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JCTVC-Q0036
Description of screen content coding technology proposal by Mitsubishi Electric Corporation

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Overview

- Proposal is built upon HEVC Range Extensions Draft 6

- Targets both objective and subjective improvement

- Tools added to HM-13.0_RExt-6.0 software as additional modes

- Previously enabled Rext-6.0 tools remain enabled

Proposed coding tools

- Inter-component prediction

- Histogram Correction mode for SAO

- Independent uniform prediction

- Palette mode

- Previously-enabled tools still enabled, including:

  – Intra block copy, including NxN/2NxN/Nx2N modes

  – Transform Skip improvements

  – Cross-component prediction

  – Rotation of Transform Skip blocks

  – RDPCM

  – Improved Rice parameter initialization

Inter-component prediction (ICP) motivation

Cross-component prediction (CCP) operates on residuals

Use of CCP in current Rext highly dependent upon degree of quantization

QP=27   QP=42

CCP used for both B (Cb) and R (Cr) components

CCP used only for B (Cb)   CCP used only for R (Cr)

Proposed solution: ICP prior to residual computation, as an additional mode

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Inter-component prediction (ICP)

- ICP extends concept of Intra LM Chroma mode
  - Extended to also work with Intra Block Copy (CU level)
  - On/off signaling for each PU
  - 3rd component can be predicted from 1st or 2nd
    - Encode PU-level selection flag

- 4:4:4 prediction formula similar to JCTVC-M0097

$$pred_C[x,y] = \alpha \times P_R[x,y] + \beta$$

Reconstructed samples bordering reference component   Reconstructed samples bordering predicted component

$$\alpha = \frac{R(P_R, P_C)}{R(P_R, P_R)}$$

$$\beta = M(P_C) - \alpha \times M(P_R)$$

$$R(A,B) = M\big((A - M(A)) \times (B - M(B))\big)$$

Intra PU decoding process after parsing ICP enable flag
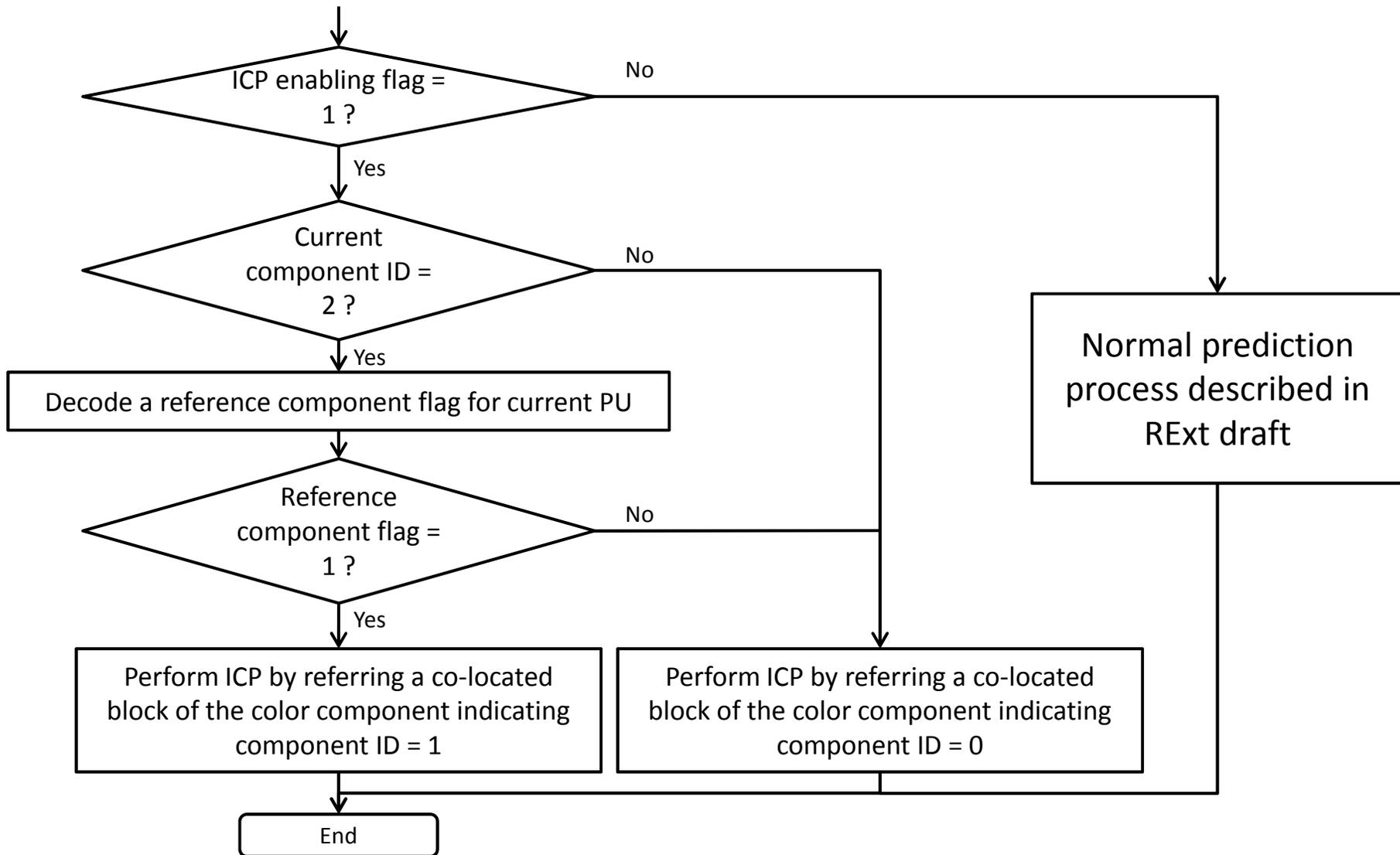
Inter-component prediction (ICP) characteristics

