



JCTVC-T0118 NON-CE1: ON ESCAPE COLOR CODING FOR PALETTE CODING MODE

Xiaoyu Xiu, Yan Ye, Yuwen He
InterDigital Communications, Inc.
Feb. 2015

INTERDIGITAL.

Creating the Living Network

Introduction

- For lossy coding of palette mode, escape colors are **quantized** at encoder and **de-quantized** at decoder
- Escape color values are coded using **truncated binary code (TBC)** that needs to know **the maximum level** as input
- Two design defects are identified in the escape color coding design in SCM-3.0
 - **Defect #1:** significant precision loss in the calculation of max TBC level, especially for low QP
 - **Defect #2:** the number of right shift bits in de-quantization becomes negative for high QP
- This contribution proposes fixes for both defects

Defect #1: max TBC level calculation

- In SCM-3.0, the maximum TBC level $cMax$ is calculated as:

- Step 1: a rounded quantization step size

$$qStep = Round(2^{(qP-4)/6})$$

- Step 2: a quantized max value

$$maxValue = Floor((1 \ll BD - 1)/qStep)$$

- Step 3: the number of bins $numBins$ to represent $maxValue$

- Step 4: the maximum quantized value

$$pLevel^{max}$$

$$= \left((1 \ll BD - 1) \cdot quantScale[qP\%6] + (1 \ll (13 + qP/6)) \right)$$

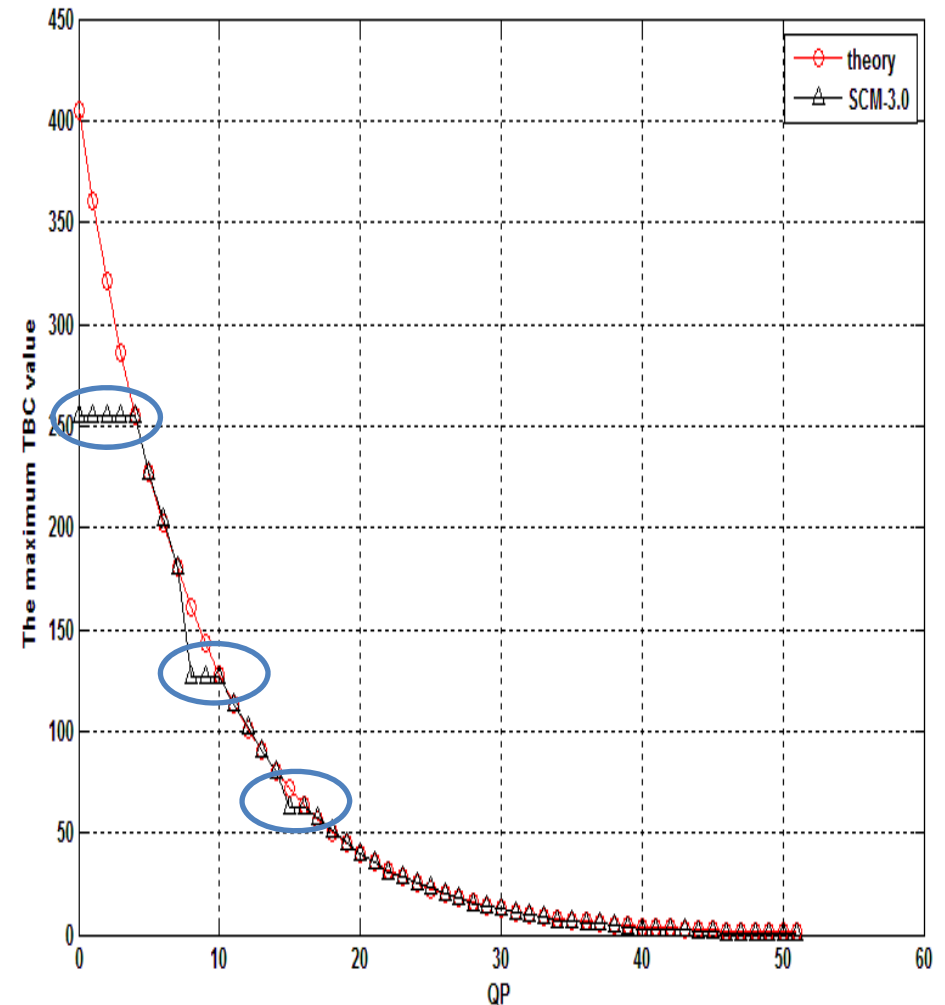
$$\gg (14 + qP/6)$$

- Step 5: the maximum TBC level

$$cMax = \begin{cases} pLevel^{max}, & pLevel^{max} \leq (1 \ll numBins - 1) \\ (1 \ll numBins - 1), & pLevel^{max} > (1 \ll numBins - 1) \end{cases}$$

