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Performance report of modified conditional joint deblocking-debanding filter (JCTVC-B056)

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Summary

- Banding-noise in video coding
- Brief review of the debanding mechanism of JCTVC-A104
  - Conditional joint deblocking-debanding filter
  - Comfort noise injection
- Modified conditional joint deblocking-debanding filter
  - No recursive filtering
  - No pseudo-noise generation by linear feedback shift register
- Simulation results
  - Significant banding-noise reduction
  - Negligible impacts on coding efficiency
    - CS1: +0.004 dB in BD-PSNR and -0.144 % in BD-Bitrate
    - CS2: -0.004 dB in BD-PSNR and +0.110 % in BD-Bitrate

Banding-noise in video coding

Banding-noise

- One of the signal-dependent noises
- Noticeable in areas of low detail with subtle pixel-intensity changes even when input video is encoded at high rates

Solutions

- Encode input video with higher sample bit-depth
- Mask it with signal independent noise by in-loop debanding and/or post debanding

Banding-noise example: Kimono1 144th frame (1/5)

Original image

Banding-noise example: Kimono1 144th frame (2/5)

Cropped and zoomed original image

Banding-noise example: Kimono1 144th frame (3/5)

(Color enhanced) Cropped and zoomed original image

Banding-noise example: Kimono1 144th frame (4/5)

(Color enhanced) AVC Anchor compressed 1.6Mbps

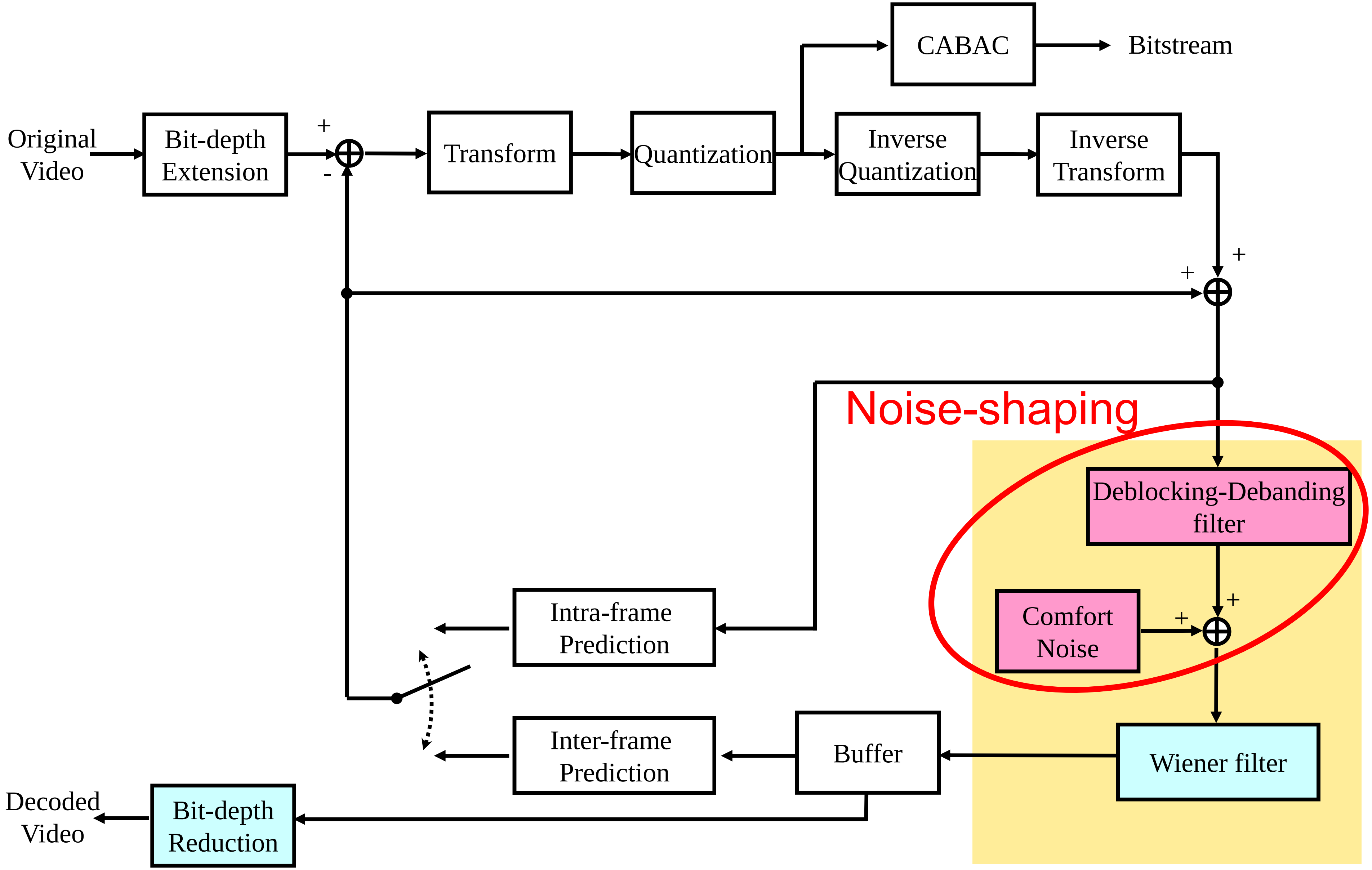
Banding-noise example: Kimono1 144th frame (5/5)

