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Quad-tree Based Sample Refinement Filter for Video Coding

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Outline

- Motivations
- Quad-tree Sample Refinement Filter (QSRF)
- The performance of QSRF

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Motivations

- The existing in-loop filter schemes: SAO and ALF are performed with a fixed filtering size.
  - SAO: filter unit is the Largest Coding Unit (LCU)
  - ALF: One picture is divided into 16 regions, one region is regarded as one filter unit.
    - lack of flexibility to deal with various contents
- The high filtering correlation existing at different in-loop filter stages is rarely considered.

Motivations

- The high filtering correlation existing at different in-loop filter stages is rarely considered.
  - confidence level *p*

$$\tilde{C}_1 = \{(i,j) \in I : Y(i,j) > X(i,j)\}$$
$$\tilde{C}_2 = \{(i,j) \in I : Y(i,j) \le X(i,j)\}$$

I: the location of all the samples.
X: the original samples.
Y: the reconstructed samples.
The whole samples can be divided into 2 classes: $\tilde{C}_1$ and $\tilde{C}_2$

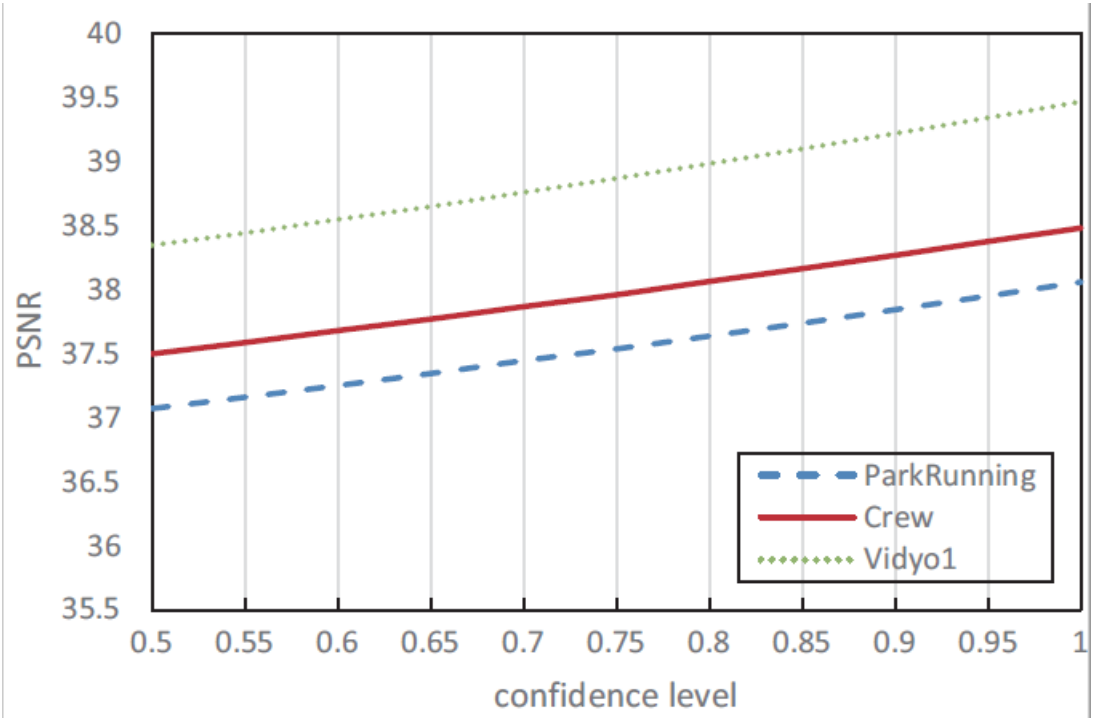
$$p = \frac{\Lambda_1 + \Lambda_2 + \ldots + \Lambda_{L-1} + \Lambda_L}{\left| C_1 \cup C_2 \cup \ldots \cup C_{L-1} \cup_{L-1} \right|}$$

$$\Lambda_k = \begin{cases} \left| C_k \cap \tilde{C}_1 \right|, \left| C_k \cap \tilde{C}_1 \right| > \left| C_k \cap \tilde{C}_2 \right| \\ \left| C_k \cap \tilde{C}_2 \right|, \left| C_k \cap \tilde{C}_2 \right| \le \left| C_k \cap \tilde{C}_2 \right|, k \in [1, L] \end{cases}$$

$\left| C_k \cap \tilde{C}_1 \right|$ equals to the number of samples both in C_k and $\tilde{C}_1$