Defect #1: max TBC level calculation

- $qStep$ in step 1 is derived by rounding real-value to integer value
- Rounding error introduces precision loss in later steps, especially for low QPs
- $cMax$ can be significantly smaller than the actual maximum value of quantized escape colors
- Clipping with $cMax$ causes large distortion for some QPs



Defect #2: De-quantization of Escape Colors

- Inverse quantization of escape color

$$pRec = \begin{cases} pLevel \cdot levelScale[qP\%6], & qP \in [36, 42) \\ \left(pLevel \cdot levelScale[qP\%6] + (1 \ll (5 - qP/6)) \right) \gg (6 - qP/6), & \text{else} \end{cases}$$

- The right shift becomes negative when $qP \geq 42$

The Proposed Fixes

- Calculate maximum TBC level to reflect actual dynamic range of escape colors

$$cMax = \left((1 \ll bitDepth - 1) \cdot quantScale[qP\%6] + (1 \ll (13 + qP/6)) \right) \\ \gg (14 + qP/6)$$

- **Bit-stream conformance constraint:** for TBC-coded syntax elements, *i.e.*, *palette_index_idc*, *palette_run_refinement_bits* and *palette_escape_val*, the signaled values of escape colors cannot be larger than the corresponding maximum TBC level.
- Inverse quantization of escape color uses fixed right shift

$$pRec = \left((pLevel \cdot levelScale[qP\%6]) \ll (qP/6) + 32 \right) \gg 6$$

Simulations

- Three QP settings
 - Setting one: the QPs of the current CTC {22, 27, 32, 37}
 - Setting two: low QPs {0, 1, 2, 3}
 - Setting three: high QPs {42, 43, 44, 45}

Thanks to ITRI for the cross-check!

Results for the CTC QPs

- The proposed method do not bring any performance difference under CTC compared to SCM-3.0

	All Intra			Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	93%			97%			96%		
Dec Time[%]	94%			94%			97%		

Results for Low QPs (1)

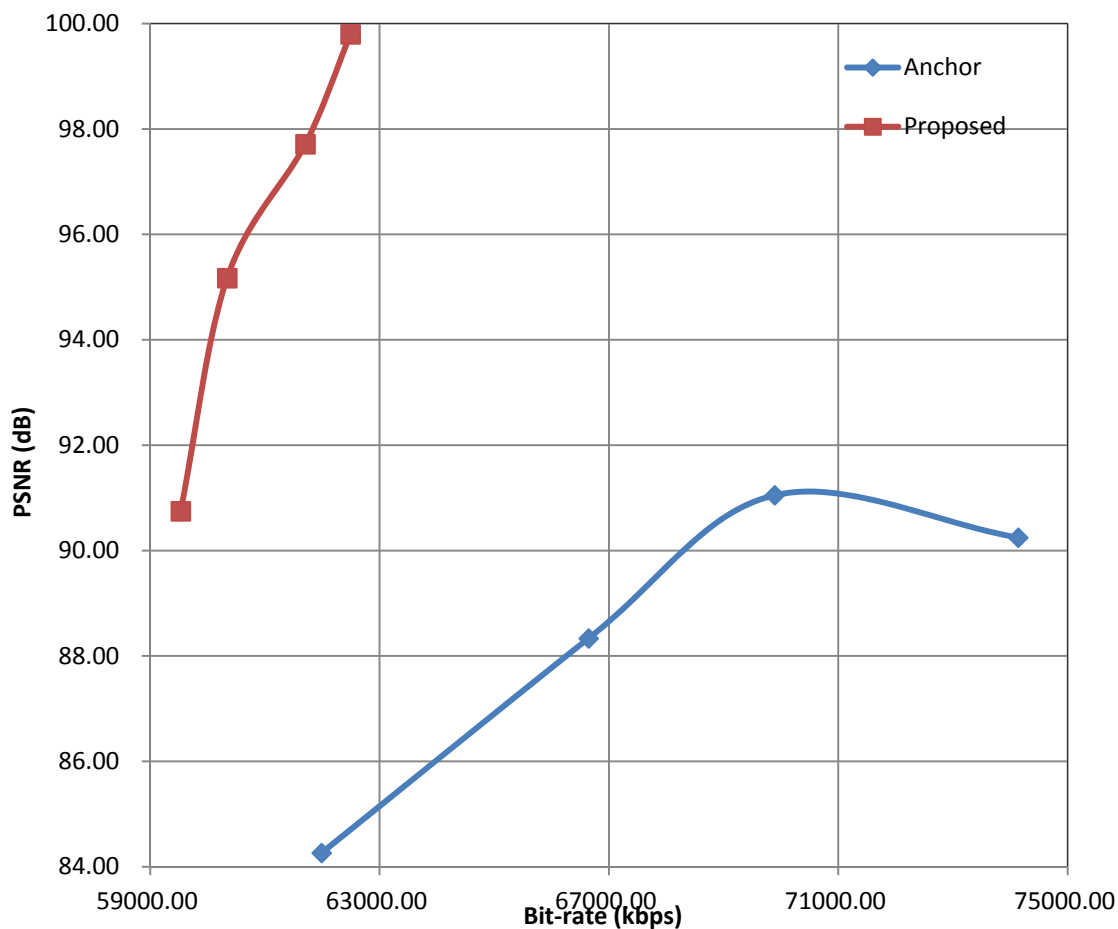
- The average BD-rate savings for *text & graphics with motion*
 - AI: {13%, 10%, 10%}
 - RA: {6.5%, 5.7%, 5.6%}
 - LB: {2.1%, 2.1%, 2.1%}

