

In-loop reference frame denoising (JCTVC-C219)

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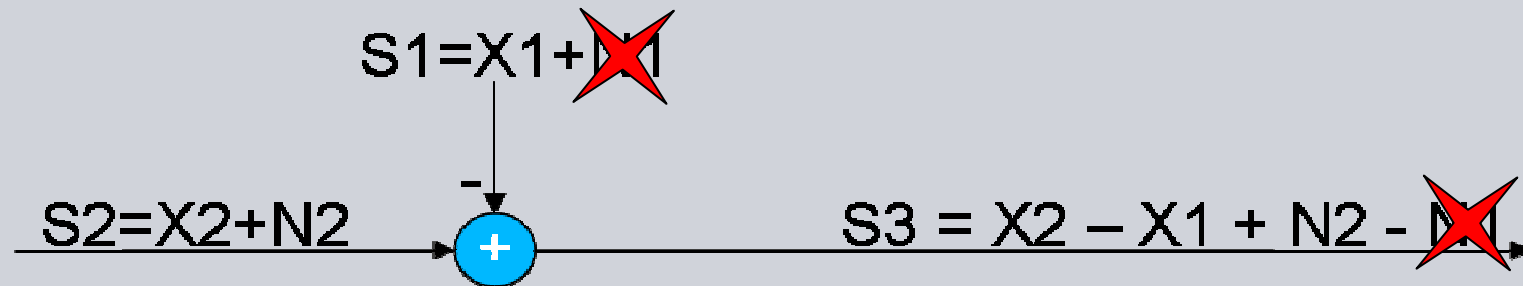
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Outline

- Motivation & idea
- Codec architecture & filtering process
- Simulation set-up & results
- Summary & conclusions

Motivation and idea

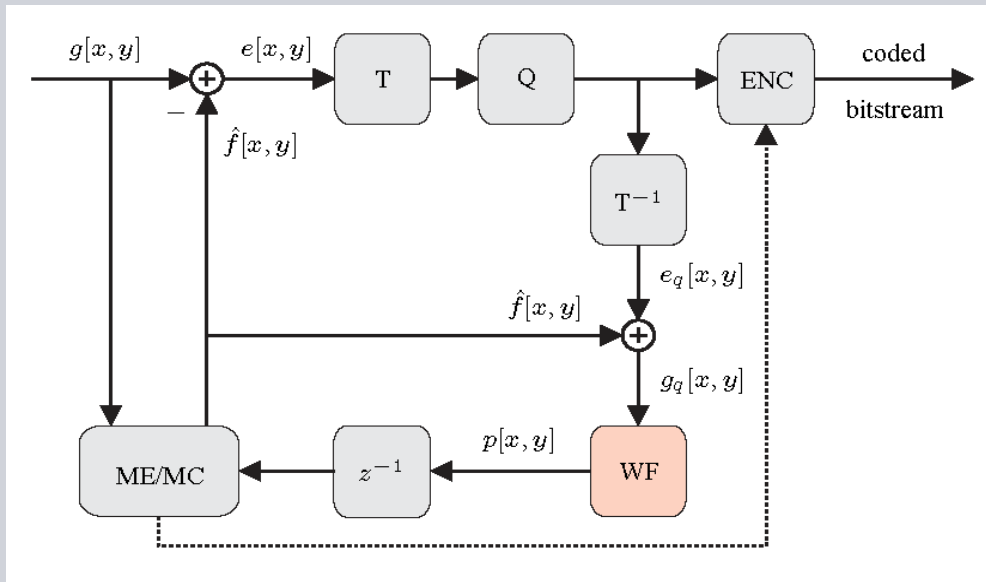
- Modeling of temporal prediction process



