



JVET-00432: AHG10: LMCS encoder improvement

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Summary of contribution

1. Non-normative encoder optimizations for LMCS

- provide LMCS support for HLG
- improve coding performance for SDR
- provide LMCS config parameters for tuning

2. Summary results

SDR															
Overall	Over VTM-5.0														
	All Intra Main 10					Random Access Main 10					Low delay B Main10				
	PSNR					PSNR					PSNR				
	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
	-0.30%	0.33%	0.32%	101%	100%	-0.16%	-0.11%	-0.12%	98%	99%	-0.20%	-0.37%	-0.59%	100%	99%

HDR - HLG										
Over VTM-5.0 (LMCS is off for HLG)										
Class H	All Intra					Random Access				
	PSNR			EncT	DecT	PSNR			EncT	DecT
	Y	U	V			Y	U	V		
	-0.17%	2.04%	1.99%	103%	103%	-1.03%	2.28%	1.94%	100%	103%



Proposed LMCS encoder optimizations algorithm

Overview of non-normative LMCS encoder

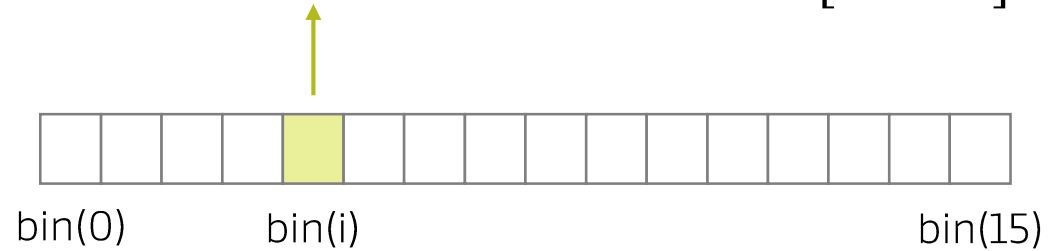
LMCS Encoder	VTM5.0	Proposed
Pre-Analyzer	- Picture histogram - Local spatial variance (fixed 5x5 window)	- Picture histogram - Local spatial variance (resolution-adaptive)
Codeword Allocation	3-level codeword Assignment - LMCS Adaptations	- Equal Assignment + Perturbation - LMCS Adaptations
Curves Derivation	Based on codeword allocation	



Resolution-adaptive Local Spatial Variance

- Local Spatial Variance

$$pxlVar = \frac{\sum_{win} pxlY^2}{N_{win}} - Average^2, \quad binVar[i] = \frac{\sum_{bin} \log_{10}(pxlVar + 1.0)}{binCnt[binIdx]}$$



- Resolution Adaptation

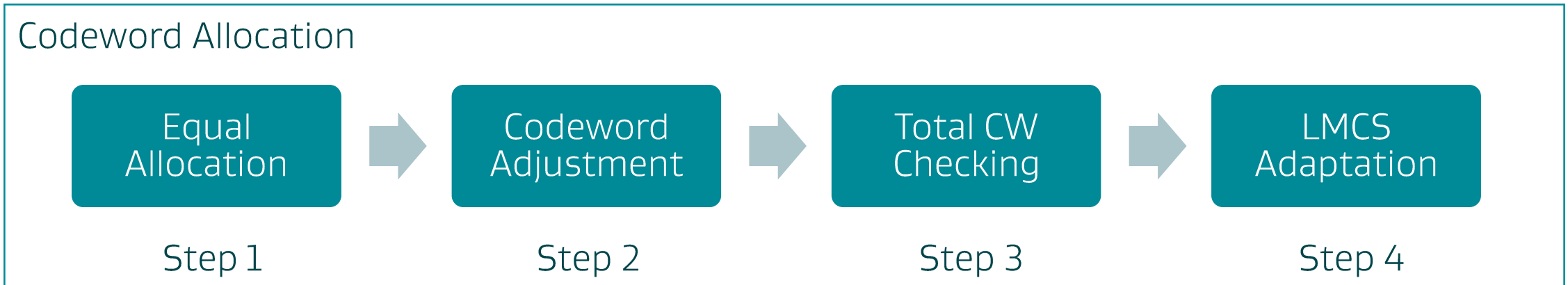
- applies variable window size (neighborhood) based on picture resolution

$$winSize = \lfloor \min(width, height) / 240 \rfloor * 2 + 1$$

The higher resolution, the larger window size.