Motivations

- The impact of the confidence level *p* on the PSNR



It can be seen that the PSNR increases with the value of the confidence level increases

Motivations

- Sample classification

$$s_k(i,j) = sign(P_k(i,j) - P_{k+1}(i,j)), \quad k=1, 2, 3$$

$$sign(x) = \begin{cases} 1, x < 0 \\ 0, x \geq 0 \end{cases}$$

$$s_* = 4 * s_1(i,j) + 2 * s_2(i,j) + s_3(i,j)$$

For S_1, S_2 and S_3, the whole samples are classified into 2 classes. For S_*, the whole samples are classified into 8 classes.

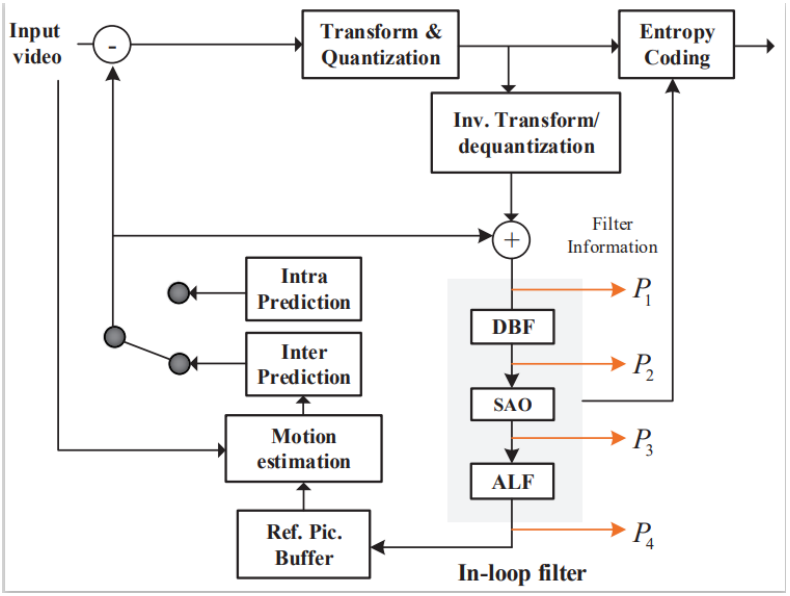
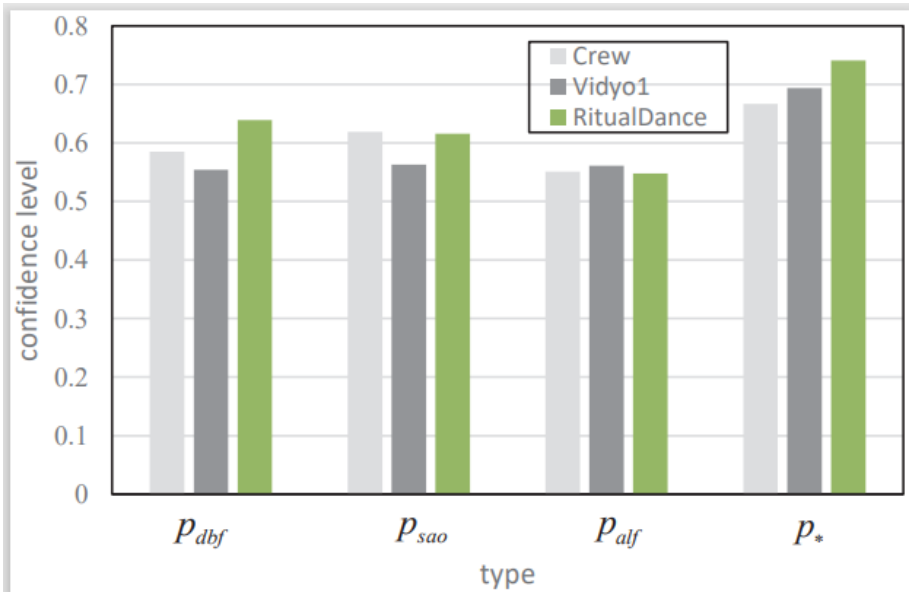


Fig.1 Encoder block diagram

Motivations

- The confidence level result
  - $p_{dbf}, p_{sao}, p_{alf}, p_*$: the confidence level of S_1, S_2, S_3 and S_*



p_* has the highest confidence value, which means that the classification method S_* has great potential to bring some coding gain.