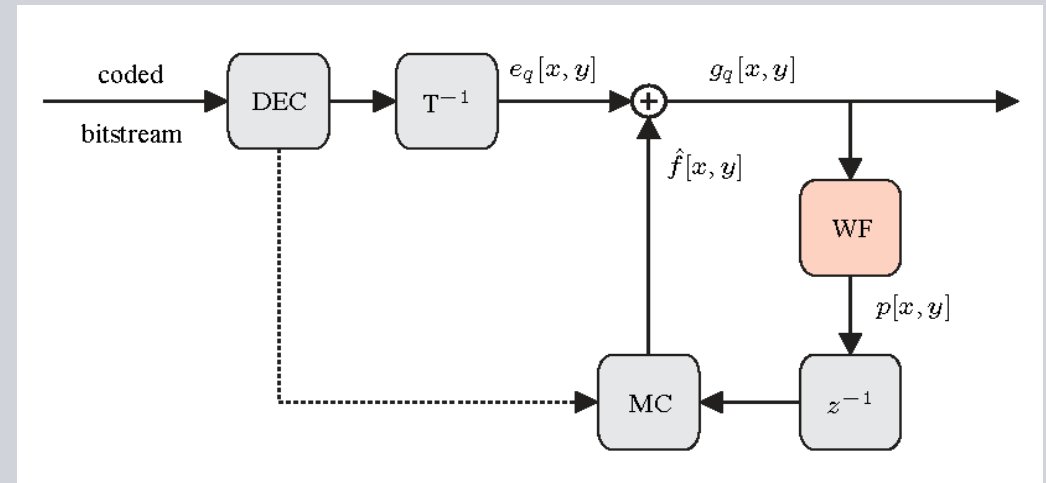
- $S1$: Predictor, i.e., buffer of previous frame(s)
 - $S2$: Current picture to be encoded
 - $X1/X2$: “Useful” signal
 - $N1/N2$: Noise
-
- Idea: Filtering of noise from predictor ($N1$) while coding the original signal ($S2 = X1 + N1$)

Codec architecture

Encoder



Decoder



Filtering process

Noise estimation *)

- On frame basis

Noise filtering *)

- Adaptive averaging filter on $(2M+1) \times (2M+1)$ window
- Dependent on the signal variance and noise variance

$$p(x, y) = m_f(x, y) + \frac{\sigma_f^2(x, y)}{\sigma_f^2(x, y) + \xi \sigma_{n_q}^2} (g_q(x, y) - m_f(x, y))$$

- f : noise free signal (only local mean and variance to be estimated)
- g : noisy signal
- n : noise signal (only variance to be estimated, zero-mean assumed)
- Parameter ξ to control the filtering strength

*) J.-S. Lee, "Digital image enhancement and noise filtering by use of local statistics," IEEE Transaction on Pattern Analysis and Machine Intelligence (PAMI), vol. 2, no. 2, pp. 165-168, March 1980.