Encoder chooses between ICP and CCP via RDO decision process

Usage map example for ICP and CCP

Proposed ICP
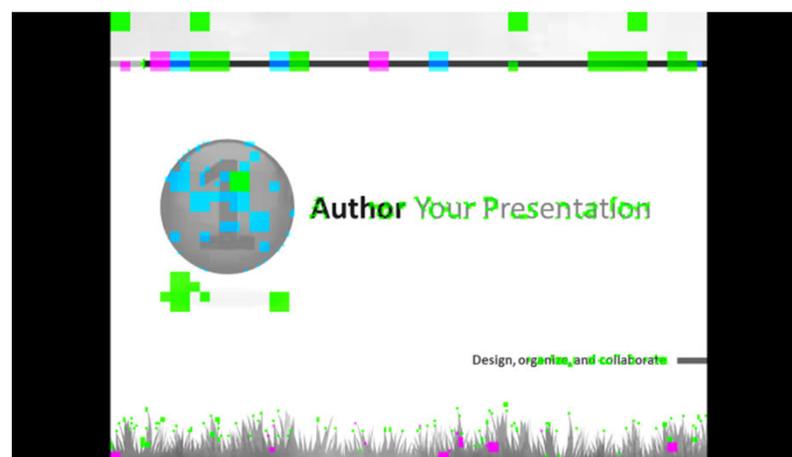
Existing CCP

■ Prediction used for both B (Cb) and R (Cr) components

■ Prediction used only for B (Cb)   ■ Prediction used only for R (Cr)

ICP tends to be used in plane and soft texture areas; CCP in sharp edge areas such as text

Histogram Correction (HC) mode for SAO: Motivation

Original

Decoded

Coding distortion
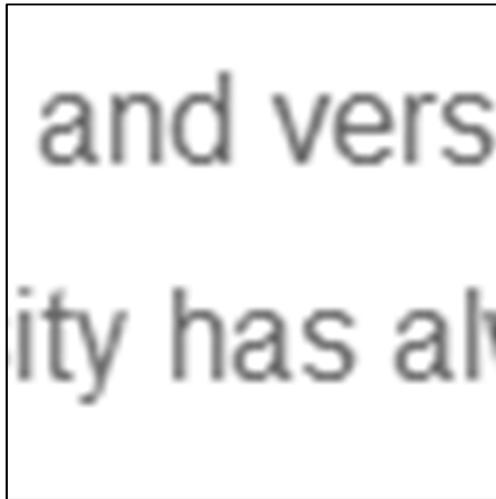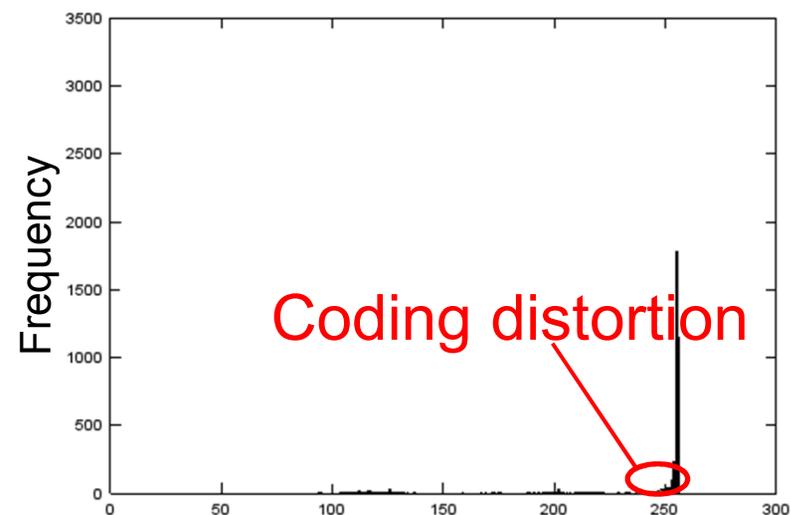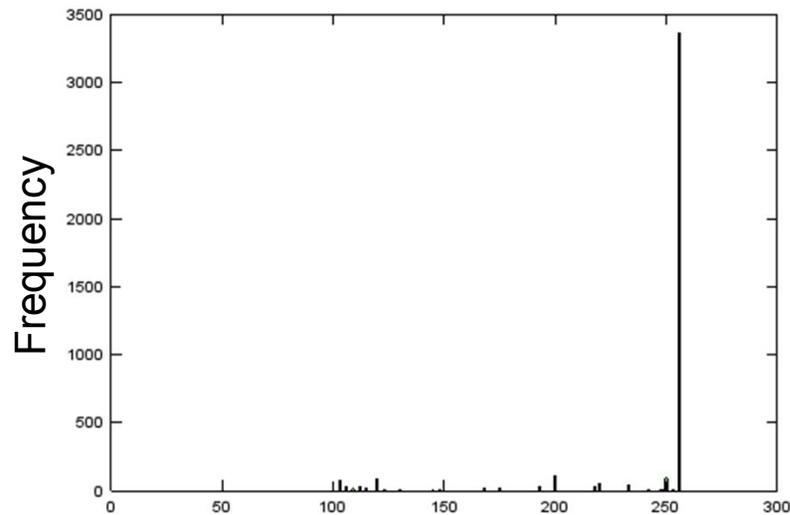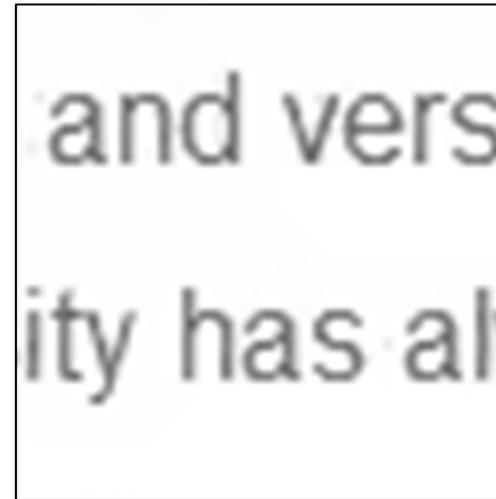
Noise removal in histogram
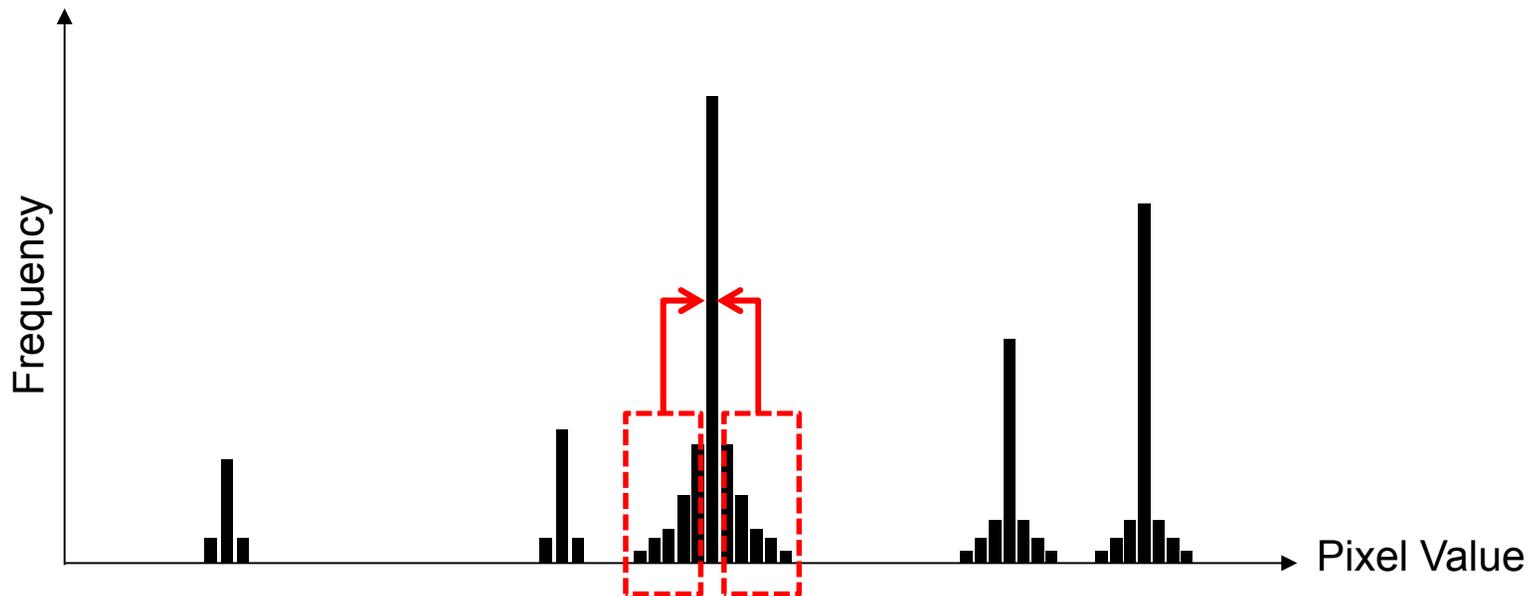
- Remove noise by replacing the pixel values around the peak with the peak value

