

Non-linear up-sampling for spatial scalability

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- Aim at higher efficiency of up-sampling prediction
- Upsampler design problem
 - Revoke the blur introduced by low-pass filtering in down-conversion
 - without enhancing noise or introducing ringing
- Instead of global optimization of a linear filter [JVT-Q083]
- Perform locally adaptive up-sampling filtering
 - Locally switch between
 - Enhancement
 - Smoothing
- Tool for achieving this goal: Bilateral Filter

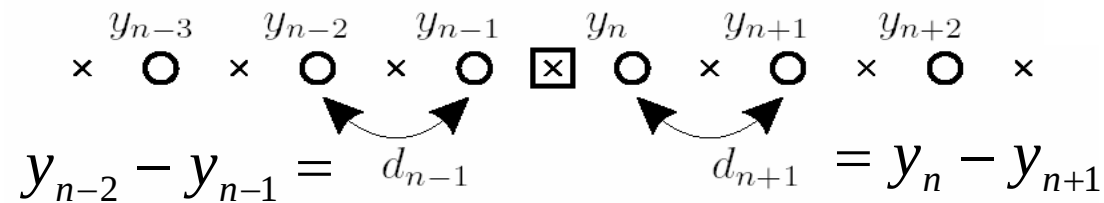
- Separable up-sampling
- Old (non-ESS) sampling positions
- Initialization using linear up-sampling e.g. $[1 \ -5 \ 20 \ 20 \ -5 \ 1]/32$
- Bilateral filtering step on linearly introduced samples $\tilde{x}$

$$\begin{array}{ccccccccccc} & y_{n-3} & & y_{n-2} & & y_{n-1} & & y_n & & y_{n+1} & & y_{n+2} \\ \times & \bigcirc & \times & \bigcirc & \times & \bigcirc & \boxed{\times} & \bigcirc & \times & \bigcirc & \times & \bigcirc & \times \end{array}$$

$$\hat{x}_n = \frac{w_1(y_{n-1} - \tilde{x}_n) \cdot y_{n-1} + \tilde{x}_n + w_1(y_n - \tilde{x}_n) \cdot y_n}{w_1(y_{n-1} - \tilde{x}_n) + 1 + w_1(y_n - \tilde{x}_n)}$$

- i.e. 3-tap weighted average using two adaptive weights

Weight Function



$$\sigma_n = \max \{ |d_{n-1}|, |d_{n+1}|, q \} \quad q = c_q \cdot 2^{QP/6}$$

$$w_1(d) = \begin{cases} S & |d| < c_A \cdot \sigma_n \\ -\kappa & \text{else} \end{cases}$$

- Weighting by w_1 depends on local activity
- Configured by 4 parameters: S , k , c_A , c_q
 - S : smoothing strength
 - k : enhancing strength
 - c_A : activity parameter
 - c_q : quantization noise weighting

- This filter can only be in one out of 4 states
 - Weight function w_1 can be a LUT
 - Weights can be integers summing to 2^n

