JCTVC-H0387

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Handling large size quantization matrices

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Introduction

- In JCTVC-G094 (TI) and JCTVC-G152 (MediaTek) it was proposed to derive large size (32x32 and 16x16) quantization matrices from 8x8 quantization matrices instead of explicit signaling.
  - By linear interpolation up-sampling.
- In this contribution, three alternative approaches and results are reported,
  - Explicit signaling of 4x4, 8x8 and 16x16, derivation of 32x32 from 16x16;
  - Explicit signaling of 4x4, 8x8, derivation of 16x16 from 8x8 by linear interpolation up-sampling, derivation of 32x32 from 16x16 by sample repetition;
  - Explicit signaling of 4x4, 8x8, derivation of partial16x16 and 32x32 from 8x8 by linear interpolation, the rest by sample repetition.

Method 1

- Explicit signaling of 4x4, 8x8 and 16x16, derivation of 32x32 from 16x16
  - Test 2a. 32x32 from 16x16 by linear interpolation
  - Test 2b. 32x32 from 16x16 by sample repetition
  - Test 1. Explicit signaling of 4x4 and 8x8, derivation of 16x16 and 32x32 from 8x8 by linear interpolation

Symmetry1	Test 1	Test 2a	Test 2b
Header Bit	1	1	1
Matrix [0][0] Bit	79	79	79
Matrix [0][1] Bit	79	79	79
Matrix [0][2] Bit	79	79	79
Matrix [0][3] Bit	81	81	81
Matrix [0][4] Bit	81	81	81
Matrix [0][5] Bit	81	81	81
Matrix [1][0] Bit	335	335	335
Matrix [1][1] Bit	2	2	2
Matrix [1][2] Bit	335	335	335
Matrix [1][3] Bit	291	291	291
Matrix [1][4] Bit	291	291	291
Matrix [1][5] Bit	291	291	291
Matrix [2][0] Bit	0	1143	1143
Matrix [2][1] Bit	0	2	2
Matrix [2][2] Bit	0	2	2
Matrix [2][3] Bit	0	825	825
Matrix [2][4] Bit	0	2	2
Matrix [2][5] Bit	0	825	825
Matrix [3][0] Bit	0	0	0
Matrix [3][1] Bit	0	0	0
Total Bit	2026	4825	4825
MaxError	19	9	9
AvgError	1.998031	0.493110	0.452264

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BD-rate: Explicit signaling 4x4 and 8x8

	All Intra HE			All Intra LC			All Intra HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A	-0.3%	-1.1%	-1.3%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Class B	-1.6%	-1.7%	-1.7%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Class C	-4.1%	-3.8%	-3.9%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Class D	-10.7%	-9.9%	-10.1%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Class E	-5.0%	-4.8%	-4.9%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Class F	-3.4%	-3.2%	-3.2%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Overall	-4.4%	-4.2%	-4.3%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	-4.4%	-4.3%	-4.3%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Enc Time[%]	100%			#NUM!			#NUM!		
Dec Time[%]	100%			#NUM!			#NUM!		

	Random Access HE			Random Access LC			Random Access HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A	-4.7%	-4.0%	-4.3%	-4.5%	-4.6%	-4.5%	-5.7%	-7.6%	-8.1%
Class B	-12.0%	-10.9%	-10.4%	-11.8%	-10.6%	-10.3%	-12.1%	-11.0%	-10.5%
Class C	-22.8%	-21.5%	-21.3%	-22.8%	-21.4%	-21.4%	#VALUE!	#VALUE!	#VALUE!
Class D	-42.6%	-40.6%	-40.9%	-43.0%	-41.5%	-41.6%	#VALUE!	#VALUE!	#VALUE!
Class E									
Class F	-21.6%	-20.4%	-20.5%	-21.4%	-20.1%	-20.3%	#VALUE!	#VALUE!	#VALUE!
Overall	-22.1%	-20.7%	-20.6%	-22.1%	-20.9%	-20.8%	#VALUE!	#VALUE!	#VALUE!
	-22.1%	-20.8%	-20.7%	-22.1%	-21.0%	-20.9%	#VALUE!	#VALUE!	#VALUE!
Enc Time[%]	100%			100%			100%		
Dec Time[%]	100%			100%			101%		

	Low delay B HE			Low delay B LC			Low delay B HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A									
Class B	-12.7%	-11.4%	-11.0%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Class C	-22.6%	-21.0%	-21.2%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Class D	-41.9%	-40.0%	-39.9%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Class E	-46.2%	-43.4%	-43.5%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Class F	-30.5%	-29.2%	-29.3%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Overall	-29.1%	-27.4%	-27.4%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	-29.1%	-27.5%	-27.5%	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Enc Time[%]	100%			#NUM!			#NUM!		
Dec Time[%]	100%			#NUM!			#NUM!		