Noise removal in histogram (2)
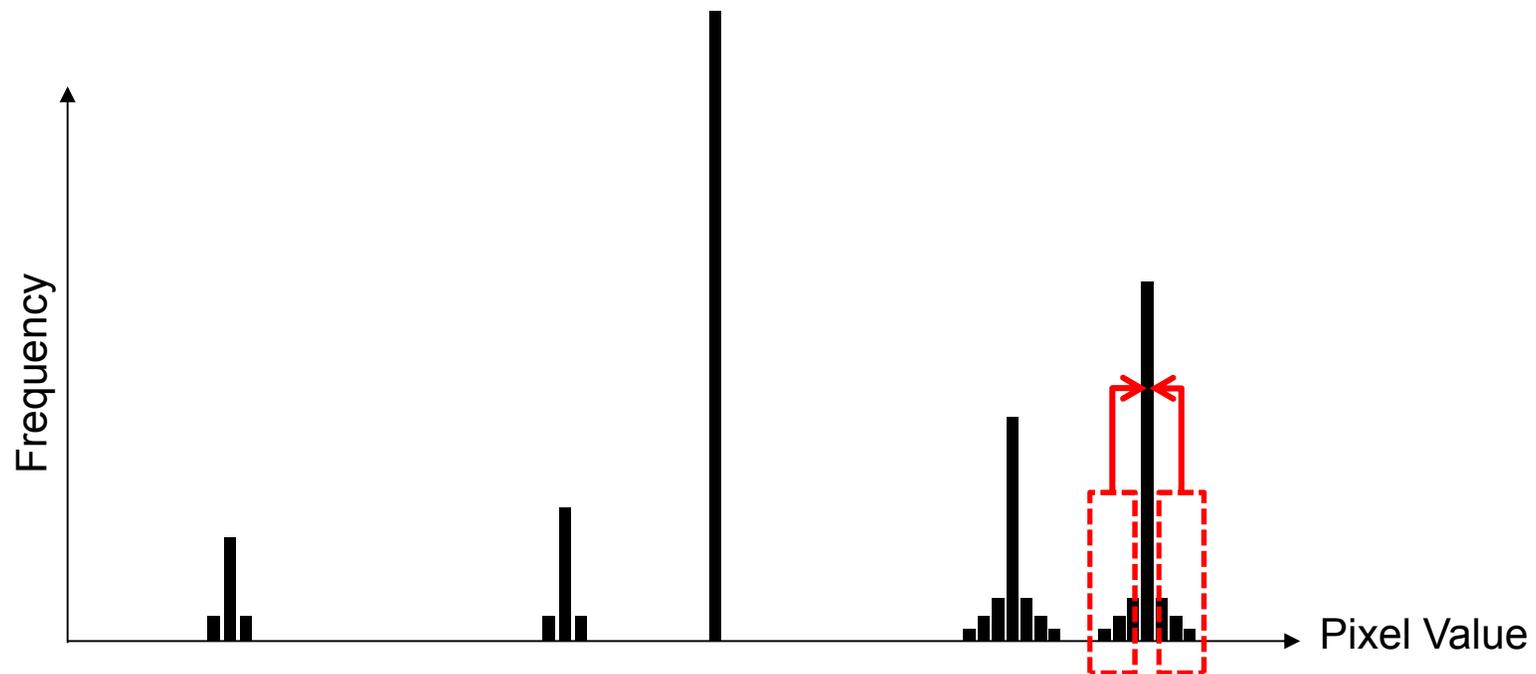
- Remove noise by replacing the pixel values around the peak with the peak value