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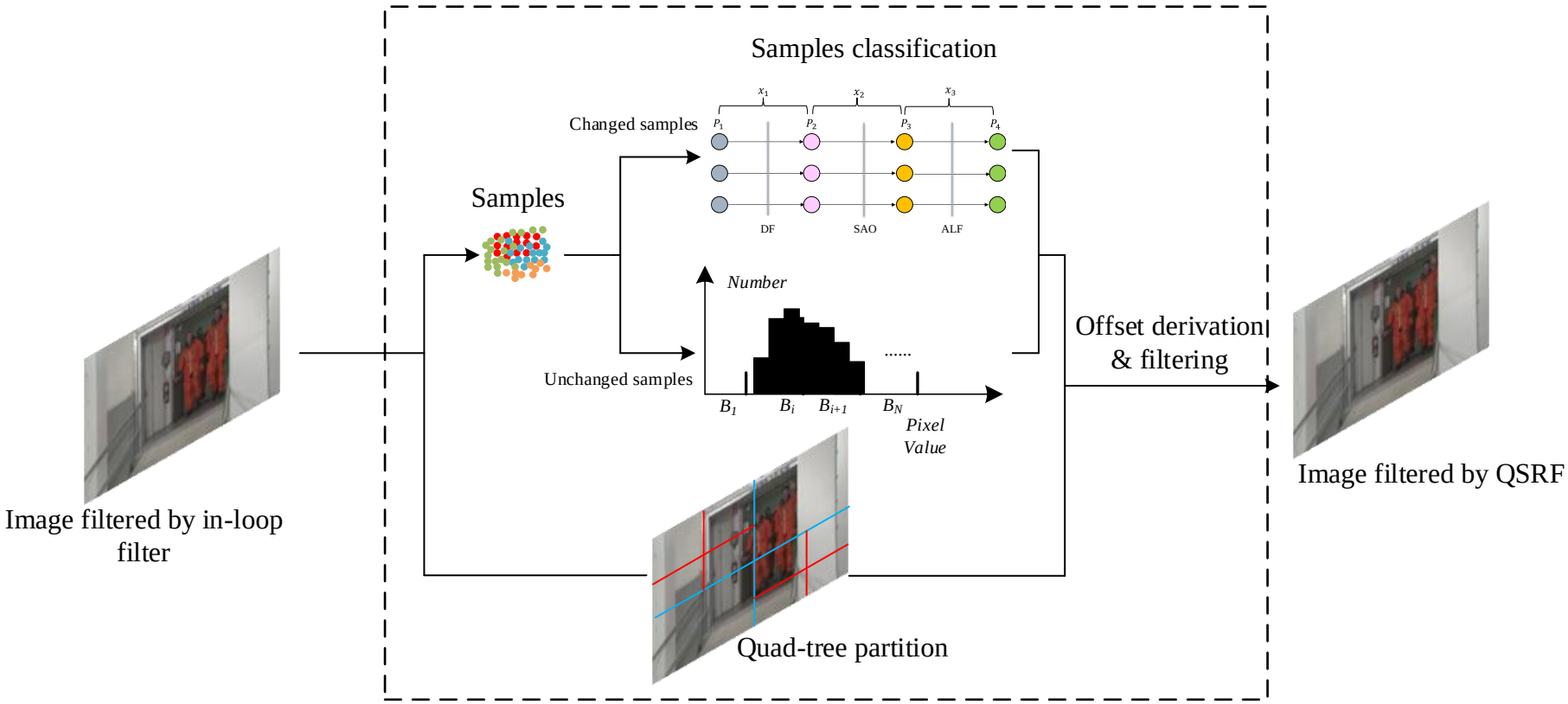
Quad-tree Sample Refinement Filter (QSRF)