Simulation set-up

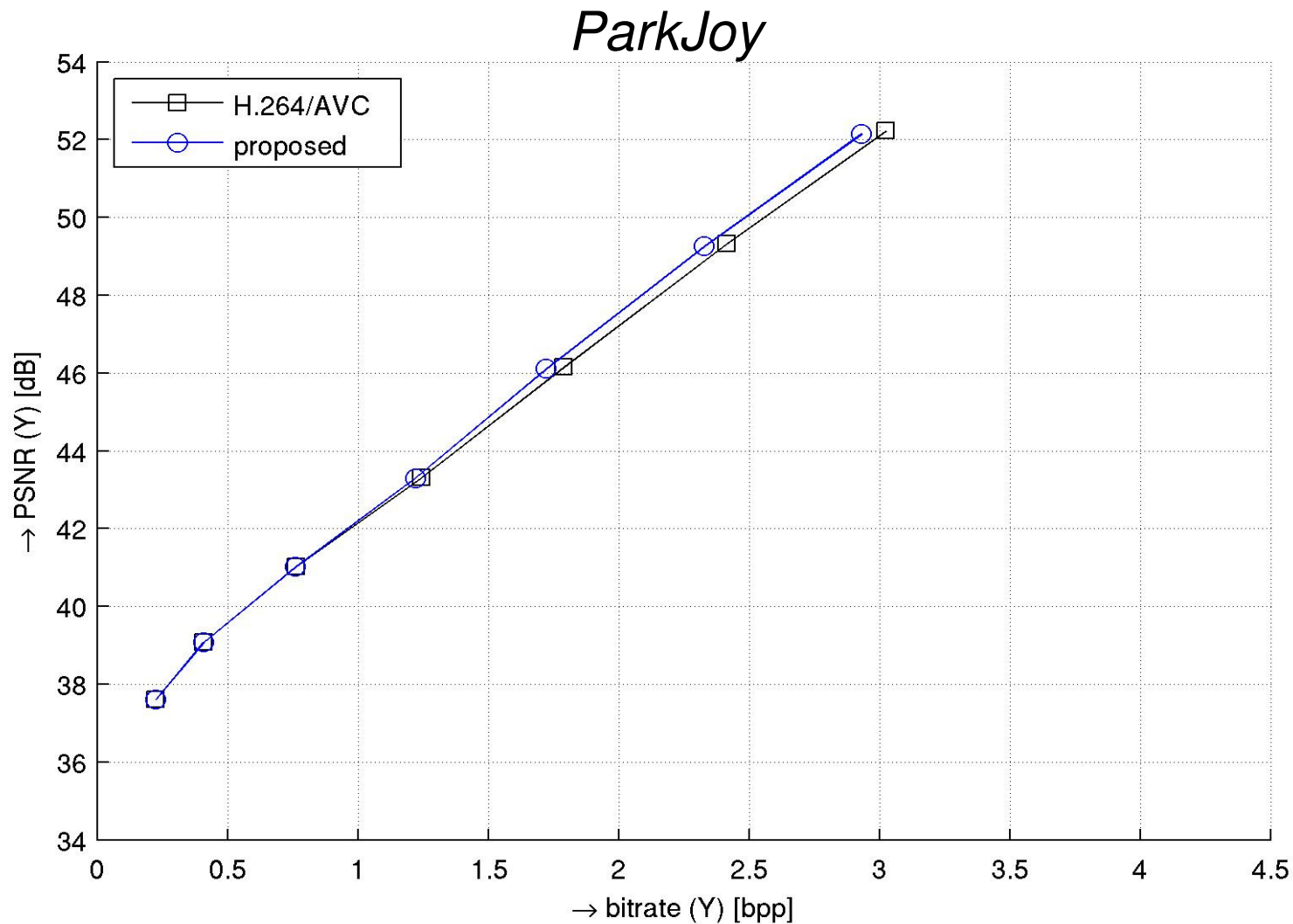
General settings

- Software basis: JM 15.1
- Sequences: *ParkJoy*, *CrowdRun*, *InToTree*, *OldTownCross*, *DucksTakeOff* (3840x2160, 50 fps)
- Settings: IPPP, 50 frames
- Number of reference frames: 5
- Quantization parameters: 28, 25, 22, 19, 16, 13, 10