- Repeatedly apply the noise removal to each peak

Noise removal in histogram (3)
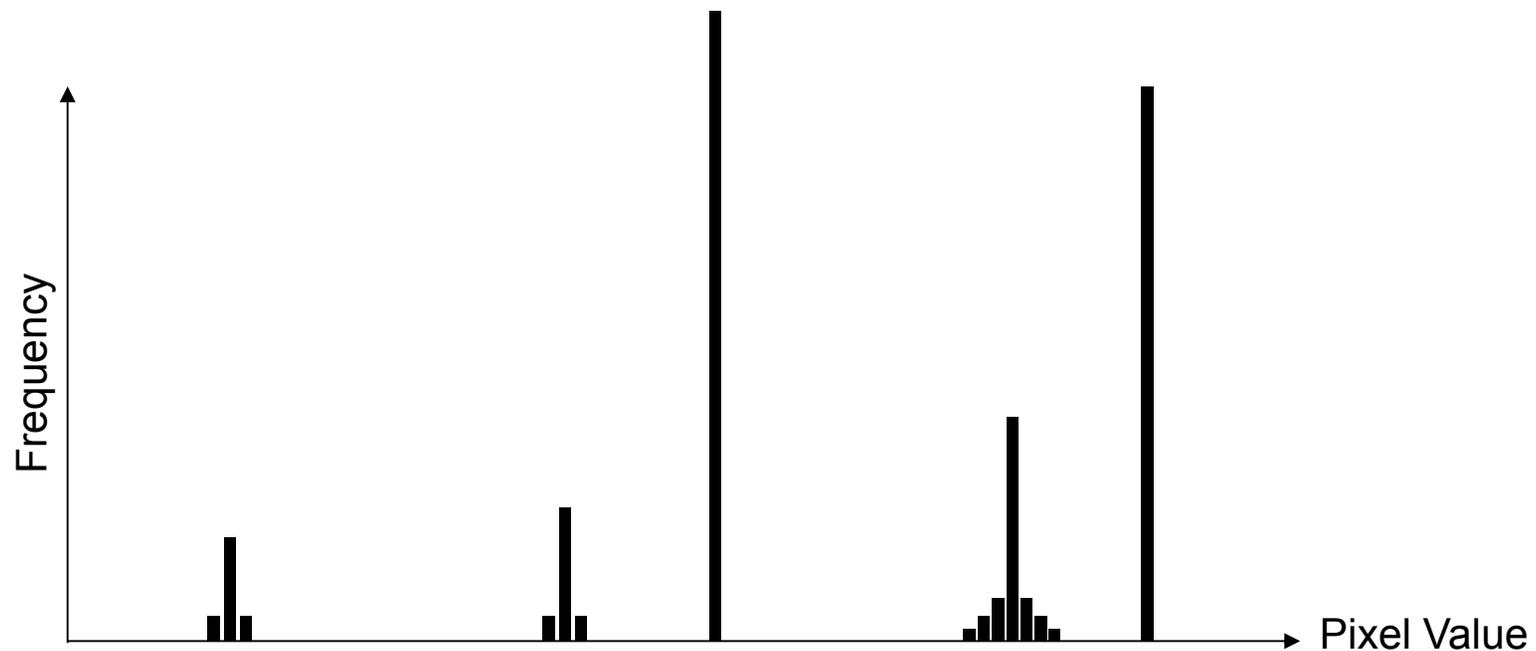
- Remove noise by replacing the pixel values around the peak with the peak value

- Repeatedly apply the noise removal to each peak
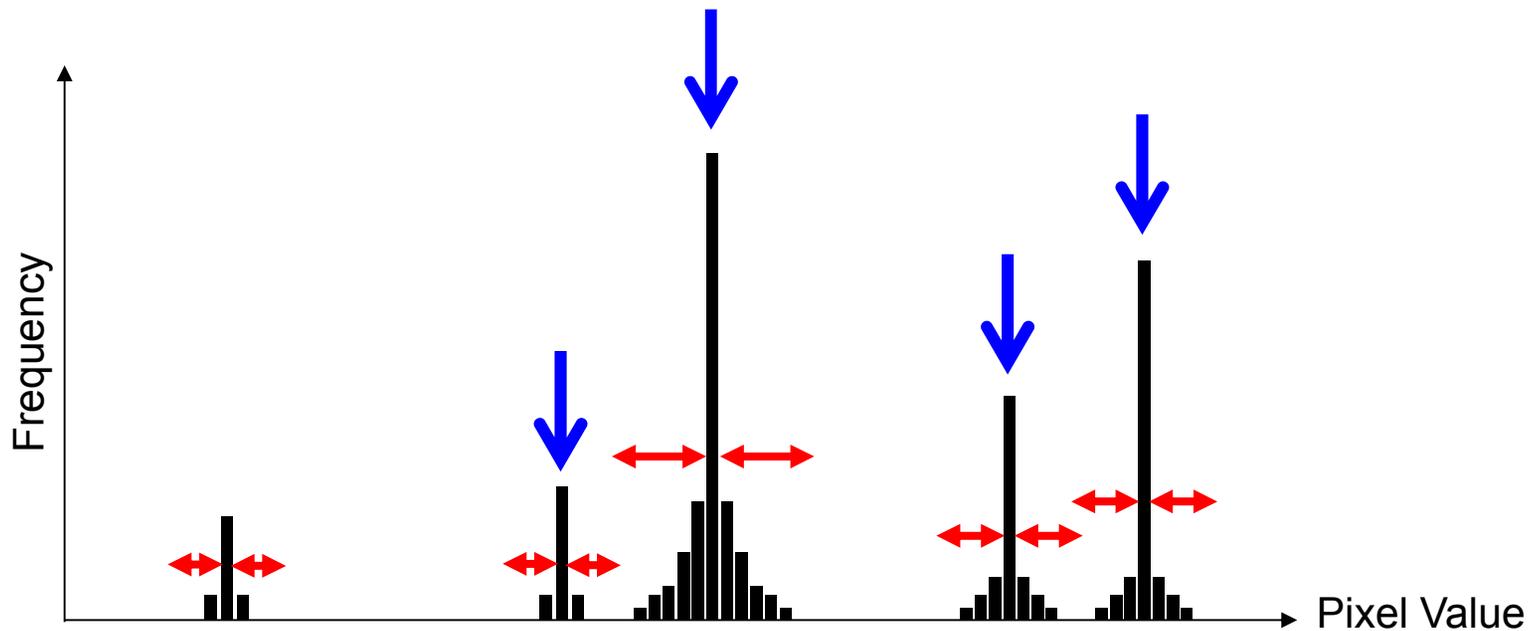
- To align with the current SAO design, use the largest 4 peaks
- Encoder optimizes the ranges and transmits them to decoder

