

## SUMMARY

- An intra interpolation filter (IF) is applied to intra reference samples.
- Cut-off freq. switchable IFs increase intra prediction performance.
- Conventional switching criteria is based on only block size but it's not always optimal for wide QP range.  
※QP=quantization parameter
- Proposed blocksize-QP dependent IFs improve BD-rate, especially up to double at high-QP range.

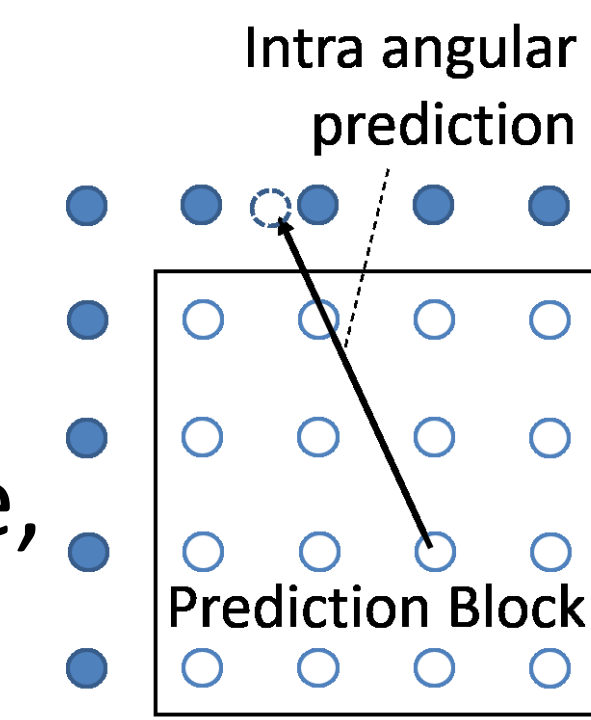


Fig. 1 Intra prediction

## RELATED WORKS[1][2][3]

- Only blocksize-based criteria for switching IF has been studied so far.
- Threshold of the criteria is fixed designed;
  - Higher-cutoff-freq. IF → Smaller ( $W|H \leq 8$ ) blocks
  - Lower-cutoff-freq. IF → Larger ( $W|H > 8$ ) blocks  
※ $W|H$  is width|height of blocks.
- The design assumes the correlation between blocksize and texture.
  - Smaller blocks: Complicated → Higher-cutoff-freq. IF (sharpening)
  - Larger blocks : Simple or flat → Lower-cutoff-freq. IF (smoothing)

Table 1. Comparison table in terms of switching criteria and using IFs

	Matsuo et al. [1]	Wei et al. [2]	Yoo et al. [3]
Switching criteria	Block size only	Block size only	Block size only
Smaller blocks ( $W H \leq 8$ )	4-tap DCT	4-tap DCT	4-tap Cubic
Larger blocks ( $W H > 8$ )	2-tap Bilinear	4-tap Gaussian	4-tap Gaussian

## REFERENCE

- [1] S. Matsuo, S. Takamura and H. Jozawa, "Improved intra angular prediction by DCT-based interpolation filter," in 20th European Signal Processing Conference (EUSIPCO), pp. 1568-1572, Aug. 2012.
- [2] R. Wei, R. Xie, L. Song, L. Zhang, and W. Zhang, "Improved Intra Angular Prediction with Novel Interpolation Filter and Boundary Filter," in Picture Coding Symposium (PCS), pp. 1-5, 2016.
- [3] S. Yoo, J. Heo, J. Choi, L. Li and J. Lim, "CE3-3.1.1: Interpolation filter selection regarding intra mode and block size," in ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, Macao, October 2018, JVET-L0130.

## PROPOSED METHOD

### PRELIMINARY EXPERIMENTS

Static criteria is not optimal since Cubic/Gaussian filters are also applied larger/smaller blocks.