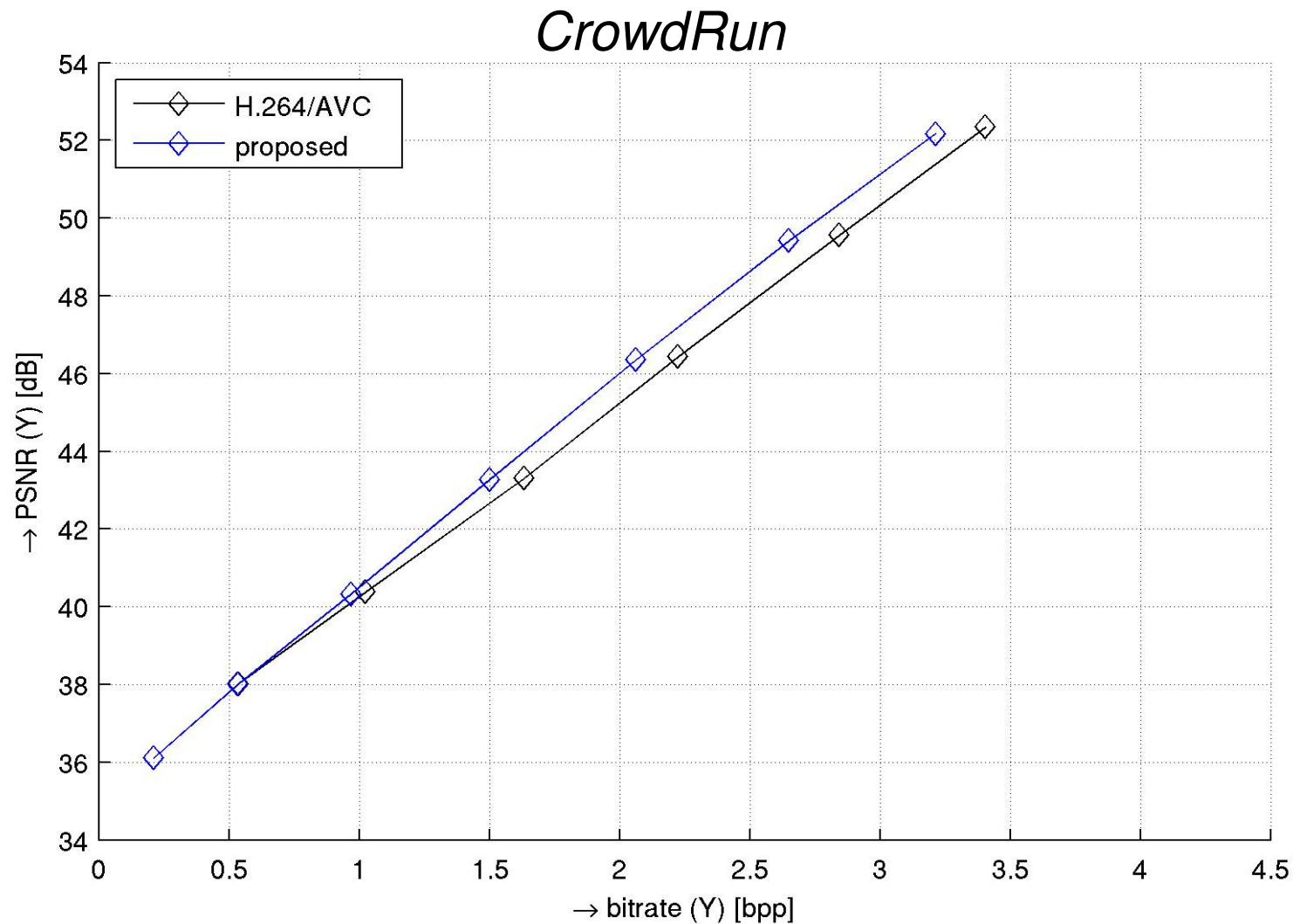
Algorithm settings

- $M=1 \rightarrow 