JCTVC-Q0037
SCREEN CONTENT CODING TECHNOLOGY PROPOSAL BY INTERDIGITAL COMMUNICATIONS

invention | collaboration | contribution

Xiaoyu Xiu, Chia-Ming Tsai, Yuwen He, Yan Ye
InterDigital Communications, Inc.

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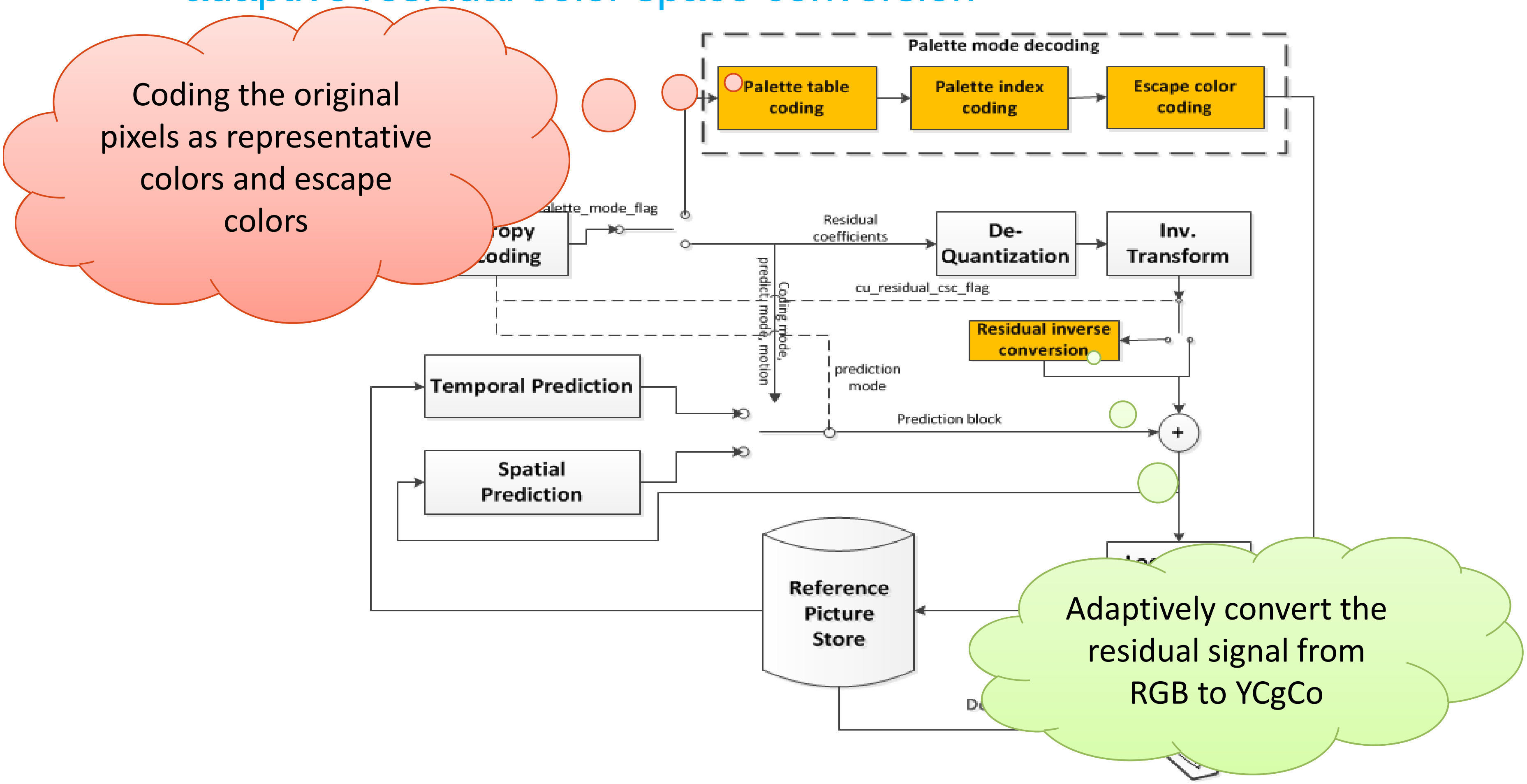
Outline