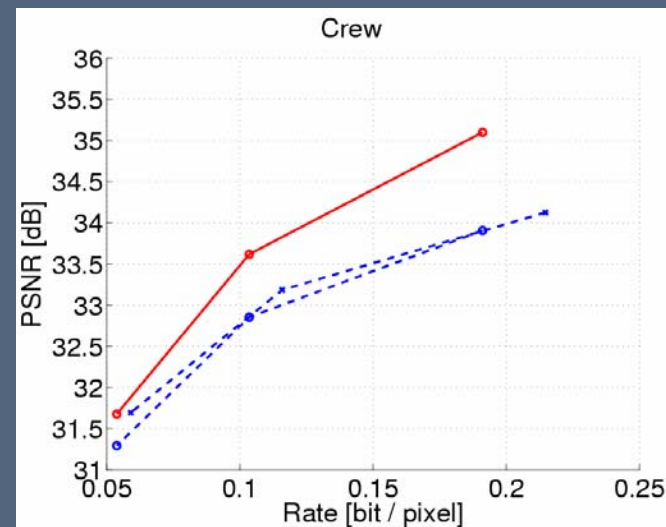
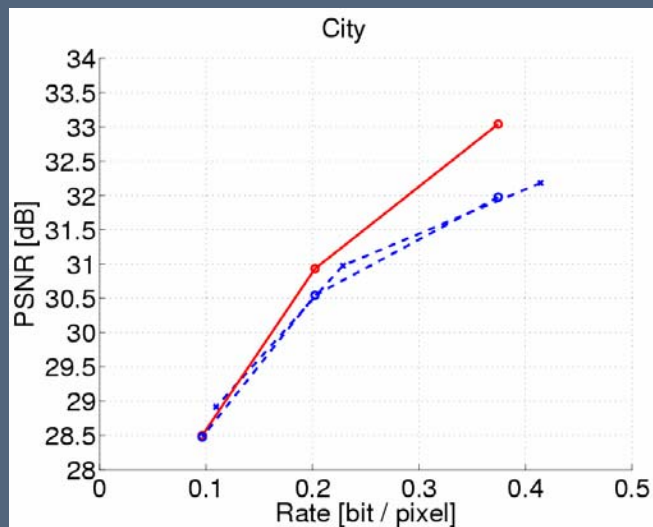
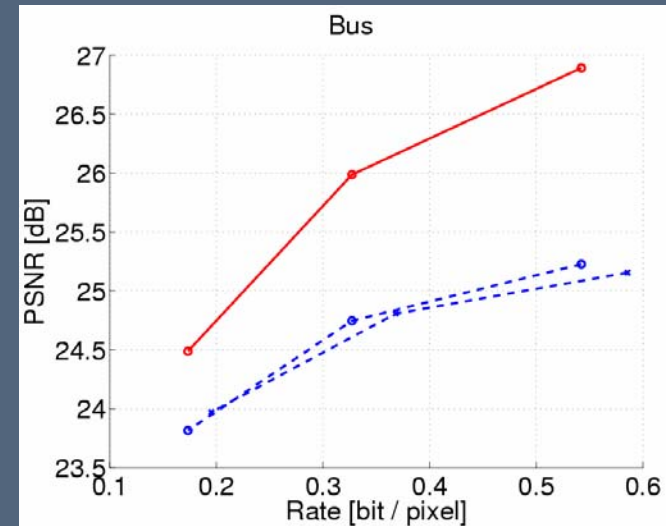
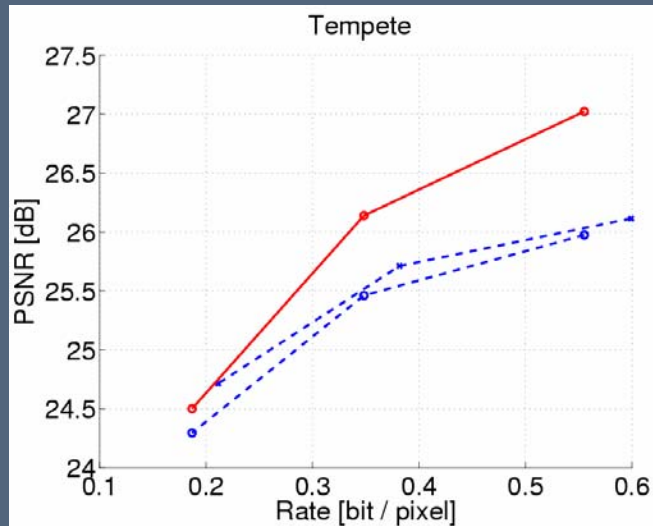
e.

Filter state		Filter coefficients		
$ y_{n-1} - \tilde{x}_n $	vs. $c_A \cdot \sigma_n$	$ y_n - \tilde{x}_n $	vs. $c_A \cdot \sigma_n$	
				w_l w_c w_r
<		<		4 8 4
<		≥		-3 13 6
≥		<		6 13 -3
≥		≥		-8 32 -8