	All Intra			Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	-15.3%	-13.0%	-12.8%	-7.6%	-7.7%	-7.6%	-2.7%	-2.8%	-2.8%
RGB, mixed content, 1440p & 1080p	-2.2%	-2.0%	-2.0%	-0.7%	-0.7%	-0.7%	-0.3%	-0.2%	-0.3%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	170.4%	-8.3%	-8.5%	-5.4%	-3.7%	-3.6%	-1.5%	-1.3%	-1.3%
YUV, mixed content, 1440p & 1080p	-1.1%	-0.9%	-0.9%	-0.2%	-0.2%	-0.2%	-0.1%	-0.1%	-0.1%
YUV, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	98%			99%			98%		
Dec Time[%]	95%			98%			96%		

This is due to strange RD behavior of *sc_console_1920x1080_60_8bit_444* of the SCM-3.0 anchor

Results for Low QPs (2)

sc_console_1920x1080_60_8bit_444, AI configuration



Results for High QPs

- BD-rate savings for *text & graphics with motion*
 - AI: {0.1%, 0.2%, 0.1%}
 - RA:{0.2%, 0.2%, 0.1%}
 - LB: {0.0%, 1.4%, 0.2%}
- Relatively small average gain does not fully reflect the actual impact on the escape colors:
 - Mainly due to not many escape colors at high QPs
 - For escape colors, the negative right shifts could cause incoherent behaviors for different platforms.

	All Intra			Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	-0.3%	-0.4%	-0.5%	-0.2%	-0.3%	-0.3%	-0.2%	-2.7%	-0.3%
RGB, mixed content, 1440p & 1080p	-0.1%	-0.4%	-0.5%	-0.1%	-0.5%	-0.4%	0.2%	-0.1%	-0.3%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.0%	-0.1%	0.3%	-0.1%	0.0%	0.0%	0.1%	-0.1%	-0.1%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.1%	0.2%	0.4%	-0.2%	0.3%	1.1%
YUV, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	98%			100%			99%		
Dec Time[%]	96%			96%			95%		

Closing Remarks

- We proposed the following fixes for escape color coding:
 - Improved TBC maximum level calculation
 - Bit-stream conformance on escape color signaling
 - Improved inverse quantization of escape colors
- Coding performance
 - CTC QPs: no coding performance difference
 - Low QPs: average BD-rate savings of 13%, 6.5% and 2.1% for AI, RA and LB.
 - High QPs: average BD-rate savings of 0.1%, 0.2% and 0.0% for AI, RA and LB.
- Suggest to adopt these fixes into SCC