(Color enhanced) AVC Anchor compressed 6.0Mbps

In-loop debanding of JCTVC-A104

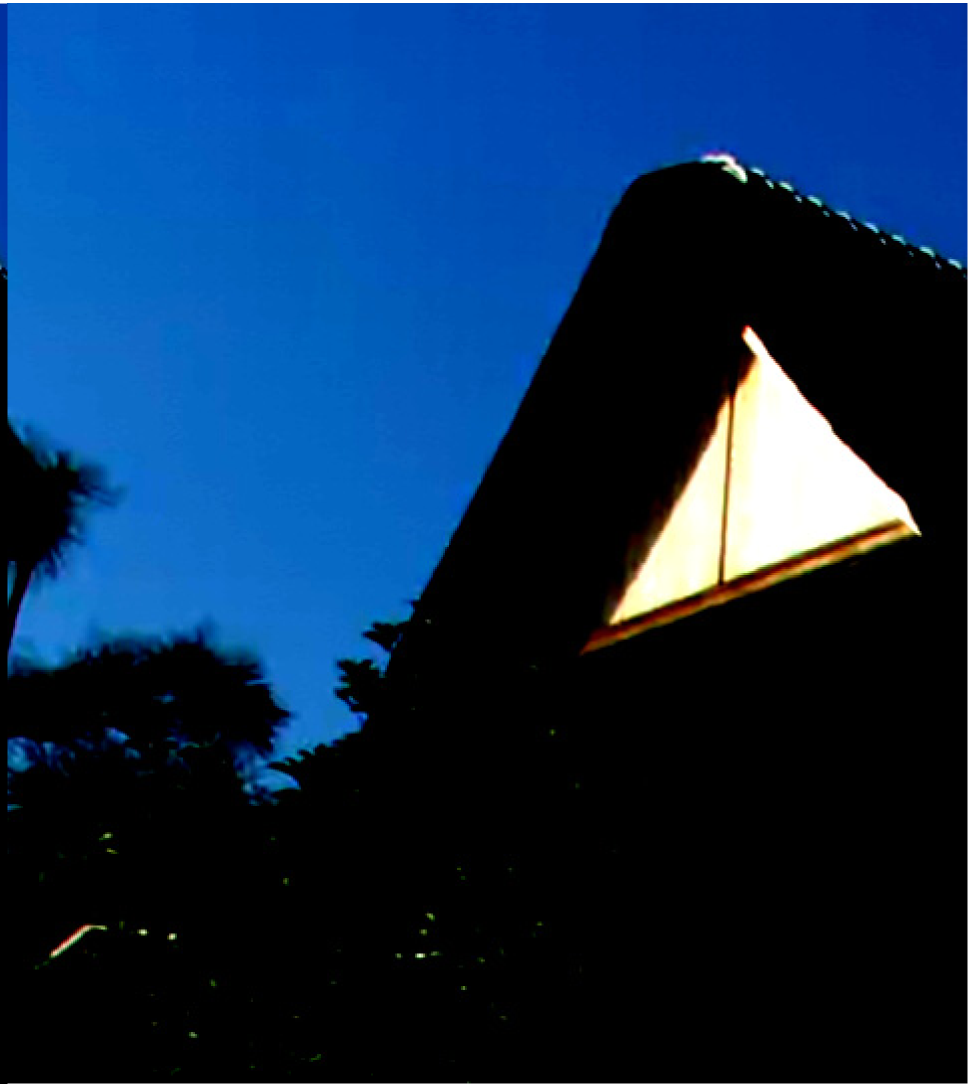
- Combination of noise-shaping and Wiener filter
- Conditional joint deblocking-debanding filter
  – Inspired by JVT-C056
  – Intra macroblock boundaries (BS=4) are filtered by recursive 5-tap filter with pseudo-noise
  – Pseudo-noise is generated by a linear feedback shift register (LFSR).
- Comfort noise injection
  − Inspired by D
  − Invoked only when IBDI is enabled
  − LFSR-based pseudo-noise is injected into LSBs of INTRA_16X16 macroblocks