3 \times 3$ window for filtering
- $\xi = 3.5$

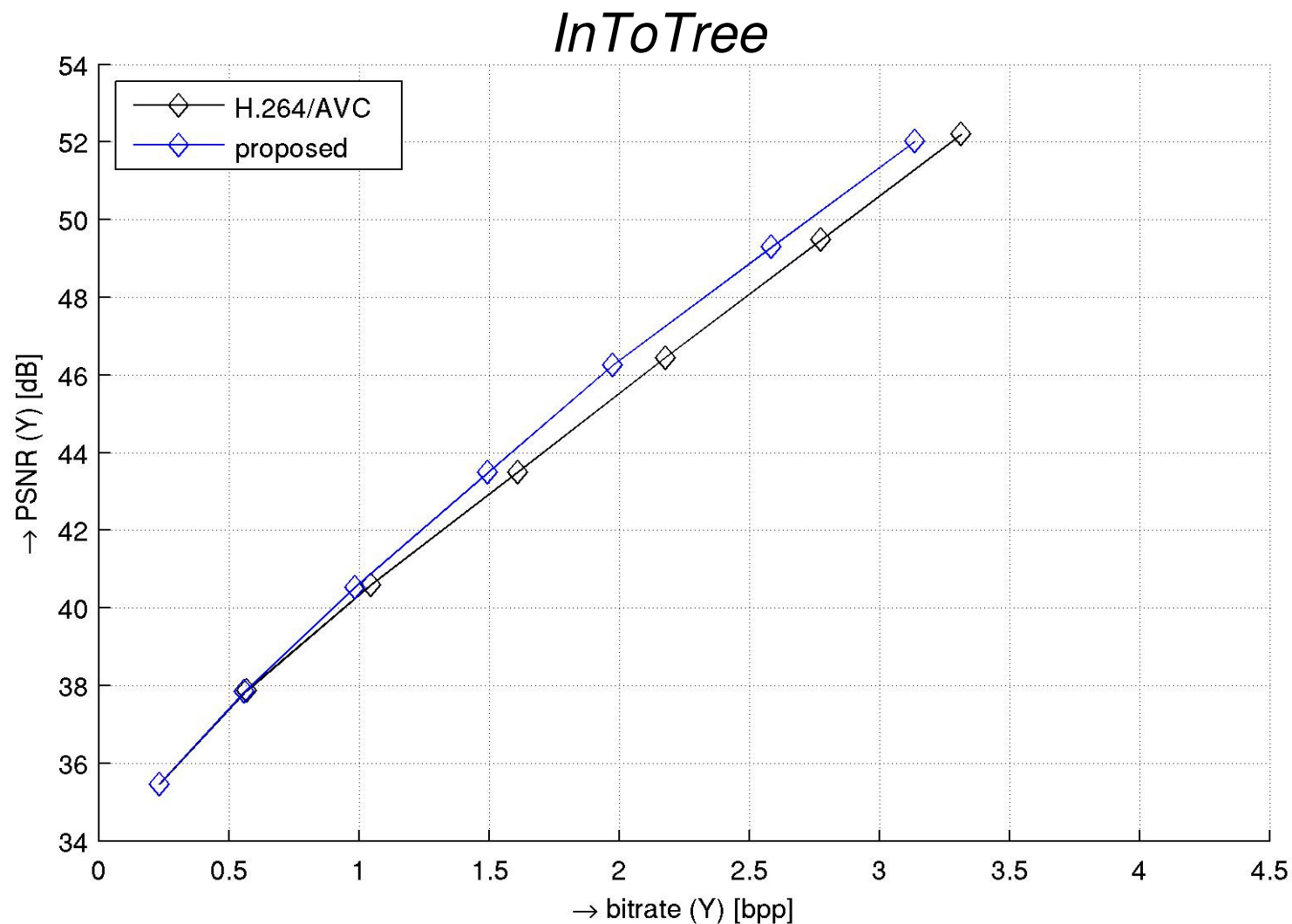
