One-addition de-quantization

JCTVC-G555

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Introduction

- Motivations of this contribution
  - Current HM quantization inherits benefits of H.264/AVC design.
    - Representation of quantization/de-quantization multipliers via mantissa and exponential bitwise shift
    - When developing for H.264/AVC it was aimed at reducing bit-depth
  - We find that additional conditions may be imposed to the choice of values of mantissa
    - We can choose that values of mantissa multiplication by which is fast
  - Mantissa that may be presented in the form 2^p+2^m or 2^p-2^m (one-addition integers)
    - Multiplication by them may be replaced with only one addition and no more than 2 shifts

Description

- De-quantization in HM-4.0
  - iAdd = 1 << (iShift - 1);
  - iCoeffQ = (piQCoef[n] * scale + iAdd) >> iShift;
- Scale is one of {40, 45, 51, 57, 64, 72} left-shifted by one of {0,..,8}
- iAdd does not change performance (also reported by JCTVC-G154)
  - Proposed to be removed
- Suitable one-addition integers covering same domain as in HM:
  - {40, 48, 56, 64, 72} only
  - 5 values -> coarser than HM
  - All are multiples of 8
  - May be reduced to {5,6,7,8,9}
- If using new set of mantissa:
  - New range of QP parameter is [0, 44]
  - Derivation of mantissa and exponent uses division by 5

Implementation into HM-4.0

- To verify proposed quantization modification
  - quantization table was set to {26215, 21846, 18725, 16384, 14564}
  - QP parameter range was changed from [0; 51] to [0; 44]
  - denominator in derivaton of mantissa and exponenta was changed from 6 to 5
  - iAdd was removed from dequantization line
  - chroma QP offset table was adjusted to new design
  - for more adequate setting, new QP set was mapped to old one at the encoder side

Compliance with QP control schemes of common test conditions

- The experimental results show that proposed quantization is compliant with current QP control schemes of common test conditions of HM-4.0.
  - Implemented with table {40, 48, 56, 64, 72}
  - For the sake of bit-rate discrepancy within 5% anchor was recomputed with matching QPs

AI-HE, AI-LC		Rest of tests	
HM-4.0rc1	Proposed	HM-4.0rc1	Proposed
21	17	21	17
27	22	27	22
33	27	32	26
39	32	38	31

Test results

- HM-4.0rc1 (same performance as HM-4.0) with common test conditions
- Our tests show that performance changes do not depend on RDOQ
- Chroma gain is mostly because of new ChromaQPoffset table

Table 3: Test results.

	All Intra HE			All Intra LC			Random Access HE			Random Access LC		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Class A	-0.6%	-0.2%	-0.1%	0.3%	-0.4%	-0.4%	0.5%	-3.6%	-4.2%	1.4%	-3.9%	-3.8%
Class B	-0.6%	-0.2%	-0.2%	0.0%	-0.2%	-0.1%	0.4%	-3.0%	-2.8%	0.9%	-3.2%	-2.8%
Class C	-0.3%	-0.4%	-0.2%	-0.1%	-0.1%	0.0%	0.1%	-2.4%	-2.1%	0.1%	-2.6%	-2.1%
Class D	-0.2%	-0.6%	-0.5%	-0.2%	-0.1%	0.0%	0.2%	-3.2%	-3.2%	0.1%	-2.5%	-2.3%
Class E	-0.3%	0.3%	0.3%	0.3%	0.3%	0.1%						
Class F	-0.2%	-0.6%	-0.7%	-0.3%	-0.4%	-0.5%						
Overall	-0.4%	-0.3%	-0.3%	0.0%	-0.2%	-0.2%	0.3%	-3.1%	-3.1%	0.7%	-3.0%	-2.7%
Enc		101%			100%			100%			103%	
Dec		100%			100%			100%			102%	

	Lowdelay B HE			Lowdelay B LC			Lowdelay P HE			Lowdelay P LC		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Class A												
Class B	-0.1%	-0.3%	-0.8%	0.5%	-0.2%	-0.2%	0.1%	-0.1%	-0.6%	1.3%	-0.1%	0.0%
Class C	-0.1%	-0.2%	-0.5%	0.1%	0.3%	0.2%	0.0%	-0.2%	-0.3%	0.5%	0.2%	0.3%
Class D	-0.1%	-1.7%	-1.4%	0.1%	-0.1%	0.2%	0.1%	-1.6%	-1.8%	0.3%	-0.1%	-0.1%
Class E	-0.8%	-2.8%	-2.7%	-0.2%	-2.2%	-1.9%	-0.4%	-2.9%	-3.3%	0.9%	-2.5%	-2.3%
Class F	-0.7%	-1.2%	-1.6%	-0.5%	-1.1%	-1.5%	-0.5%	-1.3%	-1.9%	-0.3%	-0.7%	-0.9%
Overall	-0.3%	-1.1%	-1.3%	0.0%	-0.6%	-0.6%	-0.1%	-1.1%	-1.5%	0.5%	-0.5%	-0.5%
Enc		100%			100%			100%			100%	
Dec		100%			100%			101%			100%	

cross-checked by Sharp (JCTVC-Gxxx)

Benefits

- Minimal complexity of the decoder in de-quantization part
  - 1 addition or subtraction
  - No more than 2 bitwise shifts
- Minimal bit-depth increase in de-quantization
  - Mantissa are of 4 bit bit-depth only
  - Makes possible to remove downscaling from de-quantization
  - Good for transform
- Short table similar to H.264/AVC design

Conclusions

- New design is proposed for adoption into HEVC design