- Introduction
- Proposed Technologies
  - Improved palette coding
  - Adaptive residue color space conversion
  - Miscellaneous
- Compression Performance Analysis
- Complexity Analysis
- Conclusion

Introduction

- The proposed solution on screen content coding (SCC)
  - Built upon HM-12.1 Rext-5.1software
  - Two main new coding tools: improved palette coding and adaptive residual color space conversion



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Improved Palette Coding

- The palette coding method* studied in AHG 10 was used as the basis
- The proposed improvements include:
  - Palette table prediction
    - Representative color dictionary
    - Palette table skip mode
  - Palette index coding
    - Burrows–Wheeler transform (BWT) based index grouping
    - Transition mode
    - Palette index mapping
  - Escape color prediction
  - Palette table refinement (encoder only)

** W. Pu, X. Guo, P. Onno, P.-L. Lai, J. Xu, Suggested Software for the AHG on Investigation of Palette Mode Coding Tools, Document no JCTVC-P0303, January 2014*

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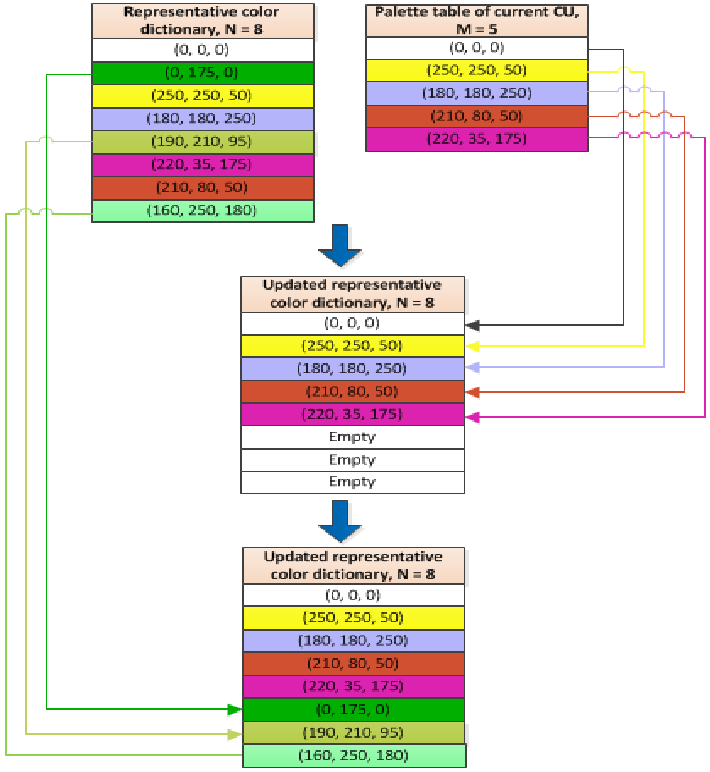
Palette Table Prediction (1)

- Representative color dictionary
  - Stores the representative colors of previous CUs coded in palette mode
  - Used to predict the palette table of current CU

- Representative color dictionary update
  - Step one: copy the representative colors of the current CU
  - Step two: add back unique representative colors



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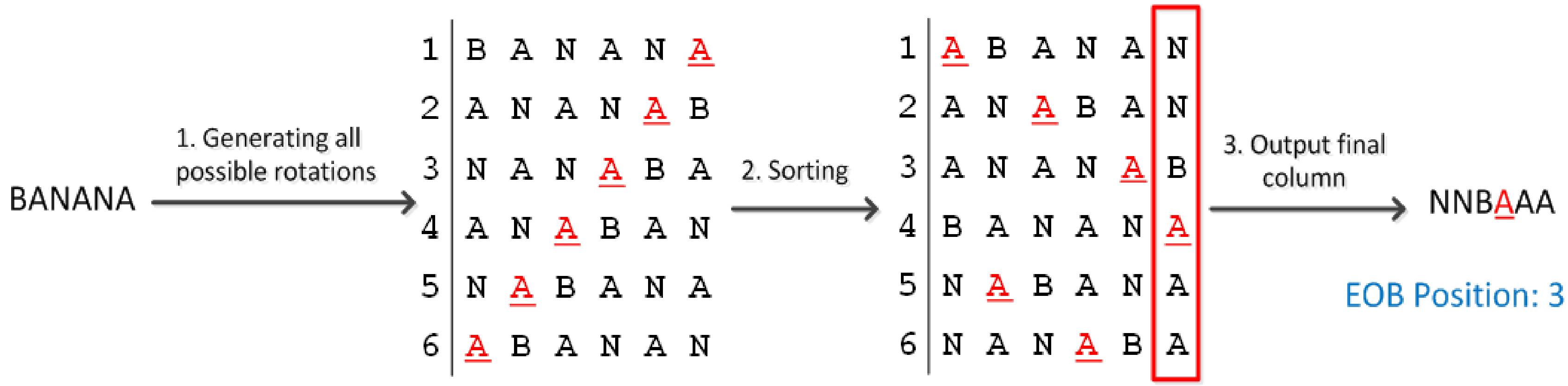
Palette Table Prediction (2)