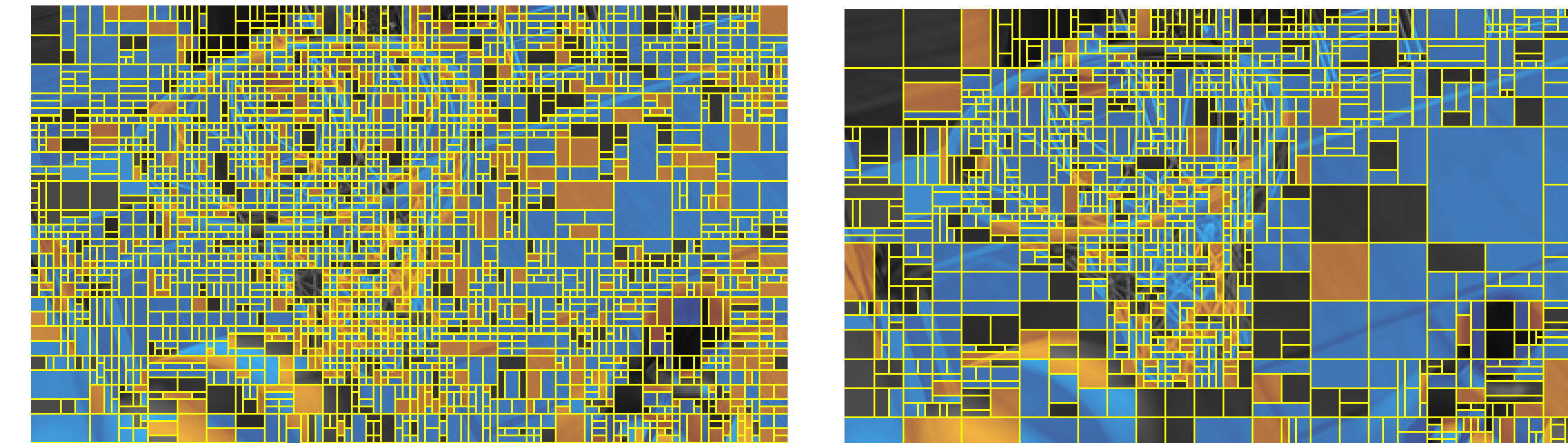


Fig. 2 Optimal IFs selection results considering bit-rate and reconstructed image error at QP=22 (left) and QP=37 (right). ( Blue=Cubic, Orange=Gaussian, Black=None)

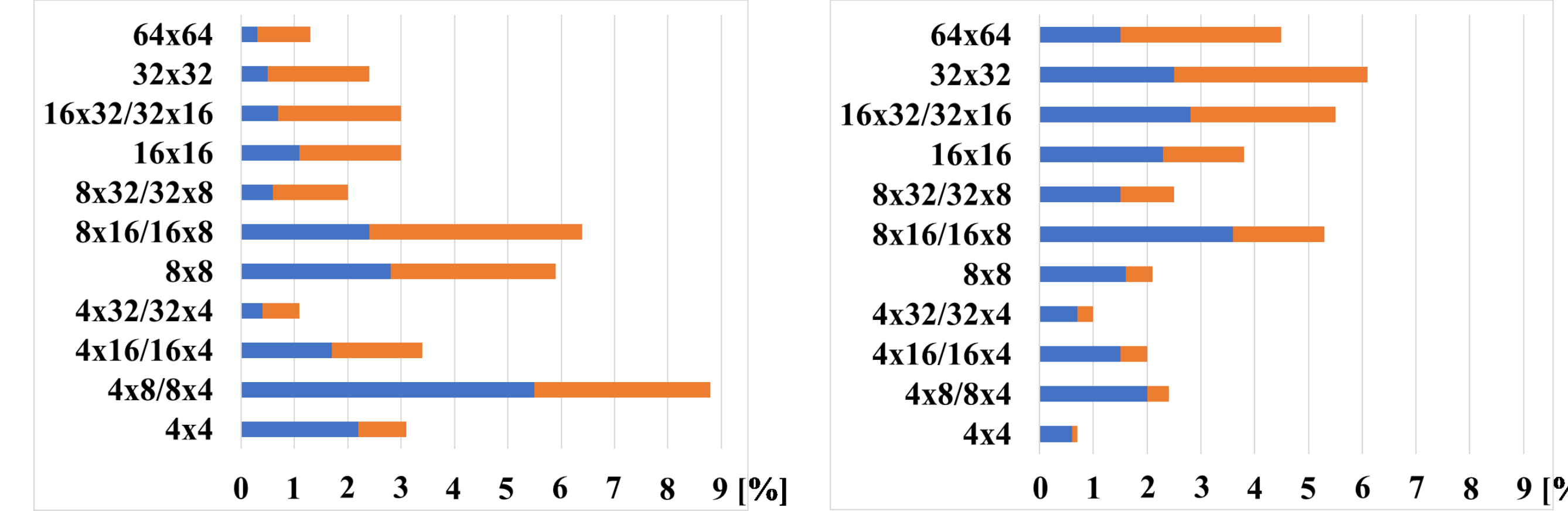


Fig. 3 Area ratio of C/G (blue/orange) filtered blocks normalized frame where all sequences and all frames are averaged at QP=22 (left) and QP=37 (right).