SAO modification

SAO OFF   SAO BO   SAO EO   SAO HC

Encoder selection

Encode index which indicates SAO OFF	Encode index which indicates SAO BO	Encode index which indicates SAO EO	Encode index which indicates SAO HC
	Encode four offsets	Encode four offsets	Encode four ranges
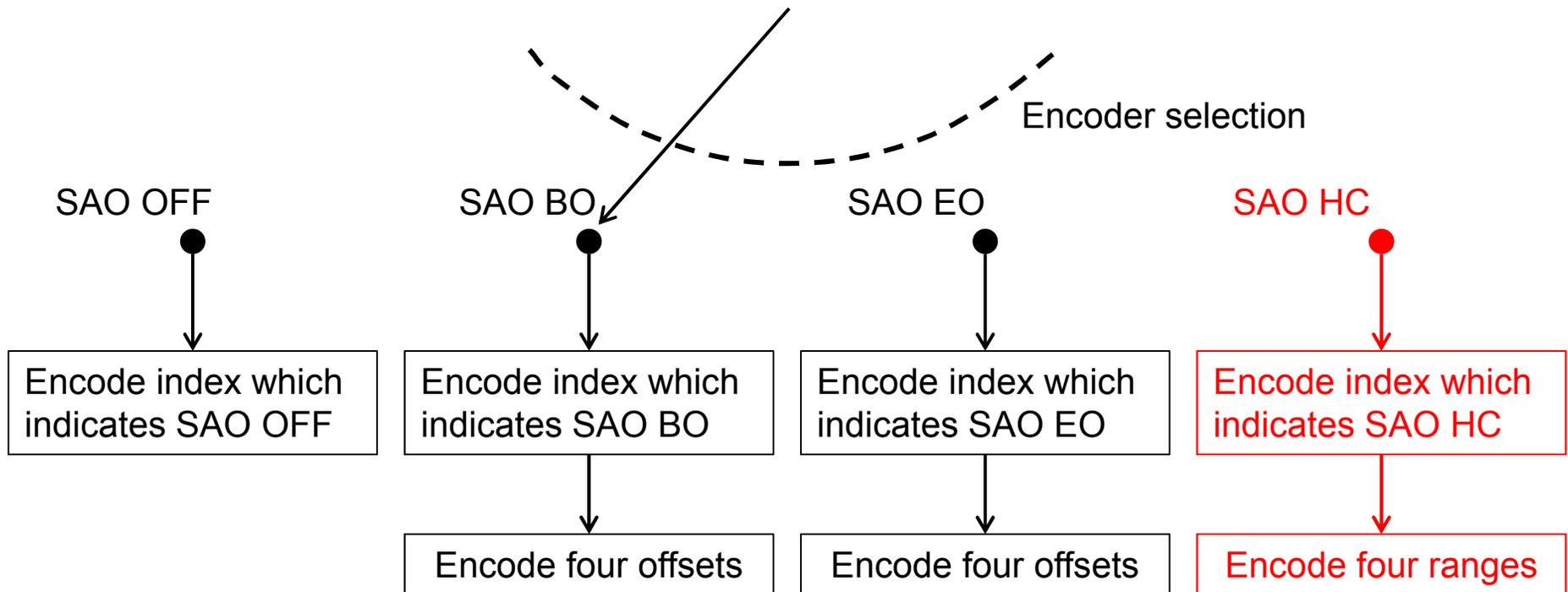
- SAO HC is additional mode
- Existing BO and EO modes available as well

Decoded pictures using original SAO (left) and SAO with HC (right)

WebBrowsing (rgb)
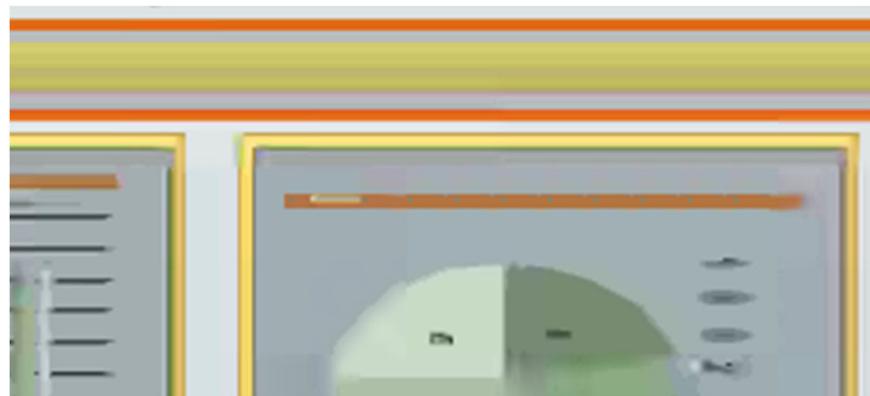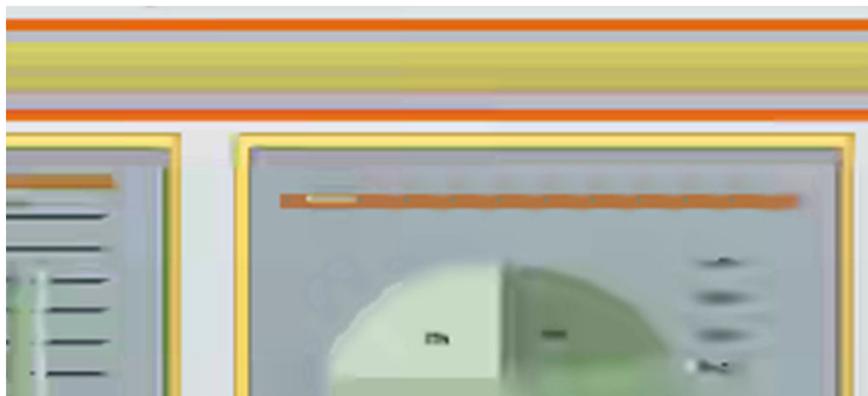
SlideShow (yuv)

SAO without HC

SAO with HC

SAO without HC

SAO with HC

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Independent Uniform Prediction (IUP)

- Screen content material, especially computer desktop videos, have large areas dominated by a very few colors, e.g. foreground and background theme colors.

- Independent Uniform Prediction
  – Basic concept: Combination of uniform prediction with a small global palette
  – All pixels in a block are predicted using the same color, per component (i.e. 3-component color vector/triplet)
  – Encoder selects and signals colors in slice header
  – These colors are available for any CU in the slice; no dependencies on neighboring CUs.