Results



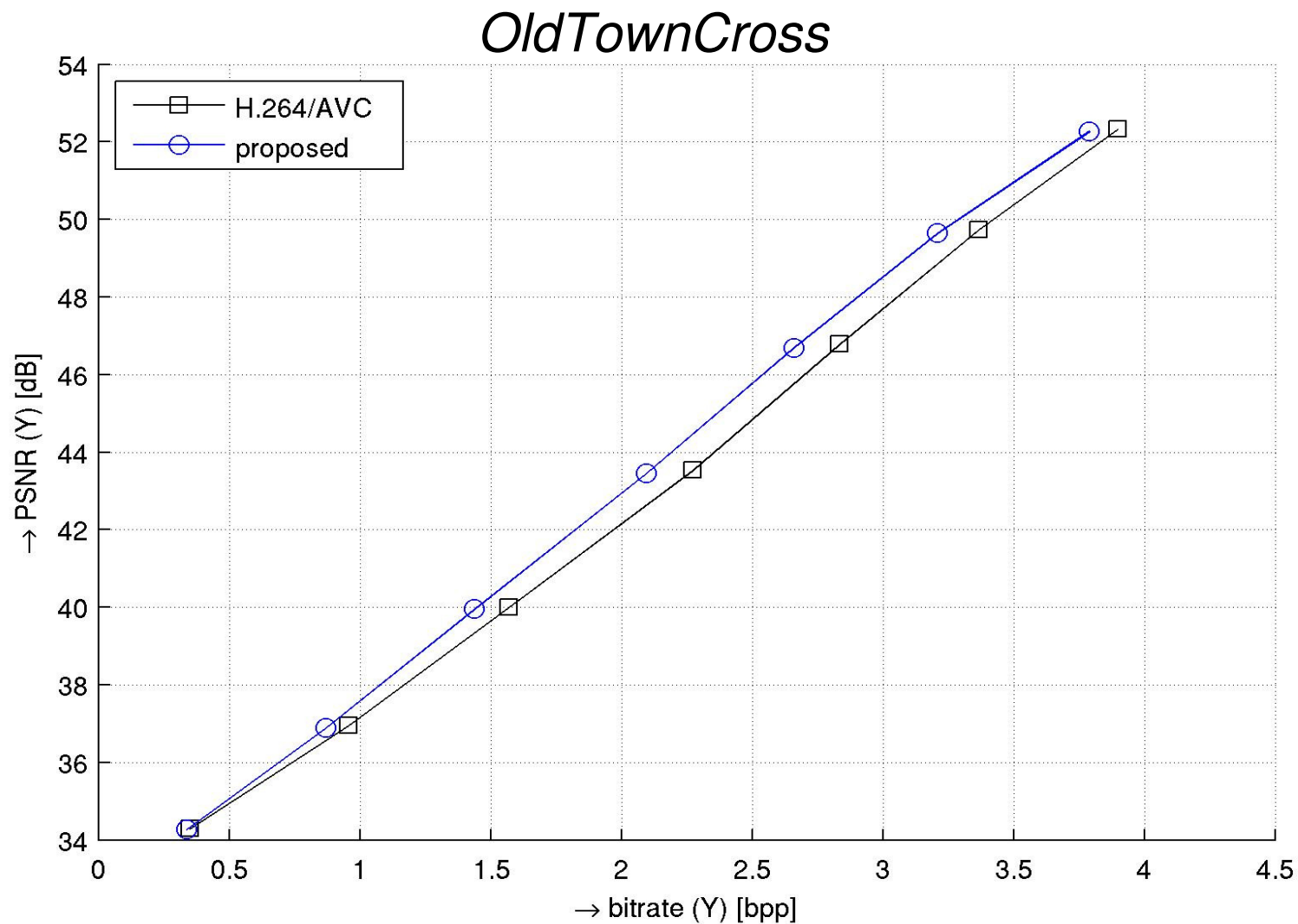
Results (cont.)