JCTVC-A104 block diagram



JCTVC-A104 debanding example (1/2)

AVC 1.6Mbps



JCTVC-A104 1.6Mbps

JCTVC-A104 debanding example (2/2)

AVC 6.0Mbps **JCTVC-A104 1.6Mbps**

Proposal: Modification of JCTVC-A104

- Integrate the comfort noise injection into the conditional joint deblocking-debanding filter
  - No recursive filtering
  - Add pseudo-noise to deblock-filtered edges

- Use a predetermined pseudo-noise stored in LUT
  - No LFSR.
  - No side information for LFSR.

➡ Parallel processing of the pixels of a deblock-filtered edge

Modified conditional joint deblocking-debanding filter

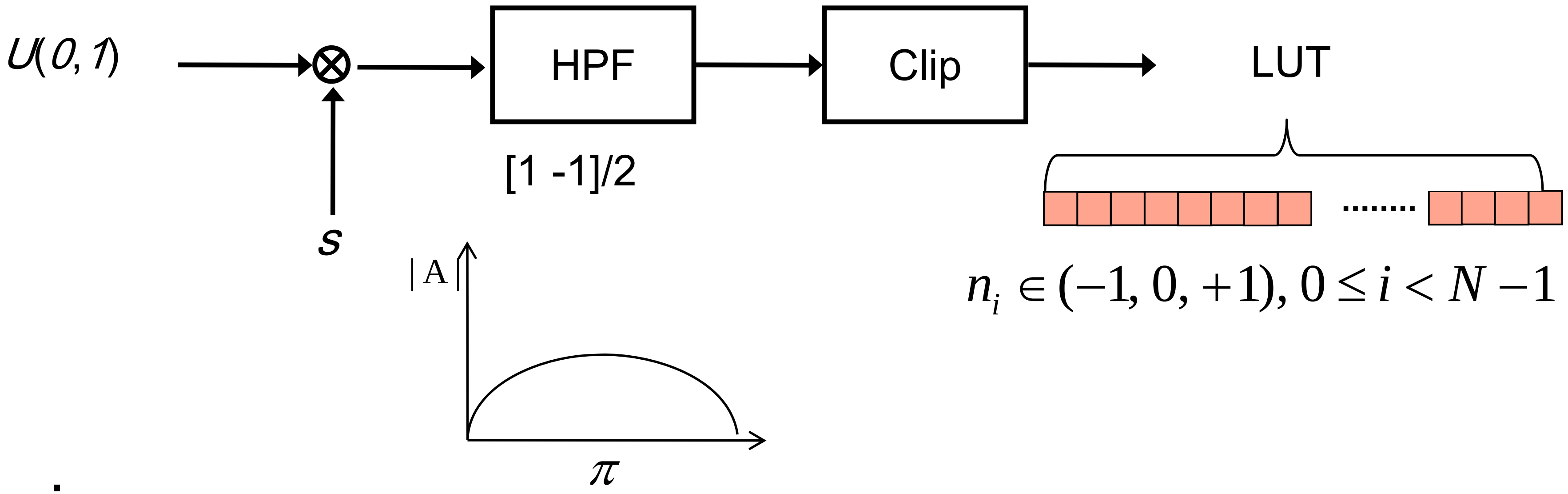
(Step1) Load pseudo-noise from LUT

(Step2) Apply strong filtering

(Step3) Conditionally add pseudo-noise to filtered image

Pseudo-noise in LUT

Procedure



$$n_i \in (-1, 0, +1), 0 \leq i < N - 1$$

Design

$$N = 4096$$

$$P(+1) = 0.25$$

$$P(-1) = 0.25$$

$$P(0) = 0.50$$

The LUT size is about 1KB.
(= 2 * 4096 / 8)
The maximum MSE increase is 1.
(= 0.5 * 1 * 2)

Load pseudo-noise from LUT

- Pseudo-noise is associated with its pixel position specified by (*i*, *k*, *mbAddr*)

