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AHG18-related: Disabling dependent quantization in lossless coding

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Overall Summary

- Three methods are proposed for lossless coding with dependent quantization (DQ) enabled at slice level
 - Method 1: disable the conversion from coefficient levels to quantized coefficients
 - Method 2: Method 1 + disable the quantization state (Q-state) transition and fix it to state 0 in coefficient coding
 - Method 3: Method 2 + skip the signalling of the position of the last significant coefficient

Anchor: VTM6.0-lossless	AI			RA		
	Bit savings (%)	EncT	DecT	Bit savings (%)	EncT	DecT
Method 1	Same as VTM6.0-lossless					
Method 2	0.15	97	99	0.25	99	97
Method 3	0.62	100	96	0.67	101	95

Introduction

- In VVC Draft 6, if DQ is enabled at slice level, a Q-state is derived according to the parity bit of the coefficient level in the coefficient parsing stage
- The following methods are designed for DQ-quantized coefficient:

1. Q-state dependent coefficient coding

- The context variable set for each coefficient's significant flag
- The Rice parameter and the position of the zero coefficient in the Golomb-Rice code

Make the lossless coding impossible

2. Q-state dependent quantized coefficient reconstruction

- Convert coefficient levels to quantized coefficients

$$\begin{aligned} &\text{TransCoeffLevel}[x0][y0][\text{cldx}][x_C][y_C] \\ &= (2 * \text{AbsLevel}[x_C][y_C] - (\text{QState} > 1 ? 1 : 0)) * (1 - 2 * \text{coeff_sign_flag}[n]) \end{aligned}$$

Proposed Method 1 (same as VTM6.0-lossless SW)

- To achieve lossless coding, disable the conversion from coefficient levels to quantized coefficients in lossless blocks

if(dep_quant_enabled_flag && ! cu_transquant_bypass_flag[x0][y0]) {
QState = startQStateSb
for(n = numSbCoeff - 1; n >= 0; n--) {
xC = (xS << log2SbW) + DiagScanOrder[log2SbW][log2SbH][n][0]
yC = (yS << log2SbH) + DiagScanOrder[log2SbW][log2SbH][n][1]
if(AbsLevel[xC][yC] > 0)
TransCoeffLevel[x0][y0][cIdx][xC][yC] =
(2 * AbsLevel[xC][yC] - (QState > 1 ? 1 : 0)) * (1 - 2 * coeff_sign_flag[n])
QState = QStateTransTable[QState][par_level_flag[n]]
}
} else {
sumAbsLevel = 0
for(n = numSbCoeff - 1; n >= 0; n--) {
xC = (xS << log2SbW) + DiagScanOrder[log2SbW][log2SbH][n][0]
yC = (yS << log2SbH) + DiagScanOrder[log2SbW][log2SbH][n][1]
if(AbsLevel[xC][yC] > 0) {
TransCoeffLevel[x0][y0][cIdx][xC][yC] =
AbsLevel[xC][yC] * (1 - 2 * coeff_sign_flag[n])
...
}
}
}
}

Proposed Method 2

- The Q-state dependent coefficient coding may not be beneficial in lossless coding
- Based on Method 1, disable the state transition and fix it to state 0 during coefficient coding
 - if(dep_quant_enabled_flag && ! cu_transquant_bypass_flag[x0][y0])
 QState = QStateTransTable[QState][AbsLevelPass1[xC][yC] & 1]
 - if(dep_quant_enabled_flag && ! cu_transquant_bypass_flag[x0][y0])
 QState = QStateTransTable[QState][AbsLevel[xC][yC] & 1

Proposed Method 3

- Based on Method 2, further proposed to remove the signalling of the last significant coefficient's position in lossless blocks
 - The position of the last significant coefficient is inferred to be TB size - 1
 - The **coded_sub_block_flag** of the last CG is signalled
 - The **sig_coeff_flag** of the last significant coefficient is signalled if the **coded_sub_block_flag** in that CG is true

Results – Method 2

- Anchor: VTM6.0-lossless
- Test: disable DQ

	All Intra			Random Access		
	ratio		bit-rate savings	ratio		bit-rate savings
	VTM6	Test		VTM6	Test	
Class A1	2.2	2.2	-0.13%	2.3	2.3	-0.15%
Class A2	1.7	1.7	0.00%	1.9	1.9	-0.07%
Class B	2.1	2.1	-0.17%	2.3	2.3	-0.28%
Class C	2.1	2.1	-0.24%	2.6	2.6	-0.44%
Class D	1.9	2.0	-0.26%	2.8	2.8	-0.50%
Class E	2.9	2.9	-0.19%			
Class F	5.5	5.5	-0.42%	39.2	39.5	-0.63%
TGM	12.3	12.3	-0.54%	112.4	113.2	-0.70%
Overall	2.2	2.2	-0.15%	2.3	2.3	-0.25%
Enc Time[%]	97%			98%		
Dec Time[%]	99%			97%		

Results – Method 3

- Anchor: VTM6.0-lossless
- Test: disable DQ + remove signaling of the position of the last significant coefficient

	All Intra			Random Access		
	ratio		bit-rate savings	ratio		bit-rate savings
	VTM6	Test		VTM6	Test	
Class A1	2.2	2.2	-0.47%	2.3	2.3	-0.48%
Class A2	1.7	1.8	-0.41%	1.9	1.9	-0.41%
Class B	2.1	2.1	-0.60%	2.3	2.3	-0.74%
Class C	2.1	2.1	-0.68%	2.6	2.6	-0.93%
Class D	1.9	2.0	-0.63%	2.8	2.8	-0.96%
Class E	2.9	3.0	-0.95%			
Class F	5.5	5.5	-0.33%	39.2	39.2	-0.49%
TGM	12.3	12.2	0.52%	112.4	112.2	0.22%
Overall	2.2	2.2	-0.62%	2.3	2.3	-0.67%
Enc Time[%]	100%			101%		
Dec Time[%]	96%			95%		

Conclusion

- In lossless coding, when DQ is enabled at slice level, three methods are proposed
 - Method 1: disable the conversion from coefficient levels to quantized coefficients
 - Method 2: Method 1 + disable the Q-state transition during the coefficient coding
 - Method 3: Method 2 + remove the signalling of the position of the last significant coefficient
- Thank Bytedance for cross-checking!

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Thank you!