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Efficient binary representation of cu_qp_delta syntax for CABAC
(JCTVC-F046/ M20458)

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Summary

- Current binary representation of cu_qp_delta syntax

- Proposed binary representation
  - Halve both maximum and average lengths of cu_qp_delta bin strings;
  - Assure that encoders do not send prohibited cu_qp_delta values.

- Simulation results
  - Average BD-rate improvements of 0.04% for HE AI, 0.04% for HE RA, and 0.09 for HE LD;
  - Average cu_qp_delta rate reductions of 1.00% for HE AI, 1.44% for HE RA, and 1.73% for HE LD.

- Recommendation: Adopt the proposal to HM4.0

Current cu_qp_delta binary representation

- Similar to that of mb_qp_delta of H.264/MPEG-4 AVC
  - Signed cu_qp_delta value is converted to an unsigned code number;
  - Then the code number is mapped to a unary binary string.

- The range is specified to be [-26, 25] in order to reconstruct cu_qp in a cyclic manner without ambiguity

(Example1) Binarization of cu_delta_qp=-2

-2 ⟶ 4 ⟶ 11110

(Example 2) Cyclic QP reconstruction (QPprev=1, cu_delta_qp=-2)

(QPprev+dQP)%52 ⟶ QP=51

Problem statement

- # of bins of a bin string is proportional to 2 * |dQP|

- Unary binary representation allows encoders to send prohibited values.
  - ➢ Due to the cyclic reconstruction, for example, if QPprev=0, then dQP=-25 and prohibited dQP=27 yield identical QP.

cu_qp_delta	Bin string													
	1st	2nd	3rd	4th	5th	6th	7th	…	49th	50th	51st	52nd	53rd	54rd
0	0													
1	1	0												
-1	1	1	0											
2	1	1	1	0										
…														
-25	1	1	1	1	1	1	1	…	1	1	0			
26	1	1	1	1	1	1	1	…	1	1	1	0		
-26	1	1	1	1	1	1	1	…	1	1	1	1	0	
27	1	1	1	1	1	1	1	…	1	1	1	1	1	0
Context index	0	2	3	3	3	3	3		3	3	3	3	3	3

Solution

- Signal |cu_qp_delta| by using truncated unary binarization
  - ➢Signal significance of cu_qp_delta in the first bin;
  - ➢Signal its sign in the second bin and determine cMax by;

    cMax = 24 + (cu_qp_delta < 0? 1 : 0)
  - ➢Signal its absolute value -1 by using a truncated unary binarization with cMax.

|cu_qp_delta|	Bin string									
	1st	2nd	3rd	4th	5th	6th	…	26th	27th	28th
0	0									
1	1	X	0							
2	1	X	1	0						
3	1	X	1	1	0					
4	1	X	1	1	1	0				
5	1	X	1	1	1	1				
…										
25	1	X	1	1	1	1	…	1		
26	1	X	1	1	1	1	…	1	1	
Context index	0	na	2	3	3	3	…	3	3	3

Analysis

- # of bins of a proposed bin string is proportional to |dQP|
  - Roughly halve both maximum and average of bin string length;
    - Reduce the maximum length of bin strings from 53 to 27.
    - Reduce the average length of bin strings from 26.52 to 14.94.
  - Significant complexity reduction

- Truncated unary binary representation assures that encoders do not send prohibited values
  - Truncate the last 0 bins of bin strings of cu_qp_delta = 25 and save more than 2.57 bits
  - Truncate the last 0 bins of bin strings of cu_qp_delta = -26 and save more than 2.64 bits.

Simulation

- Test condition: CE4 Subtest2 common test conditions
  - ➢ HM3.0 QP prediction;
  - ➢ $-6 \le cu\_qp\_delta \le 6$;
  - ➢ Evaluate BD-rate improvement, cu_qp_delta rate reductions, encoder/decoder runtime measure.

- Computing platform
  - Windows 7 64-bit on Xeon 3.33GHz and Mem. 32GB

Simulation results

	All intra		Random access		Low delay	
	Y BD-rate %	dQP inc %	Y BD-rate %	dQP inc %	Y BD-rate %	dQP inc %
Class A	-0.03	-1.20	-0.07	-1.40		
Class B	-0.03	-0.80	-0.04	-1.20	-0.06	-1.10
Class C	-0.04	-0.90	-0.07	-1.40	-0.10	-1.80
Class D	-0.04	-1.00	0.02	-1.80	-0.09	-2.20
Class E	-0.06	-1.10			-0.14	-2.20
All	-0.04	-1.00	-0.04	-1.40	-0.09	-1.70
Enc Time %	98%		98%		98%	
Dec Time %	99%		99%		99%	

Conclusions and recommendation

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