Bin-based Codeword Allocation

- Step 1: assign equal number of codewords for all valid bins
- Step 2: adjust number of codewords based on picture statistics
- Step 3: check if total number of codewords exceeds maximum allowed
- Step 4: set adaptation parameters based on statistics before and after mapping



Bin-based Codeword Allocation

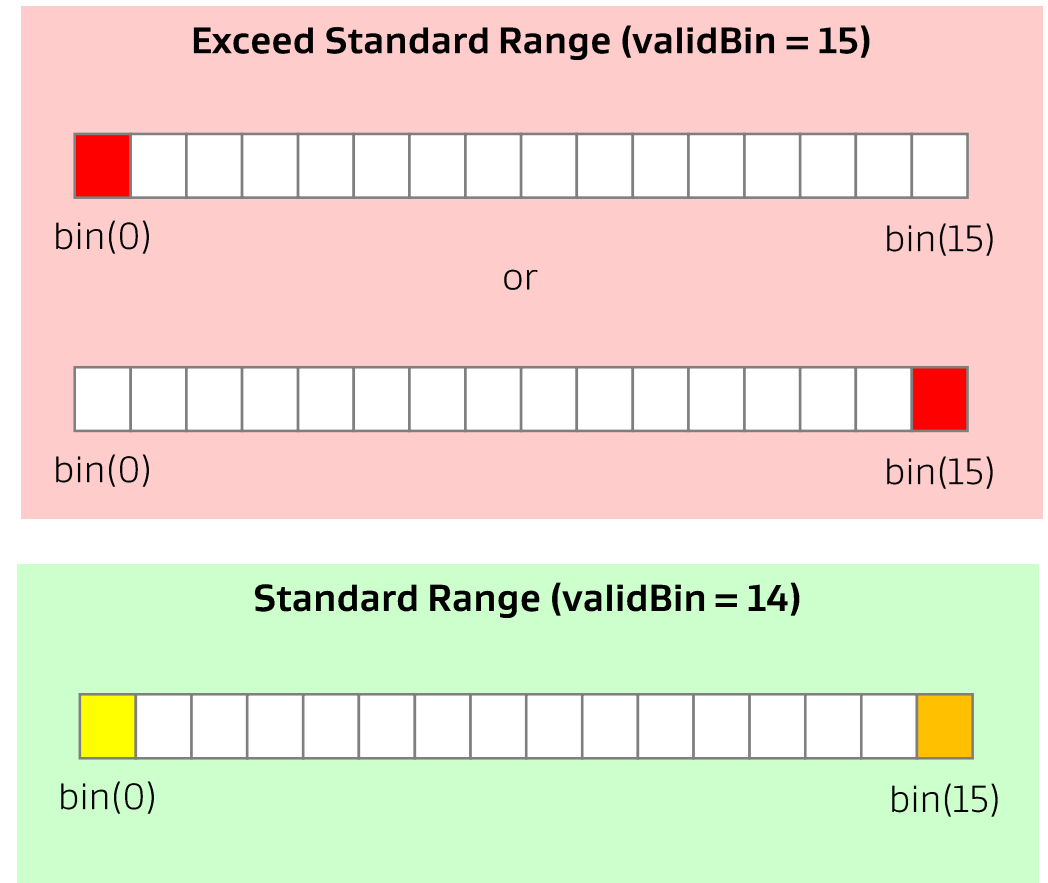
- Step 1: assign equal number of codewords for all valid bins

$$\text{binCW}[i] = \text{round}\left(\frac{\text{totalCW}}{\text{validBin}}\right)$$

$\text{binCW}[i]$ – number of codewords assigned to i th bin

totalCW – target total number of codewords

validBin – the valid bin numbers



Bin-based Codeword Allocation

- Step 2: adjust number of codewords based on picture statistics

$$\text{if } \mathit{normVar} < 1.0, \quad \mathit{binCW}[i] = \begin{cases} \mathit{binCW}[i] + \mathit{delta1}, & 0.8 \leq \mathit{normVar} < 0.9 \\ \mathit{binCW}[i] + \mathit{delta2}, & \mathit{normVar} < 0.8 \end{cases}$$

$$\text{else if } \mathit{normVar} > 1.0, \quad \mathit{binCW}[i] = \begin{cases} \mathit{binCW}[i] - \mathit{delta1}, & 1.1 < \mathit{normVar} \leq 1.2 \\ \mathit{binCW}[i] - \mathit{delta2}, & \mathit{normVar} > 1.2 \end{cases}$$

$$\mathit{normVar} = \mathit{binVar}[i] / \mathit{meanVar}, \quad \mathit{delta1} = \text{round}(10 * \mathit{hist}), \quad \mathit{delta2} = \text{round}(20 * \mathit{hist})$$

$\mathit{meanVar}$ is the mean value of the average spatial variances across all valid bins

hist is the percentage of pixels in the i th bin clipped to the range of $[0, 0.4]$

More codewords for low variance bins, less codewords for high variance bins.