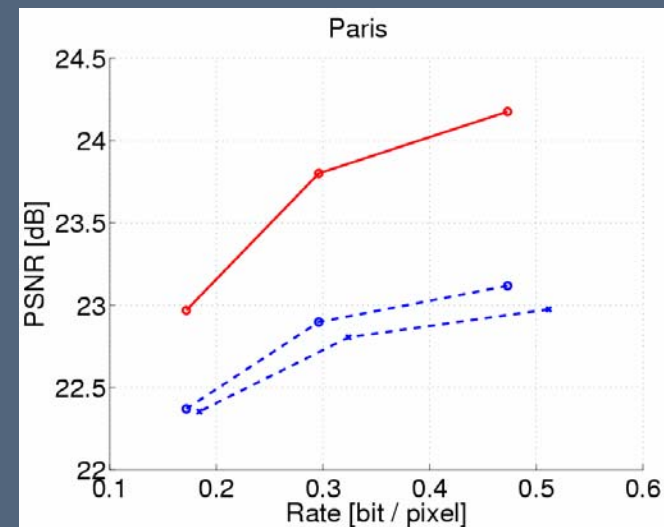
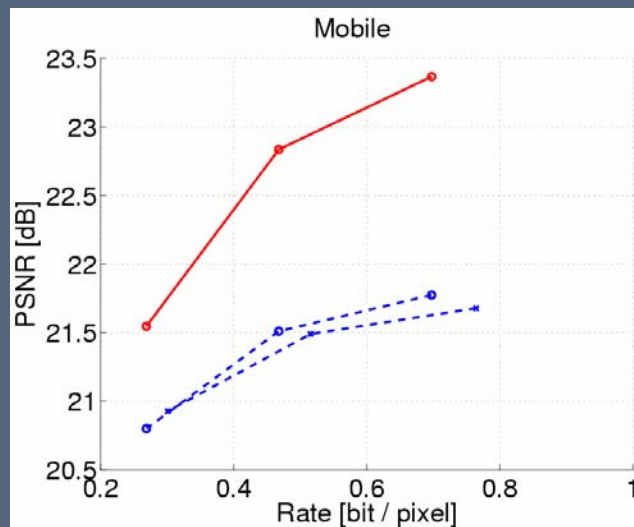
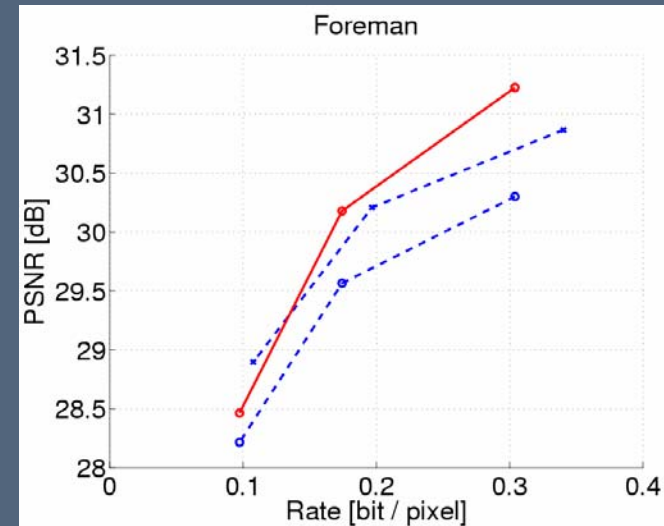
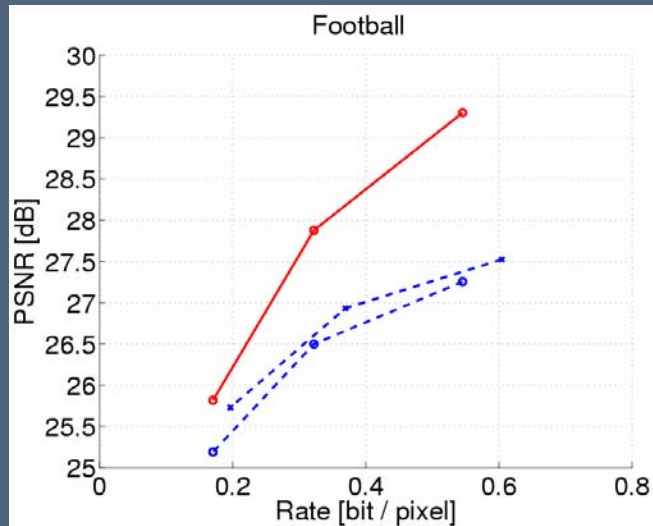
$$\hat{x}_n = (w_l \cdot y_{n-1} + w_c \cdot \tilde{x}_n + w_r \cdot y_n + 8) // 16.$$