- The whole structure of QSRF

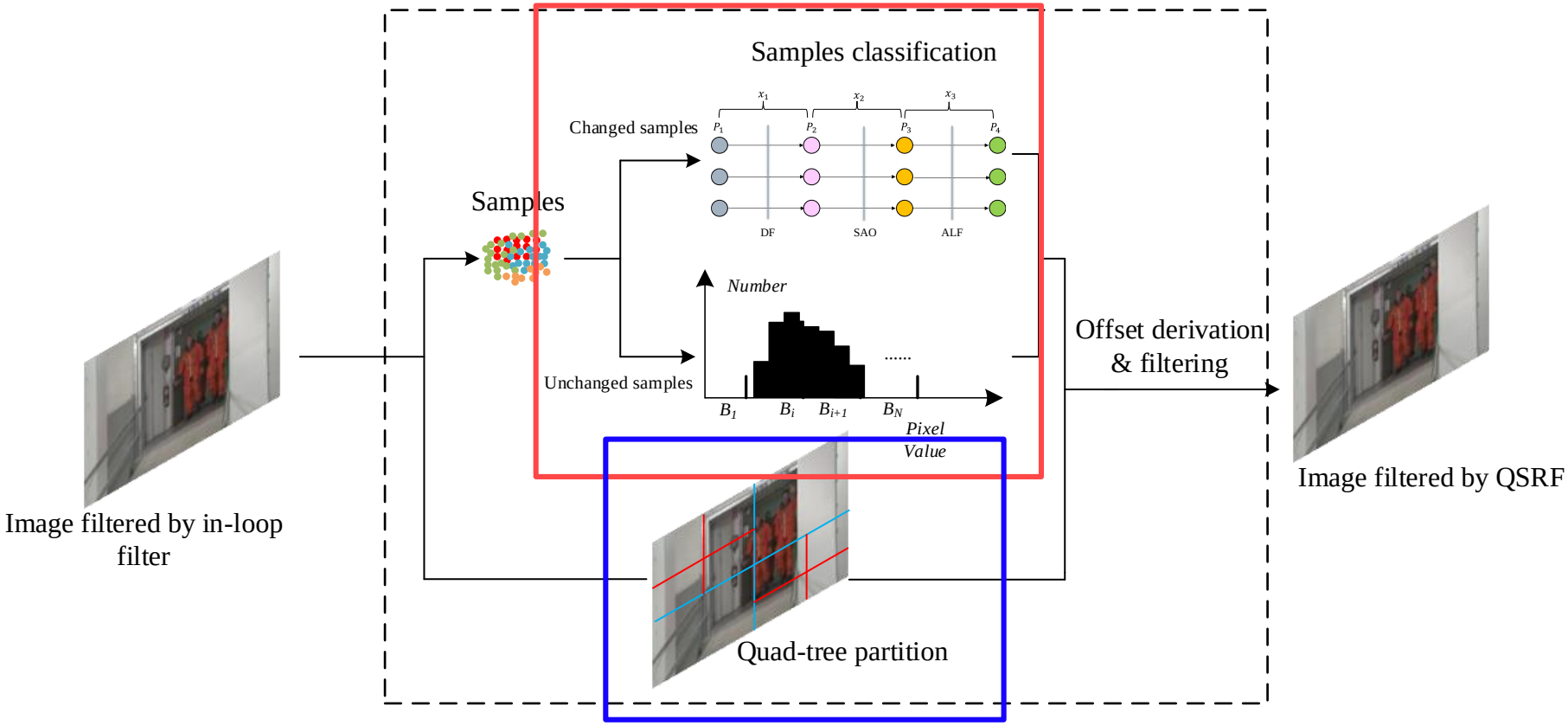


QSRF structure

Quad-tree Sample Refinement Filter (QSRF)

- The whole structure of QSRF

Part One: Samples classification



QSRF structure

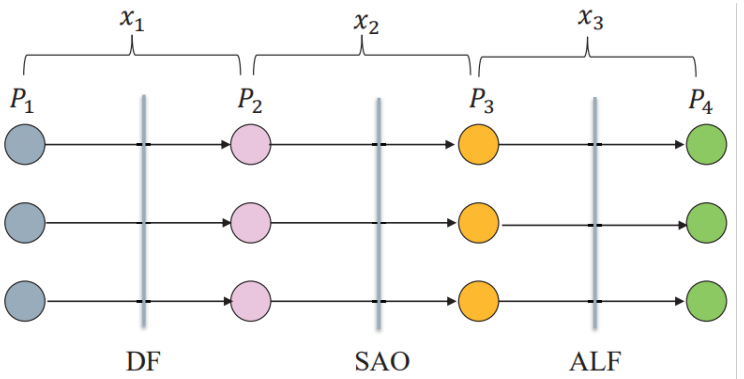
Part two: Quad-tree structure

Quad-tree based Sample Refinement Filter (QSRF)

- Part one: Samples classification
  - Changed samples: (samples are filtered by in-loop filter):

$$C(i,j) = x_1(i,j) * 9 + x_2(i,j) * 3 + x_3 \quad (1)$$

$$x_i(i,j) = \begin{cases} 0, P_i(i,j) = P_{i+1}(i,j) \\ 1, P_i(i,j) > P_{i+1}(i,j) \\ 2, P_i(i,j) < P_{i+1}(i,j) \end{cases}$$