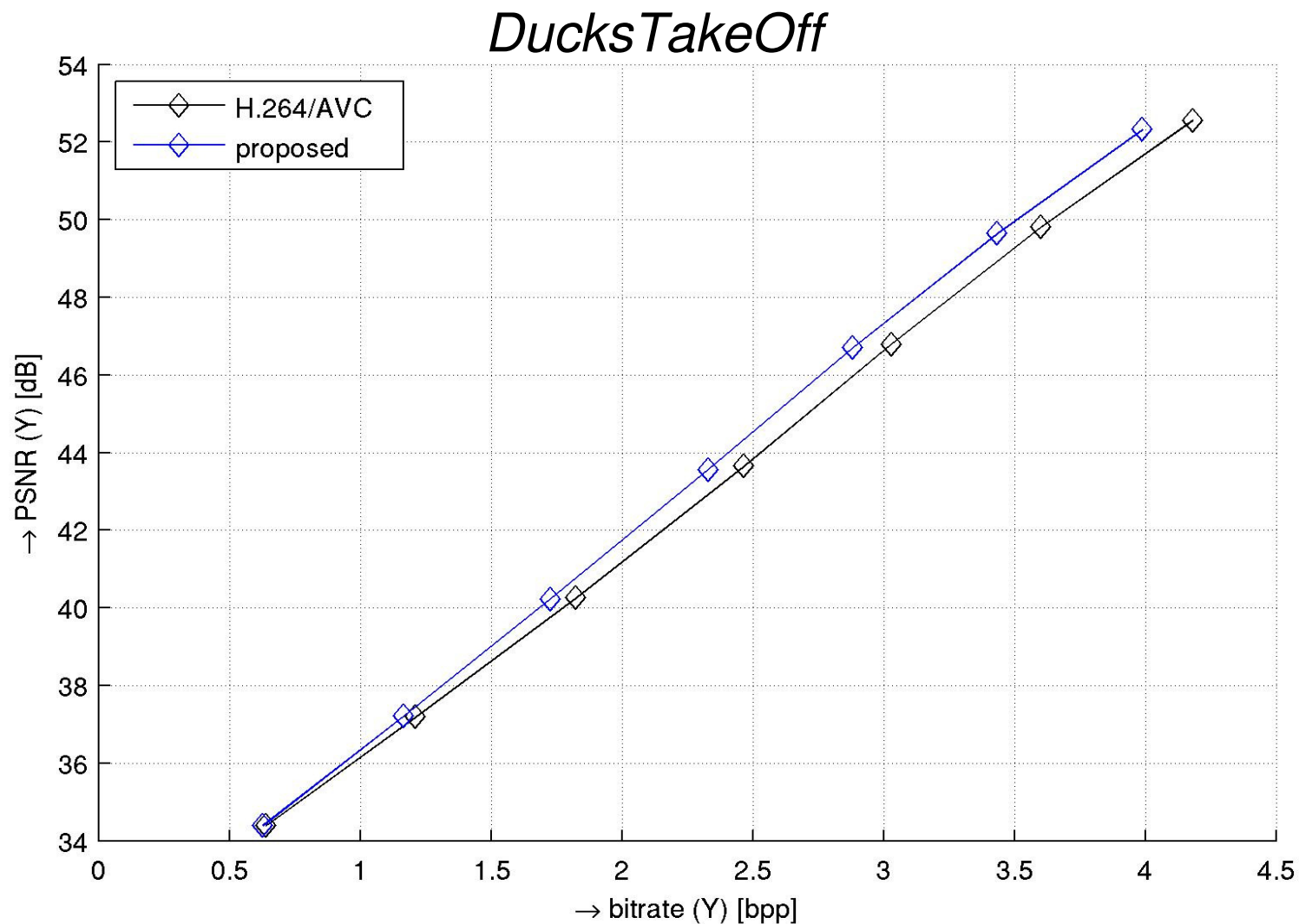
Results (cont.)



Results (cont.)



Results (cont.)



Results (cont.)

■ Summary

Sequence	Estimated noise variance	Maximum bitrate savings [%]
ParkJoy	3,1	3,30
CrowdRun	6,5	7,70
InToTree	10,5	7,70
OldTownCross	15,9	8,10
DucksTakeOff	21,6	5,10

Summary and conclusions

- **In-loop reference frame denoising**: Method to improve the temporal predictor by local noise filtering
- Same algorithm at encoder and decoder
- No filter parameters need to be transmitted
- Promising results on JM 15.1 for medium to high bit-rates and high definition material
- Results on TMuC and respective test-sets to be provided for the next meeting