BD-rate: Explicit signaling 4x4, 8x8 and 16x16

	All Intra HE			All Intra LC			All Intra HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A (8bit)	-0.4%	-0.8%	-0.8%	#VALUE!	#VALUE!	#VALUE!			
Class B	-1.2%	-1.3%	-1.3%	#VALUE!	#VALUE!	#VALUE!			
Class C	-2.8%	-2.6%	-2.6%	#VALUE!	#VALUE!	#VALUE!			
Class D	-7.3%	-6.8%	-6.8%	#VALUE!	#VALUE!	#VALUE!			
Class E	-3.5%	-3.5%	-3.4%	#VALUE!	#VALUE!	#VALUE!			
Overall	**-3.2%**	**-3.1%**	**-3.1%**	**#VALUE!**	**#VALUE!**	**#VALUE!**			
	-3.2%	-3.1%	-3.2%	#VALUE!	#VALUE!	#VALUE!			
Class F	-2.3%	-2.3%	-2.3%	#VALUE!	#VALUE!	#VALUE!			
Enc Time[%]	100%			#NUM!					
Dec Time[%]	100%			#NUM!					

	Random Access HE			Random Access LC			Random Access HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A (8bit)	-3.3%	-2.8%	-2.8%	-3.1%	-3.1%	-3.1%	-4.2%	-4.8%	-5.1%
Class B	-8.2%	-7.4%	-7.1%	-7.9%	-7.3%	-7.2%	-8.2%	-7.4%	-7.1%
Class C	-15.4%	-14.4%	-14.4%	-15.4%	-14.4%	-14.4%			
Class D	-28.7%	-27.4%	-27.4%	-28.9%	-27.8%	-28.1%			
Class E									
Overall	**-14.9%**	**-14.0%**	**-13.9%**	**-14.9%**	**-14.1%**	**-14.1%**	-6.4%	-6.3%	-6.2%
	-14.9%	-14.0%	-13.9%	-14.9%	-14.1%	-14.2%	-6.5%	-6.3%	-6.2%
Class F	-14.7%	-13.7%	-13.9%	-14.4%	-13.8%	-13.8%			
Enc Time[%]	100%			100%			100%		
Dec Time[%]	99%			99%			100%		

	Low delay B HE			Low delay B LC			Low delay B HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A									
Class B	-8.6%	-7.6%	-7.2%	#VALUE!	#VALUE!	#VALUE!			
Class C	-15.2%	-14.0%	-14.3%	#VALUE!	#VALUE!	#VALUE!			
Class D	-28.1%	-26.9%	-26.9%	#VALUE!	#VALUE!	#VALUE!			
Class E	-31.1%	-29.3%	-30.0%	#VALUE!	#VALUE!	#VALUE!			
Overall	**-19.4%**	**-18.1%**	**-18.2%**	**#VALUE!**	**#VALUE!**	**#VALUE!**			
	-19.4%	-18.1%	-18.2%	#VALUE!	#VALUE!	#VALUE!			
Class F	-20.6%	-19.7%	-19.9%	#VALUE!	#VALUE!	#VALUE!			
Enc Time[%]	100%			#NUM!					
Dec Time[%]	100%			#NUM!					

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Method 2

- Explicit signaling of 4x4, 8x8
- Derivation of 16x16 from 8x8 by linear interpolation up-sampling

$$
\begin{aligned}
C_{2Nx2N}(2*i, 2*j) &= C_{NxN}(i, j), && i=0,\ldots N-1; j=0,\ldots N-1.\\
C_{2Nx2N}(2*i, 2*j+1) &= (C_{NxN}(i, j) + C_{NxN}(i, j+1)) >> 1, && i=0,\ldots N-1; j=0,\ldots N-2.\\
C_{2Nx2N}(2*i+1, 2*j) &= (C_{NxN}(i, j) + C_{NxN}(i+1, j)) >> 1, && i=0,\ldots N-2; j=0,\ldots N-1.\\
C_{2Nx2N}(2*i+1, 2*j+1) &= (C_{NxN}(i,j) + C_{NxN}(i,j+1) + C_{NxN}(i+1,j) + C_{NxN}(i+1,j+1)) >> 2, && i=0,\ldots N-2; j=0,\ldots N-2.\\
C_{2Nx2N}(i, 2N-1) &= C_{2Nx2N}(i, 2N-2) && i=0,\ldots 2N-2.\\
C_{2Nx2N}(2N-1, j) &= C_{2Nx2N}(2N-2, j) && j=0,\ldots 2N-1.
\end{aligned}
$$