- Palette table skip mode
  - The representative color dictionary is directly reused as the palette table of the current CU
  - One flag is signaled at CU level

Palette Index Coding (1)

- BWT based palette index grouping
  - Re-group the palette index map to increase the run length of consecutive positions with same palette index
  - Applied before palette index coding
  - The end of block (EOB) position needs to be transmitted for decoding
  - One flag is signaled to enable/disable BWT at CU level



  - At most 4K byte memory, fast implementation needs only one sorting process for forward BWT and no sorting for backward BWT

**M. Burrows and D. J. Wheeler, A Block-sorting Lossless Data Compression Algorithm, Technical report SRC 124, May 1994.*

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Palette Index Coding (3)

- Transition mode
  - The transition mode* in JCTVC-P0115 is implemented
  - Allows the palette indices of consecutive positions to be predicted from a previously occurring pattern of palette indices
  - Enabled when the palette table size is larger than 14
  - Disabled when the BWT based palette index grouping is used

**C. Gisquet, G. Laroche, P. Onno, Non-RCE4: Transition copy mode for Palette mode, Document no JCTVC-P0115, January 2014*

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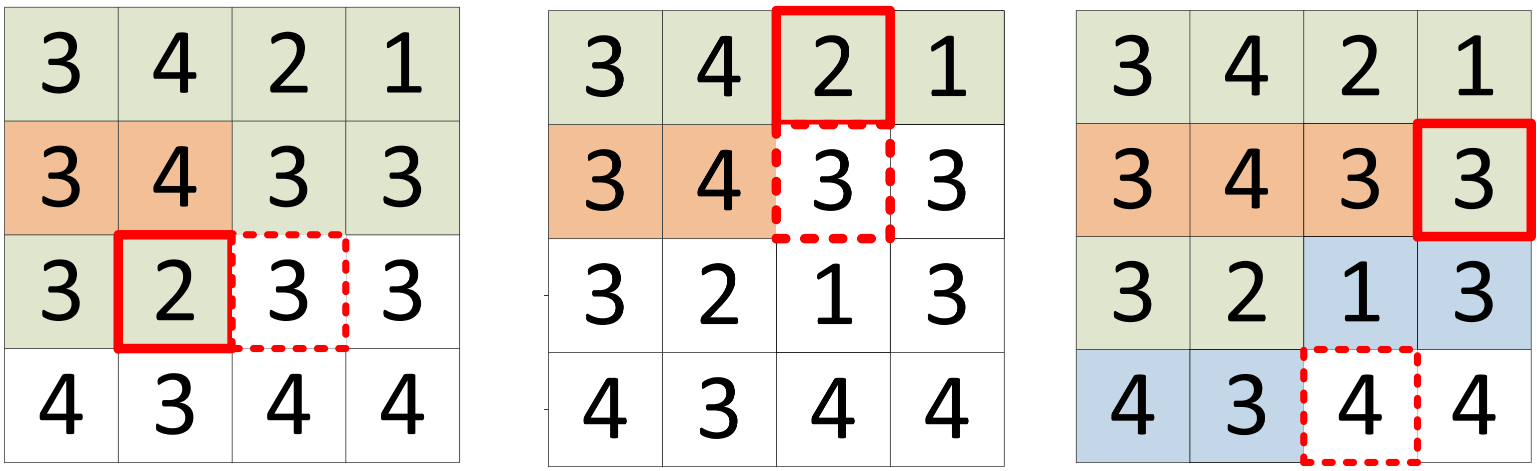
Palette Index Coding (4)