### PROPOSAL

Re-design QP-dependent thresholds considering QP affects block partitioning.

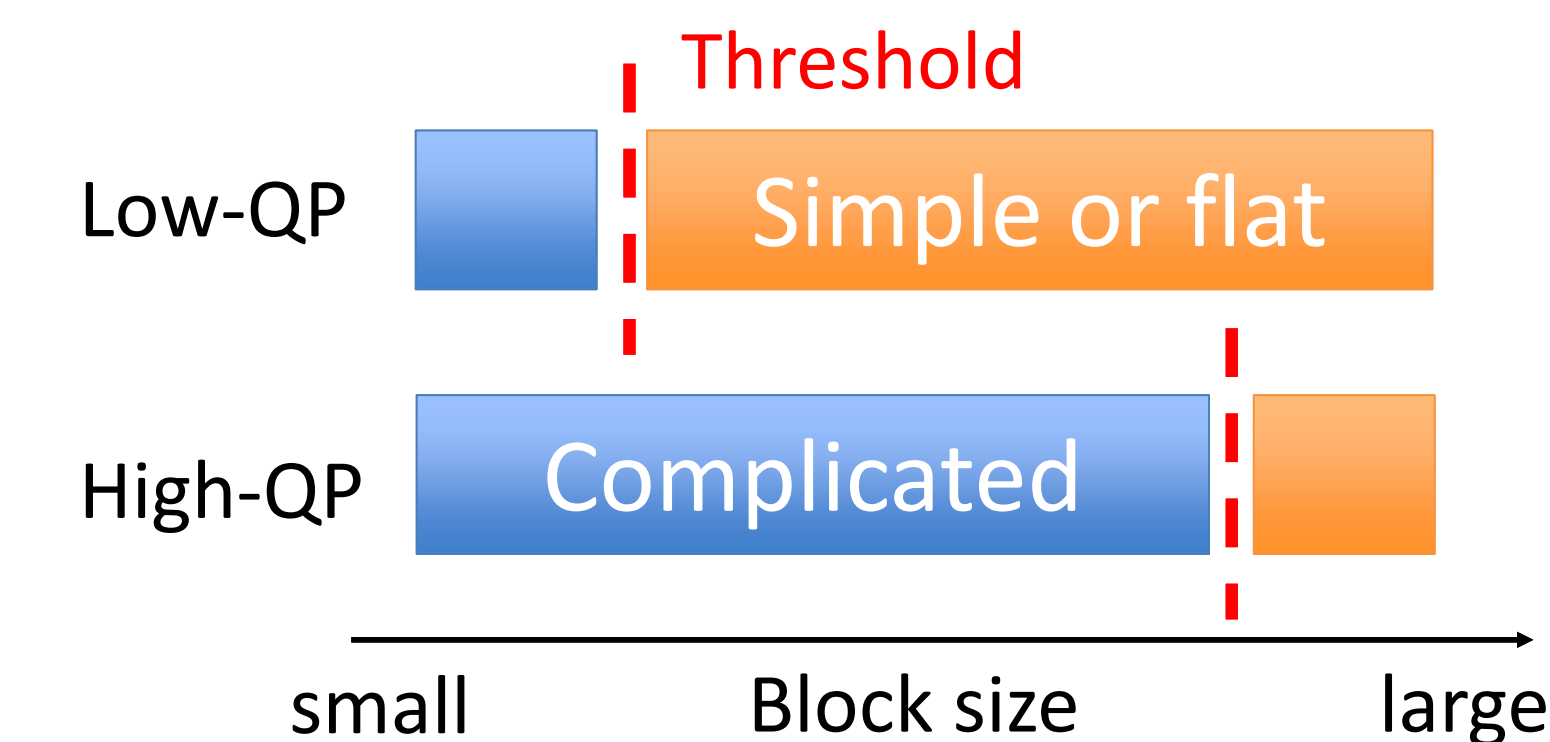


Fig. 4 Correlation of QP, block partitioning and texture

Table 2. Proposed threshold of criteria for IFs.