CU decoding with IUP

```
CU header → [ independent_uniform_pred_flag==1 ] ──No──→ Get the prediction block using other prediction modes
                          │
                         Yes
                          ↓
              [ num_uniform_colors>1 ] ──No──→ uniform_color_index=1
                          │
                         Yes
                          ↓
                  decode uniform_color_index
                          │
                          ↓
         Generate a uniform predictor block with pixel value
         uniform_colors[cIdx][uniform_color_index]
                          │
                          ↓
Reconstructed residue block → ⊕ ← (from Get the prediction block)
                          │
                          ↓
                     Decoded CU
```
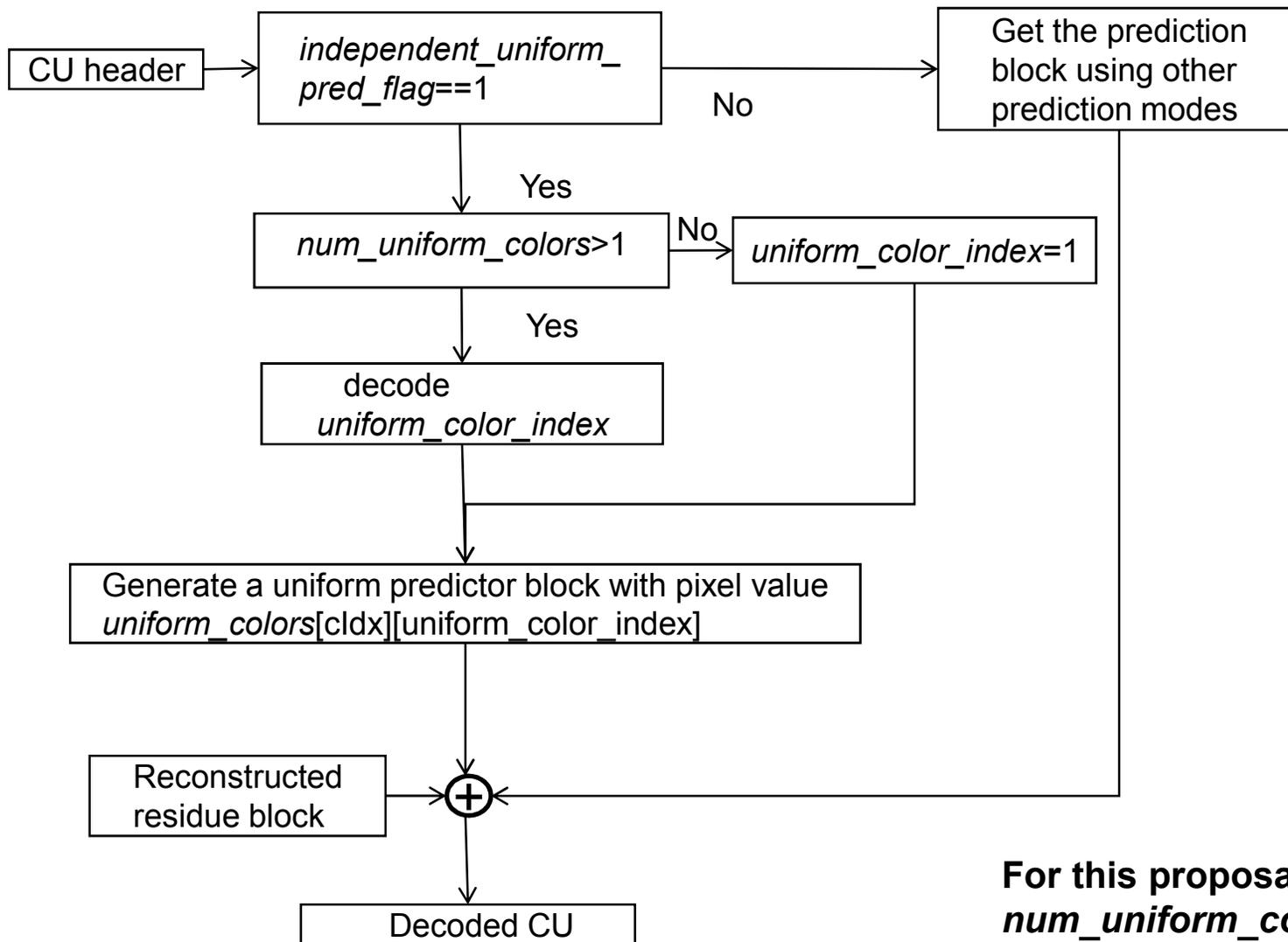
**For this proposal,**
_num_uniform_colors_ = 2

Example IUP usage maps

Uncompressed

Desktop

WebBrowsing

IUP usage map for *Desktop*


IUP   IBC   Palette
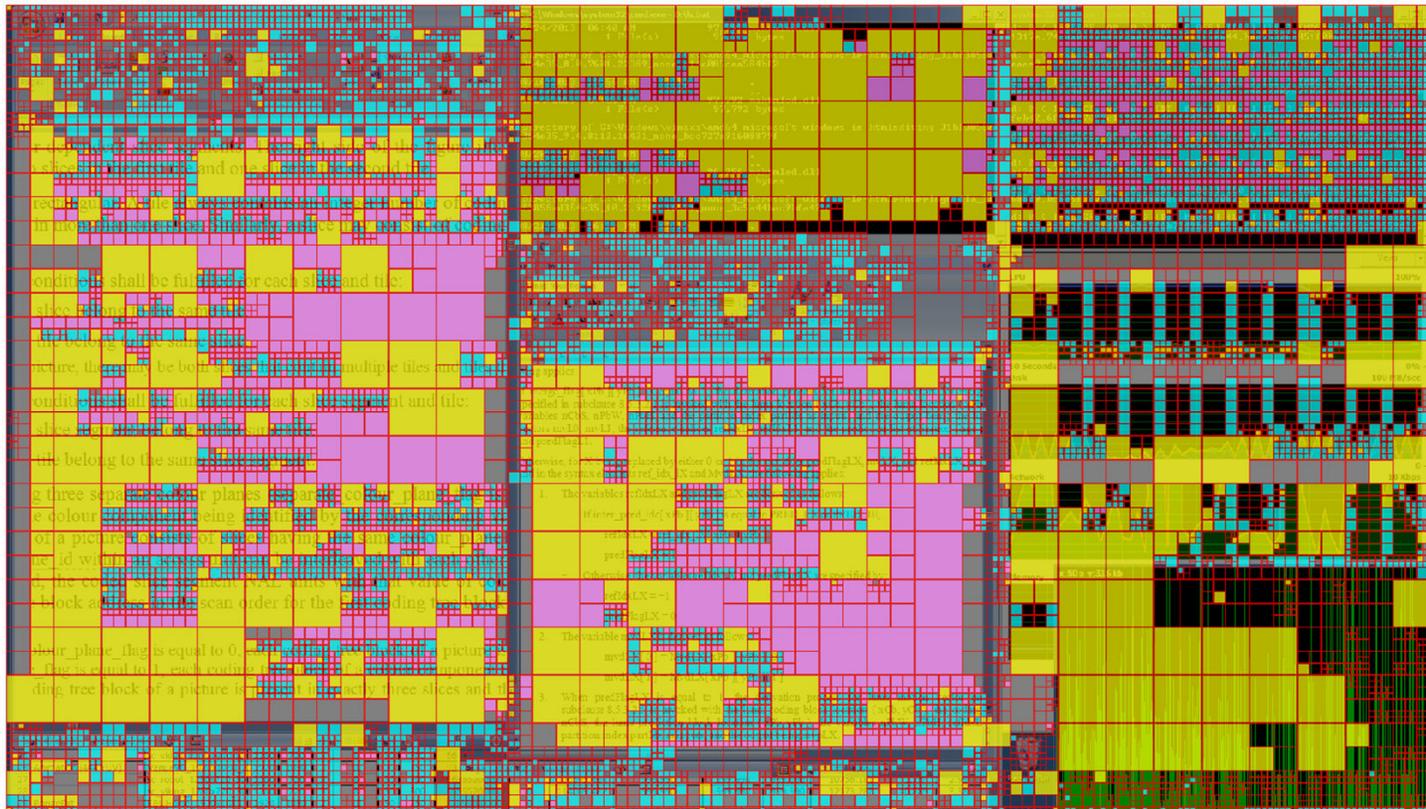
Two color IUP: Blocks with white or black backgrounds tended to be selected