- Palette index mapping in run mode
  - One comparison position is found based on the palette mode of the previous scan position



(a) Run mode (b) Copy mode (c) Transition mode

  - The palette index value of the comparison position is used to conditionally reduce the magnitude of the coded palette index at the current position

$$\mathrm{pim}'_k = \begin{cases} \mathrm{pim}_k - 1, & \mathrm{pim}_k > \mathrm{pim}_i \\ \mathrm{pim}_k, & \mathrm{pim}_k < \mathrm{pim}_i \end{cases}$$

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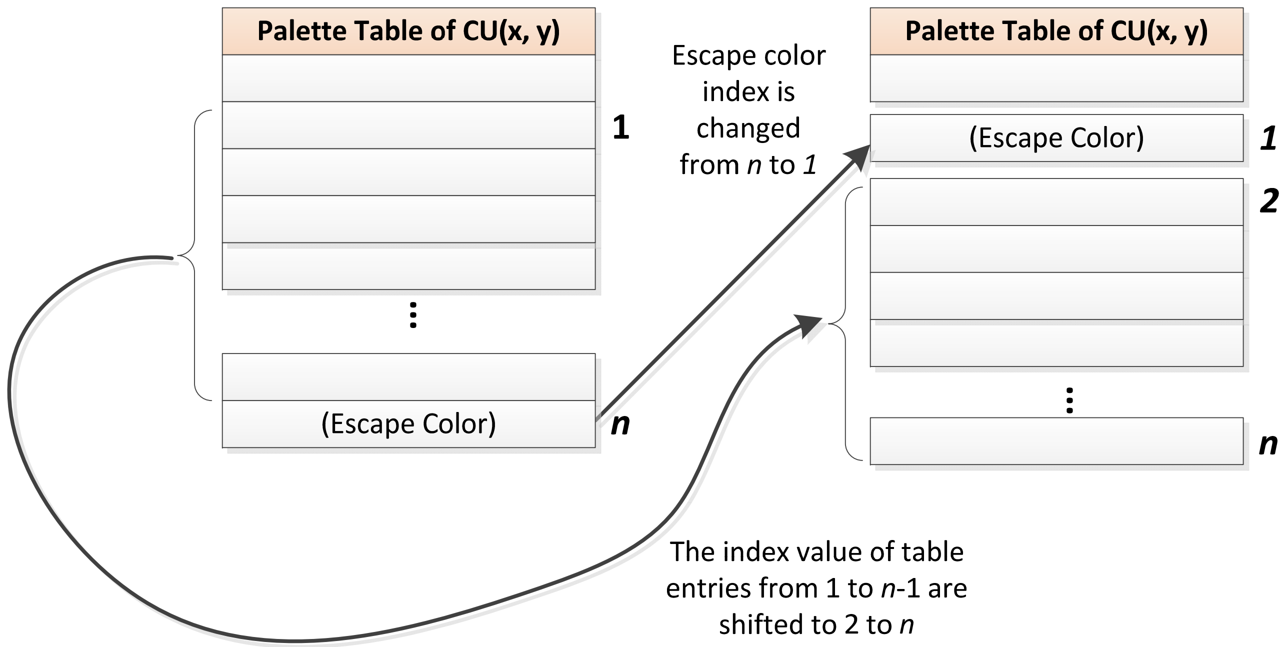
Palette Index Coding (5)

- Escape color index assignment
  - The index 1 is used to indicate escape colors
  - The other entries in the palette table are shifted backward by 1 position.



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Escape Color Prediction

- One flag is signaled to indicate if the current escape color is the same as the previous escape color or not
- If not, the current escape color is predicted from an existing entry in the palette table
  - The palette table entry is selected by minimizing the prediction error
  - The index of the selected palette table entry and the prediction difference are transmitted
  - Only applied to lossless coding

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Palette Table Generation (Encoder Only)

- Representative color initialization
  - An initial set of representative colors with highest frequency of occurrence are selected
  - For lossy coding, quantization process is applied where other non-representative colors are mapped to the closest representative colors
- Representative color refinement
  - Calculate the representative color as the weighted average of all the colors within one quantization zone
  - Weight = frequency of occurrence

$$P^{'} = \frac{\sum_i C_i \cdot P_i}{\sum_i C_i}$$

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Adaptive Residue Color Space Conversion