- AVC|h.264 INTRA coding of 2 spatial layers (QCIF/CIF)
- Downsampling using either
 - $h_{MP4} = [2 \ 0 \ -4 \ -3 \ 5 \ 19 \ 26 \ 19 \ 5 \ -3 \ -4 \ 0 \ 2]/64$
 - $h_G = [2 \ 15 \ 30 \ 15 \ 2]/64$
- Linear up-sampling initialization by $[1 \ -5 \ 20 \ 20 \ -5 \ 1]/32$
- 1st experiment
 - Low-res rate vs. High-res distortion
 - h_{MP4} & linear up (- -x- -)
 - h_G & linear up (- -o- -)
 - h_G & non-linear up (o)

Experiment 1 (1/2)



Experiment 1 (2/2)

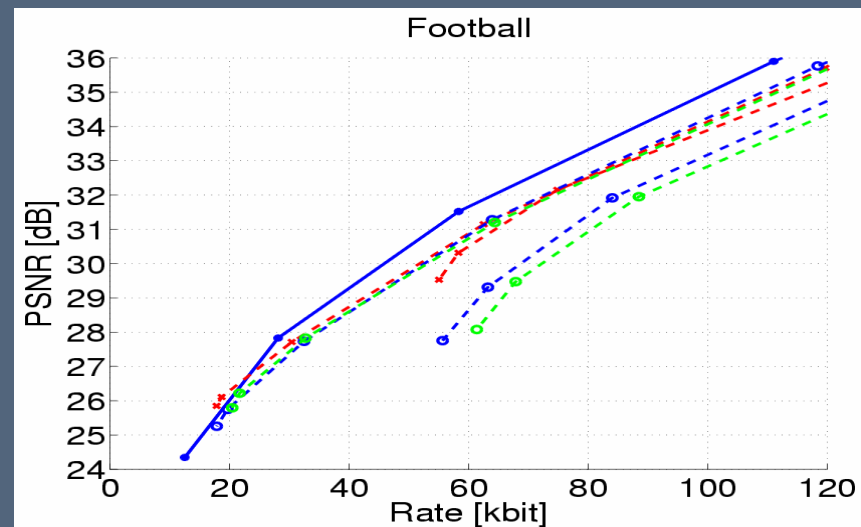
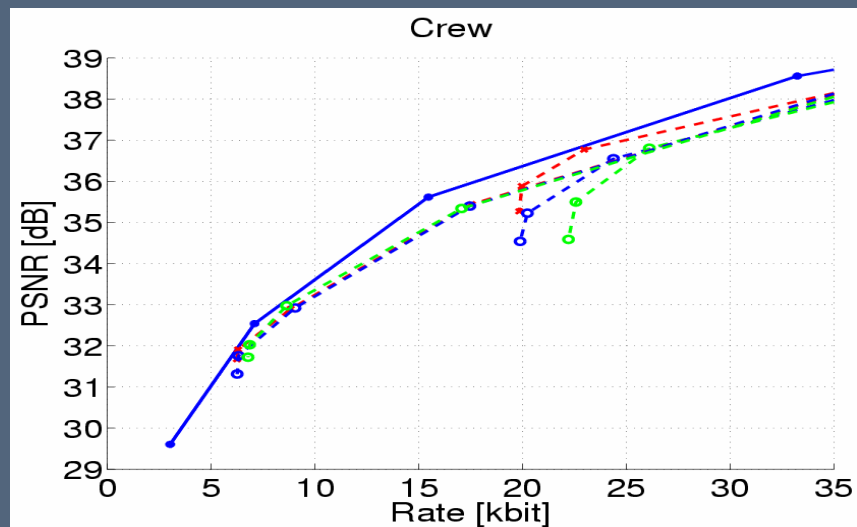
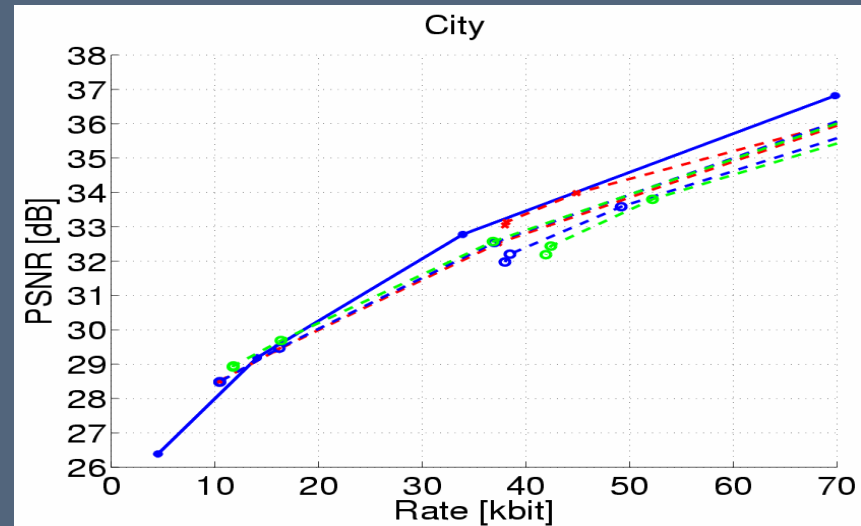
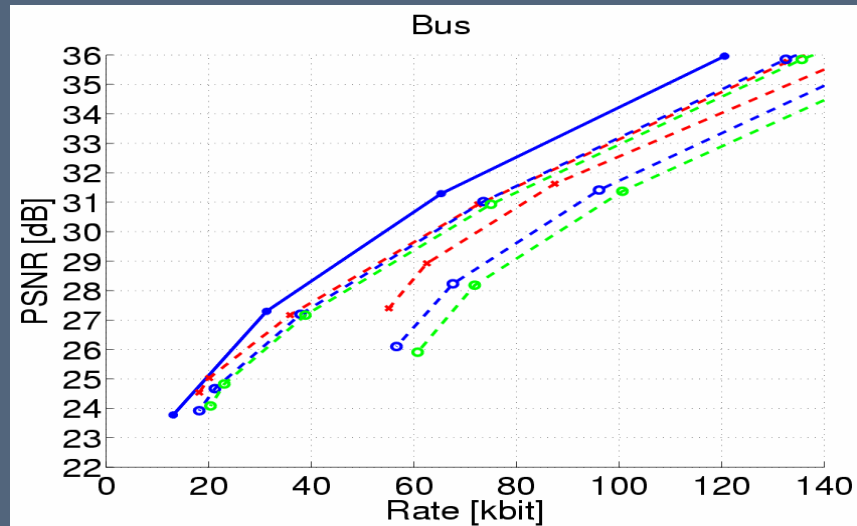