IUP usage map for *WebBrowsing*

| IUP | IBC | Palette |
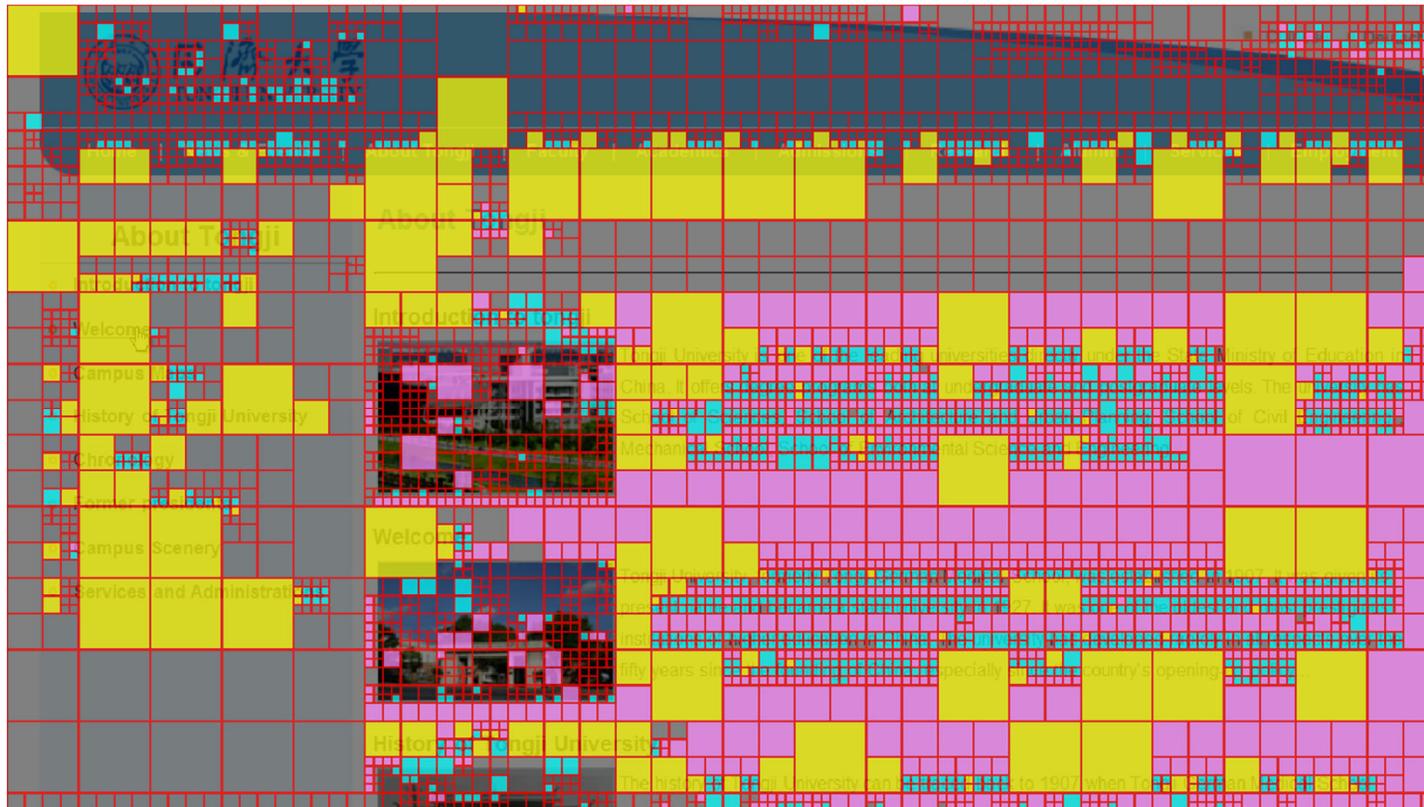
Two-color IUP: Blocks with white backgrounds tended to be selected

Lossy compression performance (AI)

	All Intra		
	Y	U	V
RGB, text & graphics with motion, 1080p	-27.0%	-28.0%	-27.6%
RGB, text & graphics with motion,720p	-19.1%	-19.3%	-20.0%
RGB, mixed content, 1440p	-11.0%	-10.9%	-11.0%
RGB, mixed content, 1080p	-13.4%	-13.6%	-13.4%
RGB, Animation, 720p	-8.2%	-10.4%	-8.0%
YUV, text & graphics with motion, 1080p	-25.5%	-27.7%	-27.6%
YUV, text & graphics with motion,720p	-14.6%	-19.6%	-22.4%
YUV, mixed content, 1440p	-8.3%	-12.8%	-12.5%
YUV, mixed content, 1080p	-11.5%	-13.8%	-13.7%
YUV, Animation, 720p	-1.8%	-6.4%	-5.8%
Enc Time[%]	301% (262%, 237%)*		
Dec Time[%]	87%		