- For RGB coding, there are a lot of redundancy between three color components
- Adaptively select the color space between RGB and YCgCo for the residual coding of RGB signals
  - For lossy coding

$$\begin{pmatrix} Y \\ Cg \\ Co \end{pmatrix} = \begin{pmatrix} 1/2 & 1/4 & 1/4 \\ 1/2 & -1/4 & -1/4 \\ 0 & -1/2 & 1/2 \end{pmatrix} \begin{pmatrix} G \\ B \\ R \end{pmatrix} \qquad \begin{pmatrix} G \\ B \\ R \end{pmatrix} = \begin{pmatrix} 1 & 1 & 0 \\ 1 & -1 & -1 \\ 1 & -1 & 1 \end{pmatrix} \begin{pmatrix} Y \\ Cg \\ Co \end{pmatrix}$$

  - For lossless coding

$$\begin{pmatrix} Y \\ Cg \\ Co \end{pmatrix} = \begin{pmatrix} 1/2 & 1/4 & 1/4 \\ 1 & -1/2 & -1/2 \\ 0 & -1 & 1 \end{pmatrix} \begin{pmatrix} G \\ B \\ R \end{pmatrix} \qquad \begin{pmatrix} G \\ B \\ R \end{pmatrix} = \begin{pmatrix} 1 & 1/2 & 0 \\ 1 & -1/2 & -1/2 \\ 1 & -1/2 & 1/2 \end{pmatrix} \begin{pmatrix} Y \\ Cg \\ Co \end{pmatrix}$$

  - The color space selection is signaled at CU level
  - Applied only to inter mode and intra block copy mode in current implementation

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Miscellaneous

- Inter-picture prediction
  - For lossy 4:4:4 YUV and RGB, the 8-tap interpolation filters are applied to all three color components
  - A flag is signaled in PPS to indicate this change
- De-blocking filter
  - The de-blocking filtering is not applied to CUs decoded in palette mode
- Coding tools from HRExt-6.0
  - Multiple PU partitions of 2Nx2N, 2NxN, Nx2N and NxN for intraBC
  - Categorized Golomb-Rice parameter adaptation

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Lossy Coding Performance: RGB sequences

- Category 1: the average BD-rate improvement of all the tested sequences
- Category 2: the average BD-rate improvement of the sequences in “text & graphics with motion” both in 1080p and 720p

Average BD-rate reduction of RGB sequences

	Coding Configuration	G	B	R
Category 1	AI	16.3%	15.9%	15.8%
	RA	13.4%	13.2%	13.1%
	LD	13.8%	13.6%	13.4%
Category 2	AI	28.9%	28.4%	28.3%
	RA	21.7%	21.1%	21.3%
	LD	18.2%	17.5%	17.8%

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Lossy Coding Performance: YUV sequences

- Category 1: the average BD-rate improvement of all the tested sequences
- Category 2: the average BD-rate improvement of the sequences in “text & graphics with motion” both in 1080p and 720p

Average BD-rate reduction of YUV sequences

	Coding Configuration	Y	U	V
Category 1	AI	13.2%	17%	17.5%
	RA	9.2%	14.3%	15%
	LD	7%	11.3%	12.1%
Category 2	AI	22.7%	27.9%	29.3%
	RA	15.7%	22.2%	24.2%
	LD	10.3%	15.6%	17.8%

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Lossless Coding Performance

- Category 1: the average BD-rate improvement of all the tested sequences
- Category 2: the average BD-rate improvement of the sequences in "text & graphics with motion" both in 1080p and 720p

Average Bit-rate savings of lossless coding

	Coding Configuration	RGB	YUV
Category 1	AI	14.8%	13.8%
	RA	16.2%	10.2%
	LD	16.7%	9.3%
Category 2	AI	27.8%	28%
	RA	25.8%	21.5%
	LD	25.9%	19.4%