n_i, =

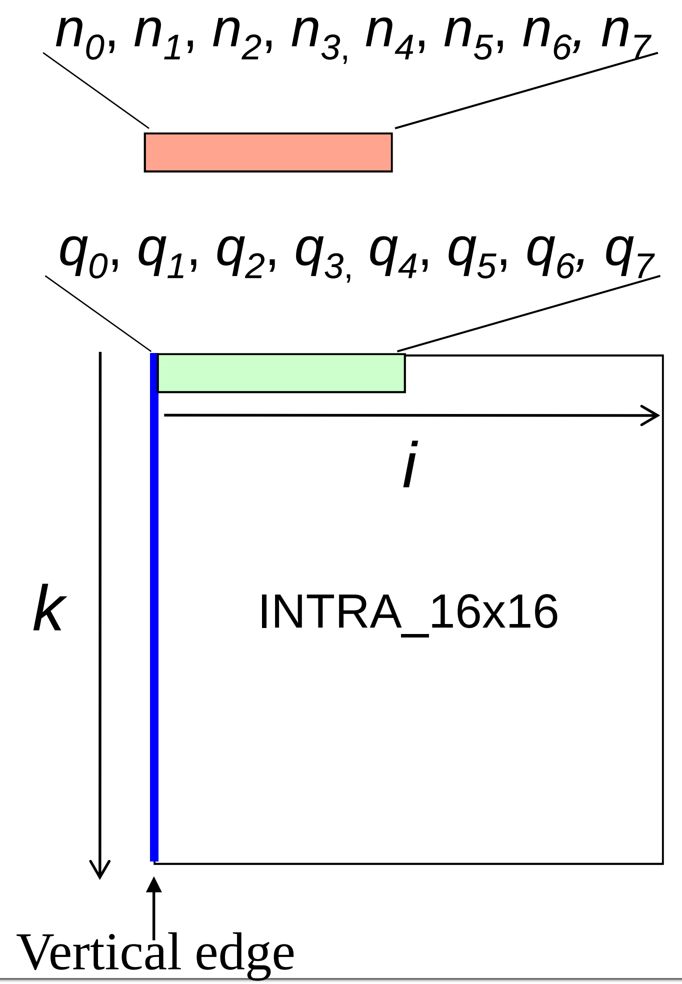
$LUT\,[(idxOffset + 8 + i\,)\ \&\ D]$

$idxOffset\ = ((C + R)\ \&\ D) + 16 * k$

$C\ = 16 * (mbAddr\ \%\ PicWidthInMb\,)$

$R = 256 * (mbAddr\ /\ PicWidthInMb\,)$

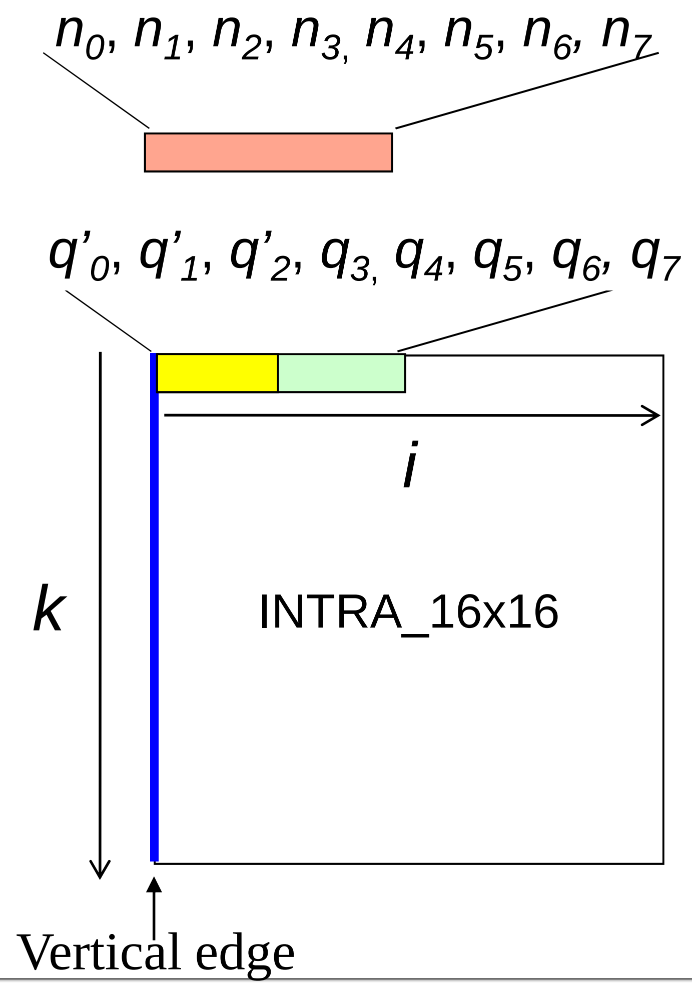
$D = N - 1$



Strong filtering

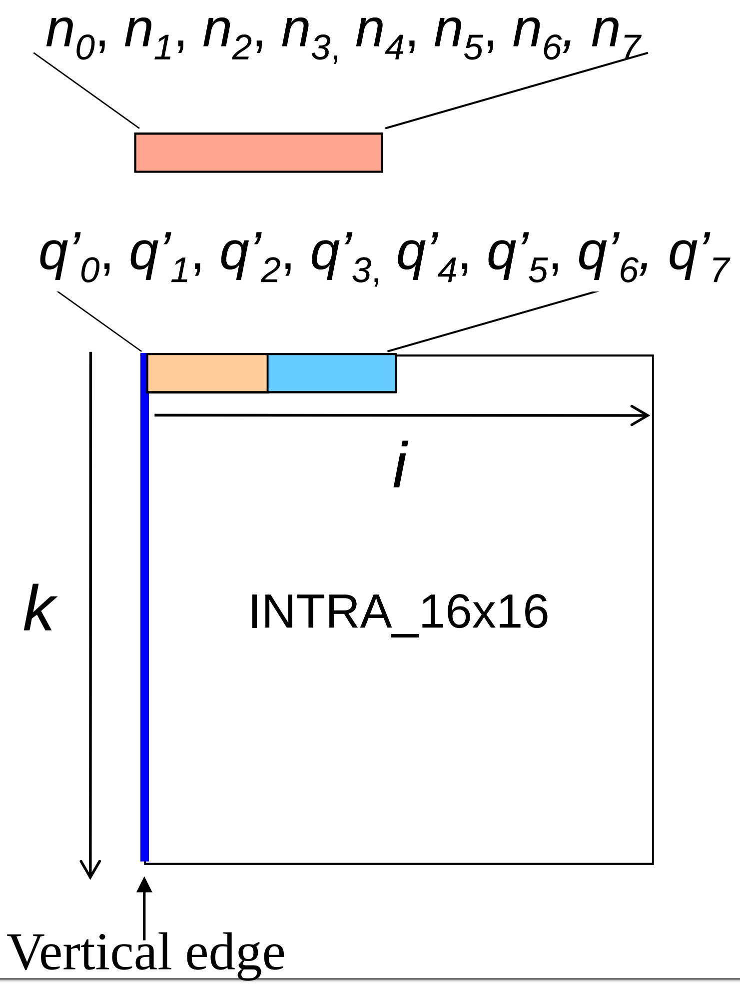
- Boundary three pixels are filtered by conventional filters as in AVC

$$q'_0 = (p_1 + 2*p_0 + 2*q_0 + 2*q_1 + q_2 + 4) >> 3$$
$$q'_1 = (p_0 + q_0 + q_1 + q_2 + 2) >> 2$$
$$q'_2 = (p_0 + q_0 + q_1 + 3* q_2 + 2* q_3 + 4) >> 3$$



Conditional pseudo-noise addition

- Add pseudo-noise if the area is supposed to be very smooth.