2nd Experiment

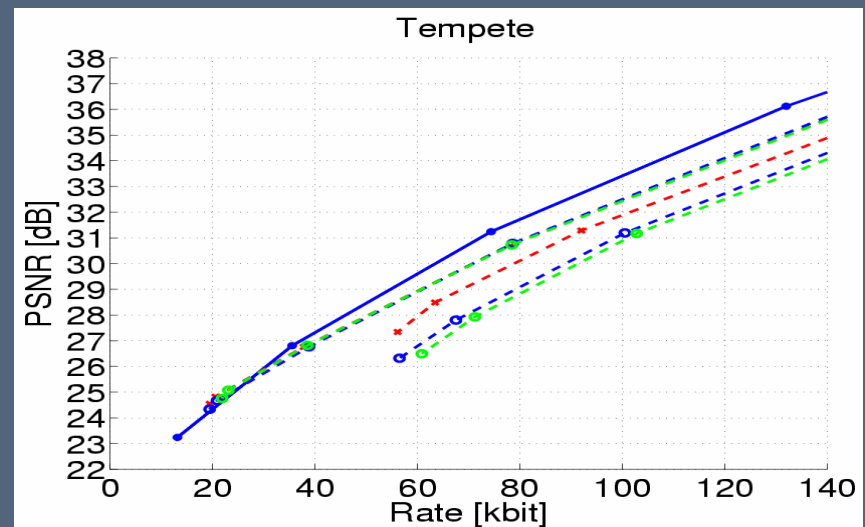
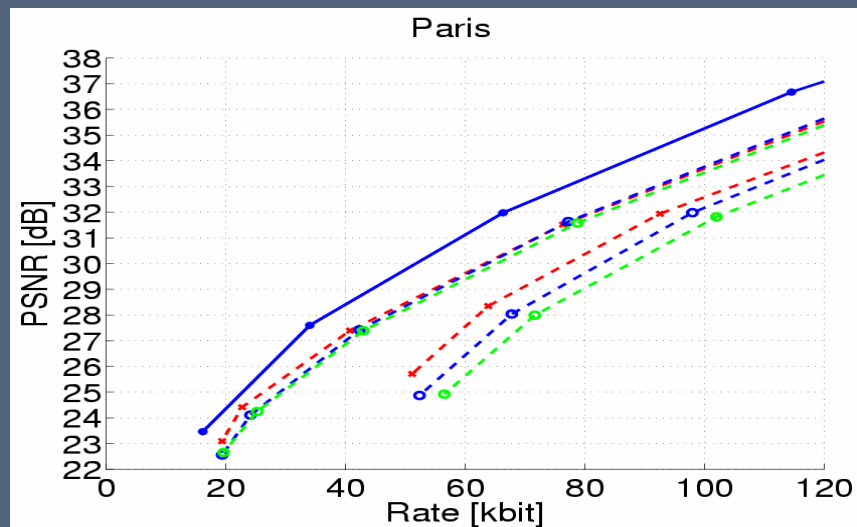
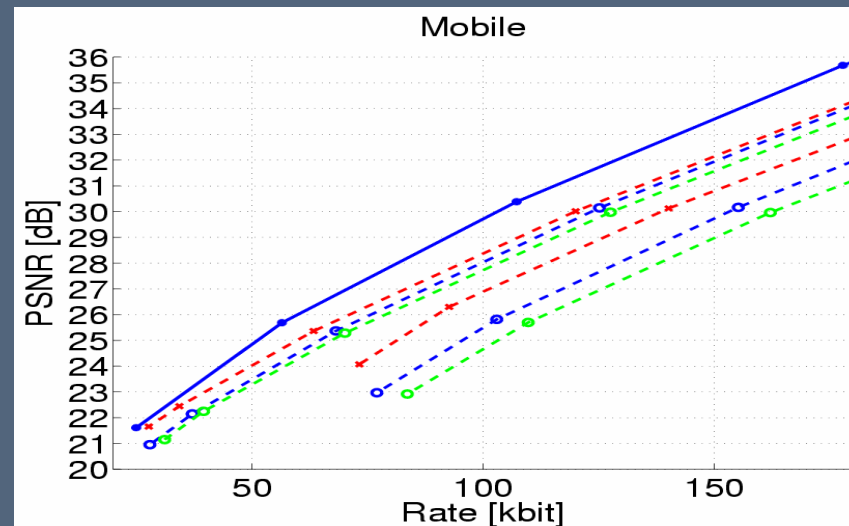
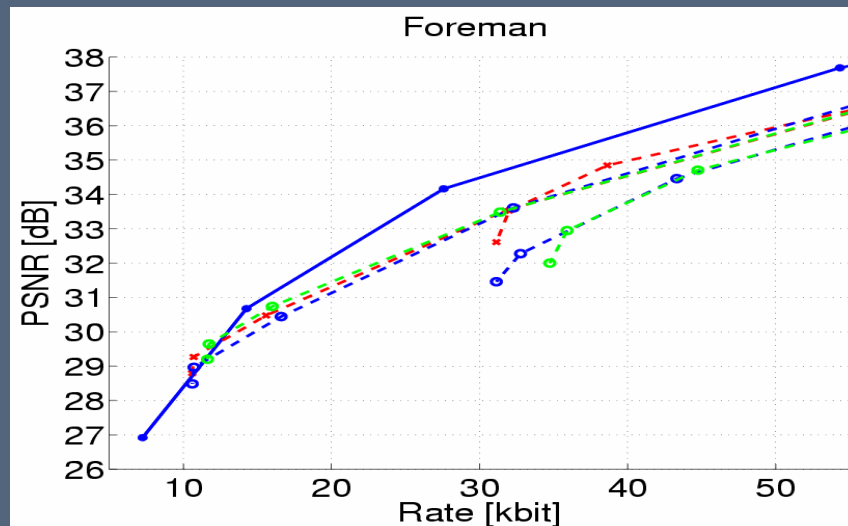


- Low-res rate + high-res rate vs. high-res distortion
- Low-res QP={22,34}
- h_G & linear up (- -o- -)
- h_{MP4} & linear up (- -o- -)
- h_G & non-linear up (- -x- -)
- Single layer coding (----)

Experiment 2 (1/2)



Experiment 2 (2/2)



- Locally adaptive up-sampling filter presented
- More than 1 dB gain for the all-INTRA case achievable
- Reduction of the R/D-penalty when spending more rate in the spatial base-layer
- Can be combined with any linear up-sampling initialization and ESS sampling location
- Division-free integer implementation possible