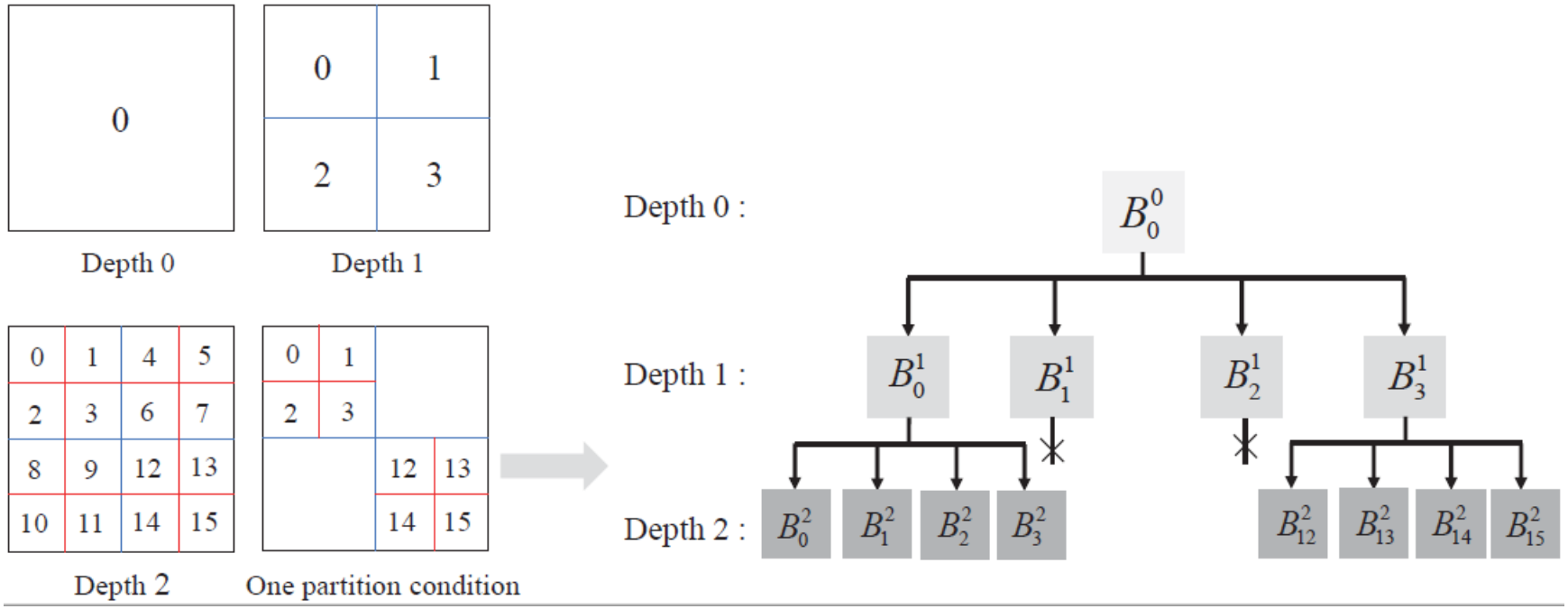
  - Unchanged samples (samples are not filtered by in-loop filter):

$$C_b(i,j) = \left\lfloor \frac{K}{2^{bitDepth}} * P_4(i,j) \right\rfloor \quad (2)$$

The whole samples are classified into total 26+K classes

Quad-tree based Sample Refinement Filter (QSRF)

- Part two: Quad-tree structure (QS)



The root of QS is one frame, the leaves of QS cover an integer number of LCU. The best partitioning result is determined by rate-distortion optimization (RDO).