*Two methods for IUP encoder speed-up subsequently developed; < 1% impact on BD-Rate measurements

Lossy compression performance (RA)

	Random Access		
	Y	U	V
RGB, text & graphics with motion, 1080p	-15.0%	-16.0%	-15.5%
RGB, text & graphics with motion,720p	-16.9%	-17.1%	-18.1%
RGB, mixed content, 1440p	-7.7%	-8.1%	-8.2%
RGB, mixed content, 1080p	-7.5%	-7.7%	-7.5%
RGB, Animation, 720p	-4.3%	-5.9%	-4.6%
YUV, text & graphics with motion, 1080p	-13.8%	-17.2%	-17.4%
YUV, text & graphics with motion,720p	-12.5%	-17.2%	-20.9%
YUV, mixed content, 1440p	-5.5%	-12.1%	-11.9%
YUV, mixed content, 1080p	-7.3%	-10.8%	-10.4%
YUV, Animation, 720p	-0.7%	-5.1%	-4.8%
Enc Time[%]	152%		
Dec Time[%]	88%		

Lossy compression performance (LB)

	Low delay B		
	Y	U	V
RGB, text & graphics with motion, 1080p	-9.4%	-10.2%	-9.7%
RGB, text & graphics with motion, 720p	-10.2%	-10.1%	-10.7%
RGB, mixed content, 1440p	-5.0%	-5.1%	-5.2%
RGB, mixed content, 1080p	-6.3%	-6.0%	-6.0%
RGB, Animation, 720p	-2.3%	-2.9%	-2.1%
YUV, text & graphics with motion, 1080p	-8.1%	-10.4%	-10.6%
YUV, text & graphics with motion, 720p	-7.3%	-10.3%	-13.5%
YUV, mixed content, 1440p	-3.6%	-10.2%	-10.1%
YUV, mixed content, 1080p	-4.4%	-7.2%	-6.8%
YUV, Animation, 720p	0.0%	-2.4%	-2.3%
Enc Time[%]	140%		
Dec Time[%]	111%		

Lossless compression performance (AI)

	AI			
	Bit-rate saving (Total)	Bit-rate saving (Average)	Bit-rate saving (Min)	Bit-rate saving (Max)
RGB, text & graphics with motion, 1080p	30.0%	31.8%	21.8%	43.3%
RGB, text & graphics with motion,720p	16.3%	17.2%	3.5%	32.0%
RGB, mixed content, 1440p	5.4%	5.7%	4.6%	6.8%
RGB, mixed content, 1080p	10.7%	9.7%	7.1%	12.3%
RGB, Animation, 720p	4.5%	4.5%	4.5%	4.5%
YUV, text & graphics with motion, 1080p	28.9%	30.4%	17.5%	45.8%
YUV, text & graphics with motion,720p	14.1%	16.3%	1.8%	37.0%
YUV, mixed content, 1440p	3.2%	3.5%	1.9%	5.0%
YUV, mixed content, 1080p	8.7%	7.7%	5.3%	10.1%
YUV, Animation, 720p	2.6%	2.6%	2.6%	2.6%
Enc Time[%]	259%			
Dec Time[%]	92%			

Lossless compression performance (RA)

	RA			
	Bit-rate saving (Total)	Bit-rate saving (Average)	Bit-rate saving (Min)	Bit-rate saving (Max)
RGB, text & graphics with motion, 1080p	20.1%	28.5%	19.1%	41.3%
RGB, text & graphics with motion,720p	7.9%	14.0%	5.8%	28.2%
RGB, mixed content, 1440p	8.2%	8.2%	7.1%	9.2%
RGB, mixed content, 1080p	11.1%	9.9%	8.6%	11.3%
RGB, Animation, 720p	7.3%	7.3%	7.3%	7.3%
YUV, text & graphics with motion, 1080p	12.6%	20.9%	11.6%	34.6%
YUV, text & graphics with motion,720p	4.9%	11.2%	1.6%	31.7%
YUV, mixed content, 1440p	1.8%	1.8%	1.4%	2.1%
YUV, mixed content, 1080p	6.8%	4.5%	1.8%	7.1%
YUV, Animation, 720p	2.0%	2.0%	2.0%	2.0%
Enc Time[%]	119%			
Dec Time[%]	105%			

Lossless compression performance (LB)

	LB			
	Bit-rate saving (Total)	Bit-rate saving (Average)	Bit-rate saving (Min)	Bit-rate saving (Max)
RGB, text & graphics with motion, 1080p	20.5%	28.3%	19.9%	40.7%
RGB, text & graphics with motion,720p	8.2%	12.6%	6.3%	21.2%
RGB, mixed content, 1440p	9.2%	9.2%	8.2%	10.2%
RGB, mixed content, 1080p	11.1%	10.3%	9.4%	11.2%
RGB, Animation, 720p	7.7%	7.7%	7.7%	7.7%
YUV, text & graphics with motion, 1080p	11.8%	17.7%	11.3%	26.6%
YUV, text & graphics with motion,720p	4.2%	8.2%	1.6%	22.6%
YUV, mixed content, 1440p	1.9%	1.8%	1.3%	2.4%
YUV, mixed content, 1080p	6.8%	4.2%	1.4%	7.1%
YUV, Animation, 720p	1.9%	1.9%	1.9%	1.9%
Enc Time[%]	122%			
Dec Time[%]	105%			

Palette mode

- Software from JCTVC-P0303 used with minor fixes

- Integrated into RExt 6.0 similar to how it was integrated into Rext 5.1

- Additional details on using a different palette mode is available in a combination of proposals in JCTVC-Q0193

Summary and conclusions

- Four tools (3 new) added to RExt-6.0
  - Inter-component prediction
  - Histogram correction mode for SAO
  - Independent uniform prediction
  - Palette mode

- Existing RExt-6.0 tools remained enabled (cfg file settings unchanged)

- Average lossy gains up to:
  - Lossy: 27%/26% for GBR/Y; 17%/14% RA; 10%/8% LB
  - Lossless: 32%/30% AI; 28%/20% RA; 28%/17% LB

- Higher gains (39%) shown in separate joint contribution JCTVC-Q0193

- Many similarities with tools proposed by others -- it would make sense to study the related tools together in core experiments; also evaluate combined tools