improvement



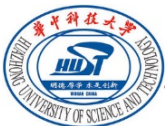
Literature review



A practical convolutional neural network as loop filter for intra frame

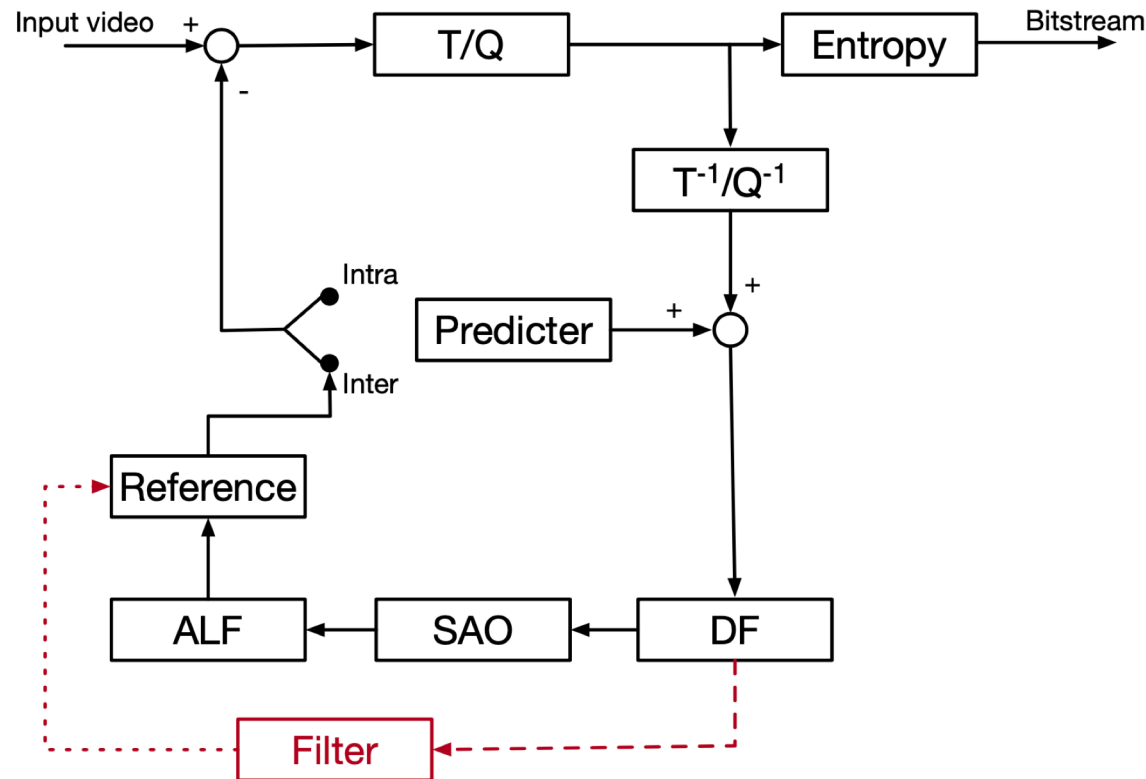


Content-aware convolutional neural network for in-loop filtering in high efficiency video coding