If all of the following conditions are true,

- q_0 is INTRA_16x16
- $| q_0 – q_7 | <= 1$

the pseudo-noise are added to the filtered pixels a

q'_i = Clip1($q'_i + n_i$) for i = 0, 1, and 2.
q'_i = Clip1($q_i + n_i$) for i = 3 …, 7.

Simulation results

- Coding conditions
  - In-loop AhG compliant
  - Software: KTA 2.6r1 with bug fixes
  - KTA tools: MDDT, HPFilter, QALF, and Ext MB
  - QP: 26, 30, 34, and 38

- Coding results
  - CS1 and CS2 with IBDI
  - CS2 and CS2 w/o IBDI (This is a option in in-loop AhG)

- Coding efficiency relative to KTA Anchor
  - BD-PSNR, BD-Rate, and, enc. and dec. time increases.

- Debanding examples in Kimono

Impacts on coding efficiency

Results of CS1 with IBDI

	BD-PSNR dB	BD-Rate %	Delta Enc. Time %	Delta Dec. Time %
Class A	0.000	0.032	-3.490	-3.180
Class B	0.010	-0.365	-0.980	-2.380
Class C	0.001	-0.025	-2.560	-2.230
Class D	0.004	-0.074	-0.680	-5.920
Total	0.004	-0.144	-1.653	-3.389

Results of CS2 with IBDI

	BD-PSNR dB	BD-Rate %	Delta Enc. Time %	Delta Dec. Time %
Class A	-0.001	0.031	-0.989	-1.713
Class B	-0.003	0.011	-0.648	-2.103
Class C	-0.004	0.111	-1.558	-1.928
Class D	-0.001	0.090	-1.746	-2.446
Class E	-0.011	0.354	-1.450	-0.348
Total	-0.004	0.110	-1.266	-1.804

Impacts on coding efficiency (Cont.)

Results of CS1 w/o IBDI

	BD-PSNR dB	BD-Rate %	Delta Enc. Time %	Delta Dec. Time %
Class A	0.006	-0.161	-1.040	-1.710
Class B	0.012	-0.452	0.210	-2.280
Class C	-0.007	0.166	-1.180	-1.020
Class D	0.010	-0.207	-0.950	-5.510
Total	0.006	-0.183	-0.638	-2.729

Results of CS2 w/o IBDI

	BD-PSNR dB	BD-Rate %	Delta Enc. Time %	Delta Dec. Time %
Class A	0.005	-0.118	-0.984	-1.978
Class B	0.009	-0.323	-0.779	-0.959
Class C	-0.003	0.083	-1.257	-1.779
Class D	0.005	-0.078	-1.517	-2.612
Class E	-0.022	0.565	-0.768	-0.564
Total	0.000	-0.008	-1.070	-1.556

Compressed images with QP=26 (3.2Mbps)

Significant banding-noise reduction in KTA Proposals.

Compressed images with QP=30 (1.8Mbps)

Compressed images with QP=34 (1.1Mbps)

KTA Proposal with IBDI is still acceptable quality.

Compressed images with QP=38 (0.6Mbps)

Banding-noise remains but no side-effect in KTA Proposals.

Conclusions

- Banding-noise in video coding

- Debanding by a pseudo-noise based in-loop processing

- Significant banding-noise reduction with a negligible impact on coding efficiency

- Recommend a study of the proposed technique in in-loop TE/CE for Test Model integration

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Appendix: Results with QP=26 for Kimono1 144th frame

Cropped and zoomed (No color-enhancement)

Appendix: TMuC result with QP=26

Cropped, zoomed, and color-enhanced