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Simulation Platform

CPU	**Intel Xeon E5-2650 / Clock speed 2.00GHz** **Intel Xeon X5675 / Clock speed 3.07GHz**
Memory for each core	2 GB
HDD characteristics	-Hard Drive Capacity: 300GB -Interface: Serial Attached SCSI -External Data Transfer Rate: 6.0 GB/sec -Rotational Speed: 10,000 rpm
Compiler	GCC version 4.4.5
Operating System (OS)	64 bit Linux

Encoding/Decoding Memory Usage

Encoder peak memory usage

Coding configuration	Resolution	Peak encoder memory usage
AI	1920x1080	962MB
	1280x720	483MB
	2560x1440	1.6GB
RA	1920x1080	3.3GB
	1280x720	1.6GB
	2560x1440	3.6GB
LD	1920x1080	2.4GB
	1280x720	1.2GB
	2560x1440	3.5GB

Decoder peak memory usage

Coding configuration	Resolution	Peak encoder memory usage
AI	1920x1080	186MB
	1280x720	158MB
	2560x1440	462MB
RA	1920x1080	1.2GB
	1280x720	585MB
	2560x1440	2GB
LD	1920x1080	1GB
	1280x720	498MB
	2560x1440	1.5GB

Complimentary results (Lossless Coding)

- The search range of intra block copy is extended to 12 neighboring CTUs in the left, top and top-left direction as used in JCTVC-Q0033

Sequences	AI		RA		LD	
	w/o IBC Ext	w/ IBC Ext	w/o IBC Ext	w/ IBC Ext	w/o IBC Ext	w/ IBC Ext
RGB, text & graphics with motion, 1080p	36.2%	45.3%	34.4%	42.5%	34.5%	42.6%
RGB, text & graphics with motion,720p	19.3%	22.4%	17.1%	19.1%	17.2%	19.2%
RGB, mixed content, 1440p	6.4%	9.6%	8.9%	9.7%	10.0%	10.7%
RGB, mixed content, 1080p	10.3%	14.4%	11.5%	12.7%	12.0%	12.7%
RGB, Animation, 720p	1.6%	1.6%	9.0%	9.0%	9.9%	9.9%
YUV, text & graphics with motion, 1080p	36.9%	45.8%	28.5%	37.0%	25.8%	34.6%
YUV, text & graphics with motion,720p	19.1%	22.3%	14.4%	16.5%	12.9%	15.0%
YUV, mixed content, 1440p	4.7%	8.3%	1.9%	2.9%	1.8%	2.7%
YUV, mixed content, 1080p	7.9%	12.4%	4.5%	5.9%	4.2%	5.1%
YUV, Animation, 720p	0.4%	0.5%	1.8%	1.8%	1.8%	1.8%

Complimentary results (Lossy Coding)

Sequences	AI		RA		LD	
	w/o IBC Ext	w/ IBC Ext	w/o IBC Ext	w/ IBC Ext	w/o IBC Ext	w/ IBC Ext
RGB, text & graphics with motion, 1080p	-35.2%	-46.9%	-22.6%	-31.0%	-18.1%	-25.7%
RGB, text & graphics with motion,720p	-22.5%	-29.9%	-20.8%	-26.0%	-18.3%	-22.9%
RGB, mixed content, 1440p	-10.6%	-19.5%	-9.4%	-14.7%	-13.7%	-16.3%
RGB, mixed content, 1080p	-12.6%	-20.7%	-12.0%	-17.7%	-13.6%	-16.3%
RGB, Animation, 720p	-0.7%	-0.9%	-2.3%	-2.4%	-5.3%	-5.3%
YUV, text & graphics with motion, 1080p	-30.3%	-43.5%	-17.9%	-26.9%	-11.4%	-19.7%
YUV, text & graphics with motion,720p	-15.1%	-24.4%	-13.4%	-20.3%	-9.1%	-14.5%
YUV, mixed content, 1440p	-9.3%	-19.7%	-7.2%	-14.1%	-8.2%	-12.1%
YUV, mixed content, 1080p	-10.8%	-19.9%	-7.3%	-14.0%	-6.0%	-9.5%
YUV, Animation, 720p	-0.6%	-0.7%	-0.4%	-0.5%	-0.5%	-0.5%

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Closing Remarks

- Two main proposed SCC tools
  - Improved palette coding
  - Adaptive residue color space conversion
- Significant performance improvement for screen content
- Low computational complexity and memory usage
- Provide a good starting point for the future development of SCC extension

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