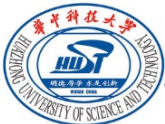


Improved Flowchart

□ Coding framework

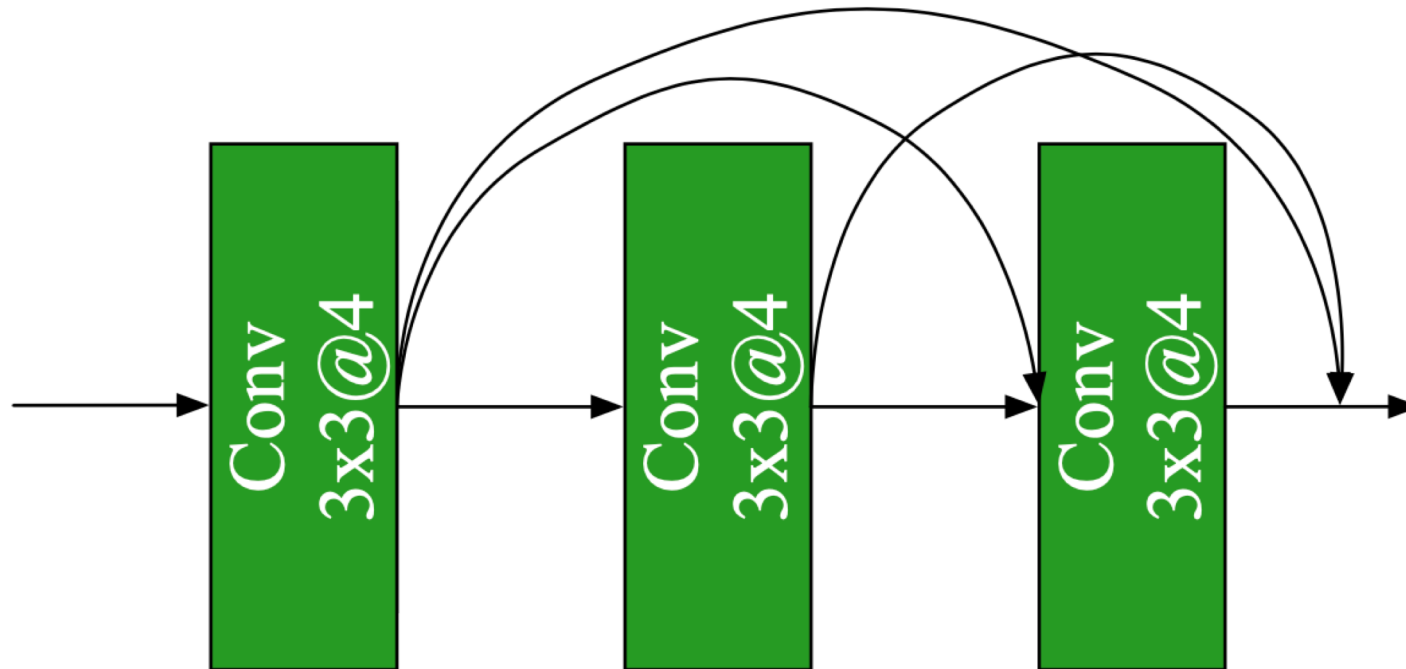


The proposed filter is incorporated into VVC reference software VTM 4.0
The filter improves the quality of reconstructed frames
The filter generates better reference frames for better inter prediction