Block size →	4	8	16	32	64
↓QP					
18	C	G	G	G	G
19	C	C	G	G	G
...	C	C	G	G	G
27	C	C	G	G	G
28	C	C	C	G	G
...	C	C	C	G	G
35	C	C	C	G	G
36	C	C	C	C	G

Table 3. Comparison table in terms of switching criteria and using IFs

	Proposal	Yoo et al.	VTM-2.0
Switching criteria	Block size / QP	Block size only	—
Interpolation filter	4-tap Cubic 4-tap Gaussian	4-tap Cubic 4-tap Gaussian	2tap-Bilinear

## EXPERIMENTAL RESULTS

### EXPERIMENTAL CONDITION

- Implement proposal on the top of VTM2 (VVC reference S/W).
- Follow the JVET common test condition (All intra).
- Evaluate two QP ranges;
  - 1) Normal-QP= {22, 27, 32, 37}, 2) high-QP = {32, 37, 42, 47}

### RATA-DISTORTION CURVE CHARACTERISTIC

The proposal provides bitrate reduction rather than the PSNR improvement.

### BD-RATE AND RUNNING TIME

The proposal improves coding performance up to double at high-QP range against Yoo et al. .

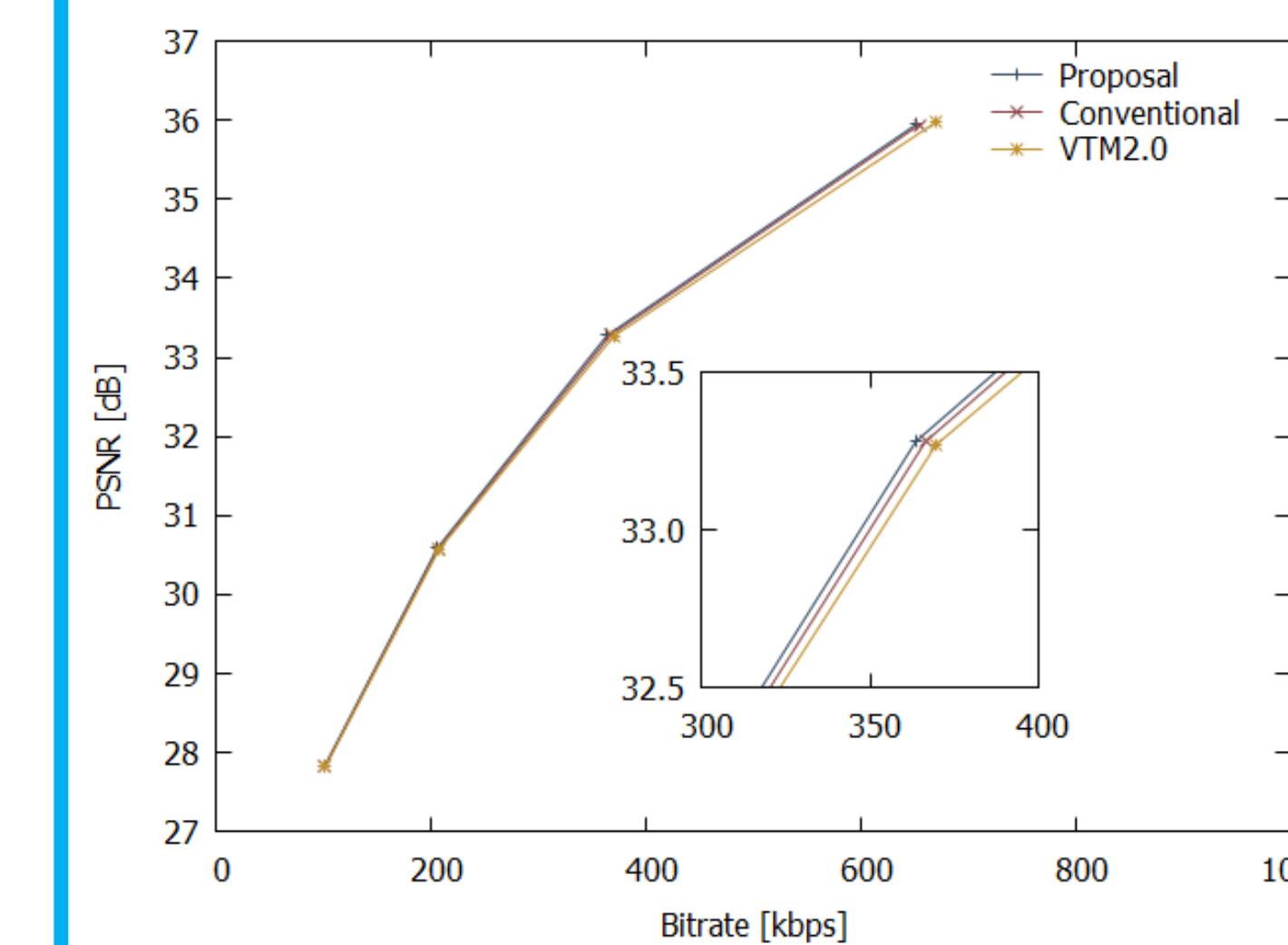