Bin-based Codeword Allocation

- **Step 3:** check if total number of codewords exceeds maximum allowed
 - reduce codewords by equal amount until total codewords number is valid
- **Step 4:** set adaptation parameters based on statistics before and after mapping
 - **Rate adaptation:** adjust assigned codewords for high bitrate cases
 - E.g., assign $64 + 2$ codewords for each bin when $QP \leq 22$
 - **Slice adaptation:** apply LMCS for 1) intra and inter; 2) Tid=0 only; 3) inter only
 - E.g., for source with high spatial variance, or variance increases a lot after mapping, disable LMCS for intra
 - **Chroma adjustment:** apply CRS based on ratio of chroma and luma variance
 - E.g., for source with great chroma variance compared with luma variance, disable CRS



Proposed LMCS encoder configuration parameters

LMCS encoder configuration parameters

Table 1 LMCS encoder configuration parameter settings in VTM5.0

Parameter Name	Default Value	Description
LumaReshapeEnable	1	0: disable; 1: enable
ReshapeSignalType	0	0: SDR; 1: PQ; 2: HLG

Table 2 Proposed LMCS encoder configuration parameter settings

Parameter Name	Default Value	Description
LumaReshapeEnable -LMCSEnable	1	0: disable; 1: enable
ReshapeSignalType -LMCSSignalType	0	0: SDR; 1: PQ; 2: HLG
LMCSUpdateCtrl	0	0: RA; 1: AI; 2: LDB/LDP
LMCSAdpOption	0	0: automatic model; 1: LMCS enabled for intra and inter, and 66 codewords allocated for each bin for QP<=22; 2: LMCS enabled only for Tid0 (for all QP); 3: LMCS enabled only for inter, and 66 codewords allocated for each bin for QP<=22; 4: LMCS enabled for inter (for all QP).
LMCSInitialCW	0	user-defined total number of codewords

JVET-N1003 "Guidelines for VVC reference software development."

Simulation Results: SDR (anchor: LMCS on)

	All Intra Main10				
	Over VTM-5.0				
	Y	U	V	EncT	DecT
Class A1	-0.17%	-1.91%	-2.13%	90%	101%
Class A2	-1.07%	-1.38%	-1.34%	91%	104%
Class B	-0.20%	0.75%	0.84%	104%	102%
Class C	-0.21%	1.84%	1.81%	107%	96%
Class E	0.05%	1.58%	1.55%	112%	95%
Overall	-0.30%	0.33%	0.32%	101%	100%
Class D	-0.27%	2.67%	2.40%	106%	98%
Class F	-0.07%	0.23%	0.25%	108%	101%

	Random access Main10				
	Over VTM-5.0				
	Y	U	V	EncT	DecT
Class A1	0.17%	-0.96%	-0.80%	96%	103%
Class A2	-0.70%	1.96%	1.86%	98%	100%
Class B	-0.19%	-0.71%	-0.80%	99%	97%
Class C	0.01%	-0.26%	-0.27%	98%	98%
Class E					
Overall	-0.16%	-0.11%	-0.12%	98%	99%
Class D	-0.09%	-0.82%	-0.87%	100%	93%
Class F	-0.04%	-0.21%	-0.18%	100%	101%

	Low delay B Main10				
	Over VTM-5.0				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.42%	-1.24%	-1.63%	100%	102%
Class C	-0.02%	0.92%	1.05%	104%	96%
Class E	-0.08%	-0.64%	-1.03%	95%	99%
Overall	-0.20%	-0.37%	-0.59%	100%	99%
Class D	0.06%	-0.97%	-0.93%	101%	96%
Class F	0.03%	-0.83%	-0.24%	98%	101%

Simulation Results: HLG (anchor: LMCS off)

	All Intra Main10				
	Over VTM5.0				
	Y	U	V	EncT	DecT
Class H (HLG)	-0.17%	2.04%	1.99%	103%	103%

	Random Access Main 10				
	Over VTM5.0				
	Y	U	V	EncT	DecT
Class H (HLG)	-1.03%	2.28%	1.94%	100%	103%

Conclusion

- Proposed non-normative LMCS encoder optimizations
 - provides support for HLG
 - improves coding performance for SDR
 - provides LMCS cfg parameters (JVET-N1003 “Guidelines for VVC reference software development.”)
- Recommended to adopt the proposed non-normative encoder implementation into VTM

Acknowledgement

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