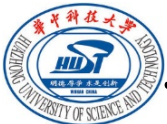


Densely Connected Unit

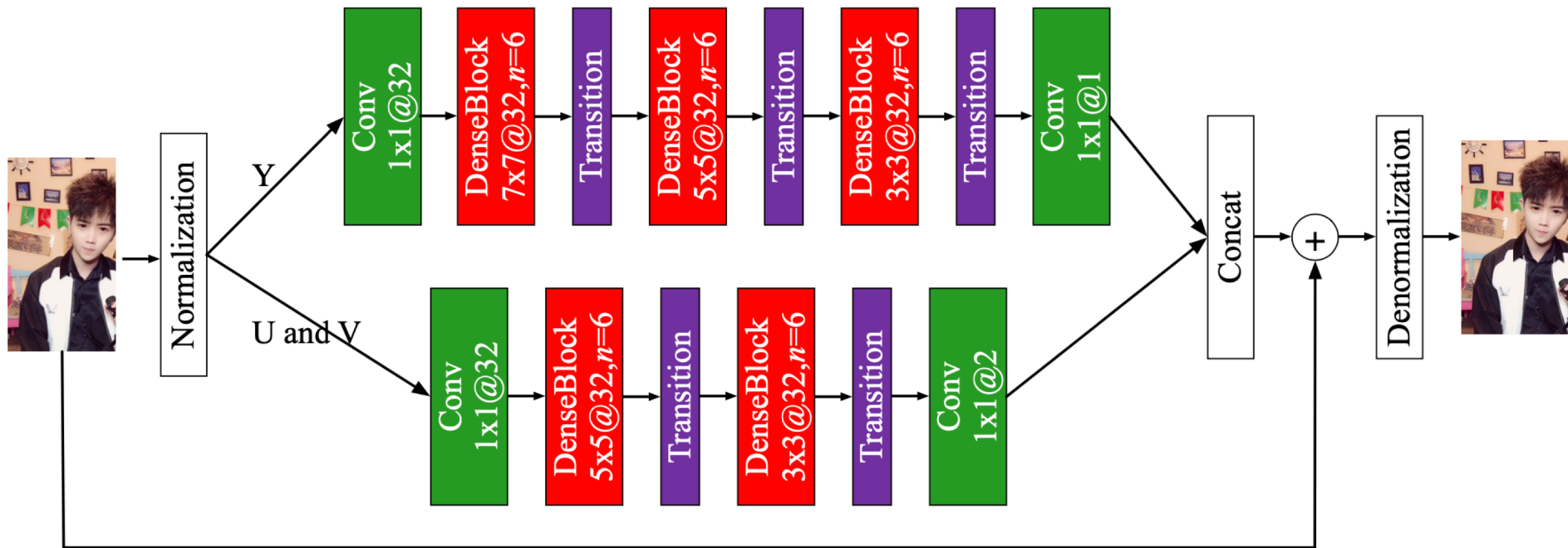
- Densely connected unit



Reuse feature maps
Reduce feature redundancy
Make it easy to train the network



Proposed Network



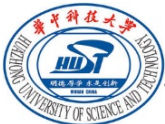
Normalization & De-normalization

$$\hat{x}_8(i, j) = \frac{x_8(i, j)}{255}$$

$$\hat{x}_{10}(i, j) = \frac{x_{10}(i, j)}{1023}$$

$$\widetilde{x}_8(i, j) = \text{round}(\hat{x}_8(i, j) \times 255)$$

$$\widetilde{x}_{10}(i, j) = \text{round}(\hat{x}_{10}(i, j) \times 1023)$$



Data Training

□ Data Collection

For each QP band, videos are compressed at current QP, QP-1 and QP+1,

□ Iteration Training

Batch Size	Initial learning rate	Decay rate	Training epoch
64	0.1	0.1 per 200	2000

□ Loss Function

$$l(\Theta) = \frac{1}{N} \sum_{i=1}^N \|F(x_i, \Theta) - y_i\|_1$$



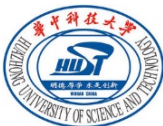
Experimental Result

□ All intra Main10

Sequences	VRCNN [12]	CNNF-R [23]	Proposed filter
video01	-2.71%	-3.34%	-4.12%
video02	-2.82%	-4.03%	-4.42%
video03	-1.47%	-2.26%	-4.35%
video06	-4.01%	-5.42%	-6.38%
video08	-1.42%	-2.31%	-2.80%
video09	-3.36%	-3.52%	-4.14%
video10	-4.85%	-5.68%	-4.63%
video13	-3.05%	-4.02%	-5.18%
Average	-2.55%	-3.82%	-4.50%

12.Y. Dai, D. Liu, and F. Wu, "A convolutional neural network approach for post- processing in HEVC intra coding," in Int. Conf. Multimedia Modeling. Springer, 2017, pp. 28–39.

23.D. Li and L. Yu, "An in-loop filter based on low-complexity CNN using residuals in intra video coding," in 2019 IEEE Int. Symp. Circuits & Syst. (ISCAS). IEEE, 2019, pp. 1–5.



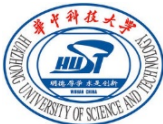
Experimental Result

□ Random Access Main 10

Sequences	VRCNN [12]	CNNF-R [23]	Proposed filter
video01	-0.82%	-1.12%	-2.07%
video02	-1.25%	-1.78%	-2.98%
video03	-0.06%	-0.32%	-1.63%
video06	-2.72%	-3.21%	-4.02%
video08	-0.42%	-2.48%	-2.69%
video09	-1.02%	-3.11%	-3.26%
video10	-1.71%	-2.68%	-2.95%
video13	-0.63%	-1.25%	-1.25%
Average	-1.08%	-1.99%	-2.61%

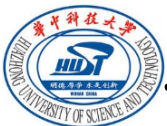
12.Y. Dai, D. Liu, and F. Wu, "A convolutional neural network approach for post- processing in HEVC intra coding," in Int. Conf. Multimedia Modeling. Springer, 2017, pp. 28–39.

23.D. Li and L. Yu, "An in-loop filter based on low-complexity CNN using residuals in intra video coding," in 2019 IEEE Int. Symp. Circuits & Syst. (ISCAS). IEEE, 2019, pp. 1–5.



Conclusion

- ❑ Designed a densely connected unit to analyze and extract feature maps of images
- ❑ Based on the designed unit, a filtering network is proposed to enhance the quality of the reconstructed frame
- ❑ The proposed loop filter is embedded into VVC to improve overall coding efficiency.





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Thanks