Fig. 5 RD curve of proposal at AI main 10 condition in high-QP range.

	Proposal Normal-QP	Yoo et al. Normal-QP	Proposal High-QP	Yoo et al. High-QP
Class A1	-0.06%	-0.18%	-0.08%	-0.18%
Class A2	<b>-0.17%</b>	-0.15%	<b>-0.10%</b>	-0.03%
Class B	<b>-0.43%</b>	-0.41%	<b>-0.52%</b>	-0.20%
Class C	<b>-0.76%</b>	-0.65%	<b>-0.72%</b>	-0.37%
Class E	<b>-0.73%</b>	-0.59%	<b>-0.57%</b>	-0.20%
Overall	<b>-0.45%</b>	-0.41%	<b>-0.43%</b>	-0.20%
Class D	<b>-0.55%</b>	-0.53%	<b>-0.50%</b>	-0.40%
EncT	101%	102%	101%	103%
DecT	101%	101%	101%	101%

Table 6 BD-rate comparison of two methods (proposal vs. Yoo et al.) and two condition (CTC-QP vs. High-QP). Both anchor is VTM-2.0. Note that EncT/DecT are averaged.

### SUBJECTIVE EVALUATION

Compared to anchor image, the subjective quality is not sacrificed by the proposal.

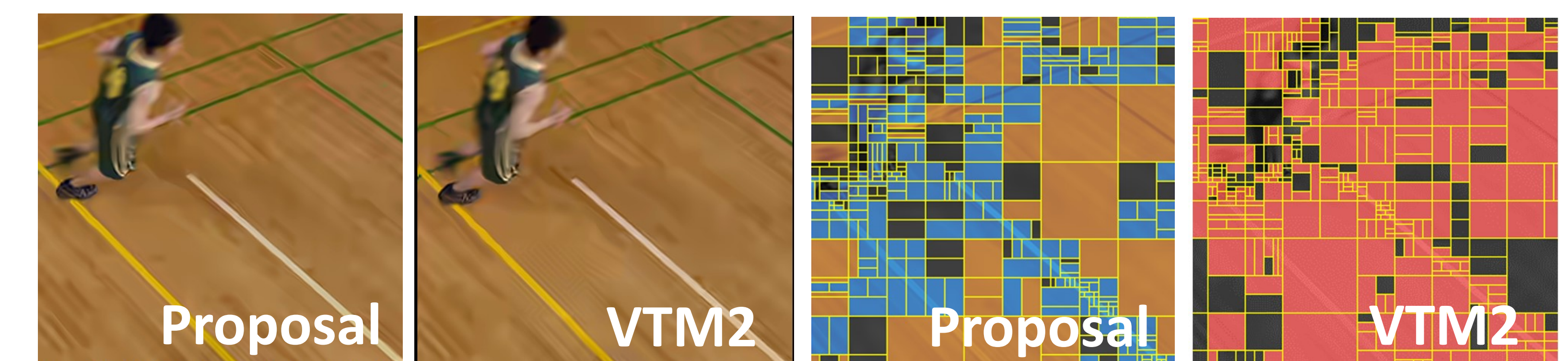


Fig. 7 Subjective results and corresponding IF selection at QP=37 condition. ( Blue=Cubic, Orange=Gaussian, Red=Bilinear, Black=None)