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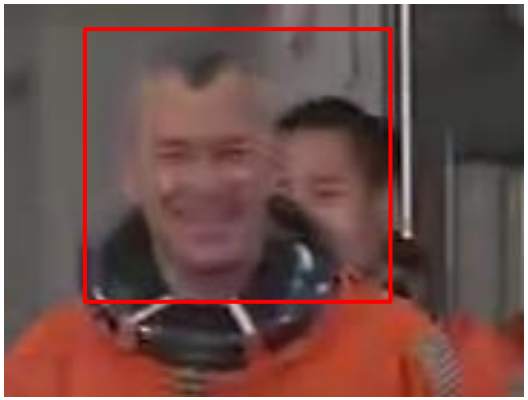
The performance of QSRF

- Objective result
  - HPM-7.0 (the software of AVS3)

Resolution	Sequence	RA			LDB			LDP		
		Y	*U*	*V*	*Y*	*U*	*V*	*Y*	*U*	*V*
Class A	Tango2	-0.14%	-2.59%	-0.78%	-0.44%	0.06%	-0.23%	-0.41%	-0.10%	-0.49%
	Parkrunning3	-0.37%	-0.21%	-0.11%	-0.53%	-0.18%	-0.21%	-0.53%	-0.07%	-0.09%
	Campfire	-0.59%	-0.62%	-1.29%	-0.80%	-0.72%	-1.20%	-0.82%	-0.67%	-0.97%
	DayLightRoad2	-0.05%	-0.60%	-0.21%	-0.77%	-1.02%	-0.66%	-0.62%	-0.96%	-0.37%
Class B	Cactus	-0.17%	-0.06%	-0.21%	-0.29%	-0.06%	-0.63%	-0.19%	-0.00%	-0.04%
	BasketballDrive	-0.19%	-0.13%	-0.95%	-0.48%	-0.79%	-0.56%	-0.41%	-0.59%	-0.68%
	MarketPlace	-0.37%	-1.08%	-0.76%	-0.71%	-1.44%	-0.79%	-0.79%	-0.03%	-0.55%
	RitualDance	-0.84%	-1.22%	-2.31%	-0.80%	-0.73%	-0.82%	-0.95%	-0.47%	-0.91%
Class C	City	-0.49%	-0.34%	0.03%	-1.26%	-0.66%	0.90%	-1.23%	-0.42%	-0.24%
	Crew	-0.44%	-7.68%	-2.58%	-0.94%	-6.18%	-2.18%	-1.01%	-5.74%	-2.14%
	vidyo1	-0.48%	-0.23%	-1.64%	-1.23%	-0.98%	-0.16%	-0.75%	0.01%	-0.03%
	vidyo3	-0.55%	-0.93%	-1.38%	-1.03%	-1.86%	-0.69%	-0.75%	0.13%	-0.35%
Class A (3840×2160)		-0.29%	-1.00%	-0.60%	-0.63%	-0.46%	-0.57%	-0.59%	-0.45%	-0.48%
Class B (1920×1080)		-0.39%	-0.62%	-1.06%	-0.57%	-0.76%	-0.70%	-0.58%	-0.27%	-0.54%
Class C (1280×720)		-0.49%	-2.30%	-1.39%	-1.12%	-2.42%	-0.53%	-0.93%	-1.51%	-0.69%
Overall		**-0.39%**	**-1.31%**	**-1.01%**	**-0.77%**	**-1.21%**	**-0.60%**	**-0.70%**	**-0.74%**	**-0.57%**

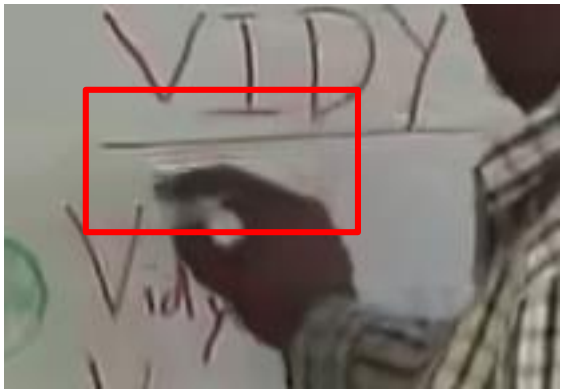
The performance of QSRF

- Subjective result

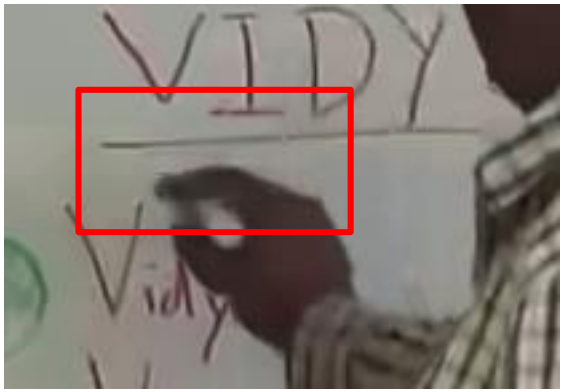


Anchor

Test



Anchor



Test

Thanks!