- Derivation of 32x32 from 16x16 by sample repetition

$$
\begin{aligned}
C_{2Nx2N}(2*i, 2*j) &= C_{2Nx2N}(2*i+1, 2*j)\\
&= C_{2Nx2N}(2*i, 2*j+1)\\
&= C_{2Nx2N}(2*i+1, 2*j+1)\\
&= C_{NxN}(i, j)\ , && i=0,\ldots N-1; j=0,\ldots N-1.
\end{aligned}
$$

Method 2 Result

	symmetry1	symmetry2	symmetry3	symmetry4	symmetry5	symmetry6	asymmetry1	asymmetry2	asymmetry3	asymmetry4	asymmetry5	asymmetry6
Header Bit	1	1	1	1	1	1	1	1	1	1	1	1
Matrix [0][0] Bi	79	59	97	91	79	97	89	65	101	117	89	101
Matrix [0][1] Bi	79	59	97	91	79	97	89	65	101	117	89	101
Matrix [0][2] Bi	79	59	97	91	79	97	89	65	101	117	89	101
Matrix [0][3] Bi	81	45	91	89	81	91	107	55	105	135	107	105
Matrix [0][4] Bi	81	45	91	89	81	91	107	55	105	135	107	105
Matrix [0][5] Bi	81	45	91	89	81	91	107	55	105	135	107	105
Matrix [1][0] Bi	335	261	427	385	261	335	381	281	473	621	281	381
Matrix [1][1] Bi	2	2	2	2	2	2	2	2	2	2	2	2
Matrix [1][2] Bi	335	261	427	385	261	335	381	281	473	621	281	381
Matrix [1][3] Bi	291	141	385	413	141	291	349	177	431	571	177	349
Matrix [1][4] Bi	291	141	385	413	141	291	349	177	431	571	177	349
Matrix [1][5] Bi	291	141	385	413	141	291	349	177	431	571	177	349
Matrix [2][0] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [2][1] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [2][2] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [2][3] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [2][4] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [2][5] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [3][0] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [3][1] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Total Bit	2026	1260	2576	2552	1428	2110	2400	1456	2860	3714	1684	2430
MaxError	19	14	66	37	62	103	10	11	86	129	55	134
AvgError	1.599656	3.278789	20.371309	4.82751	18.964813	34.380413	1.652313	2.61811	17.65502	15.503937	15.686762	28.735236

Method 3

- Explicit signaling of 4x4, 8x8, derivation of partial16x16 and 32x32 from 8x8 by linear interpolation, the rest by sample repetition.
  - Example: 8x8 to 16x16 up-conversion.

6	10	13	16	18	23	25	27
10	11	16	18	23	25	27	29
13	16	18	23	25	27	29	31
16	18	23	25	27	29	31	33
18	23	25	27	29	31	33	36
23	25	27	29	31	33	36	38
25	27	29	31	33	36	38	40
27	29	31	33	36	38	40	42

Linear interpolation →

Sample repetition→

6	8	10	11	13	14	16	17	18	18	23	23	25	25	27	27
8	9	10	12	14	15	17	18	18	18	23	23	25	25	27	27
10	10	11	13	16	17	18	20	23	23	25	25	27	27	29	29
11	12	13	15	17	18	20	22	23	23	25	25	27	27	29	29
13	14	16	17	18	20	23	24	25	25	27	27	29	29	31	31
14	15	17	18	20	22	24	25	25	25	27	27	29	29	31	31
16	17	18	20	23	24	25	26	27	27	29	29	31	31	33	33
17	18	20	22	24	25	26	27	27	27	29	29	31	31	33	33
18	18	23	23	25	25	27	27	29	29	31	31	33	33	36	36
18	18	23	23	25	25	27	27	29	29	31	31	33	33	36	36
23	23	25	25	27	27	29	29	31	31	33	33	36	36	38	38
23	23	25	25	27	27	29	29	31	31	33	33	36	36	38	38
25	25	27	27	29	29	31	31	33	33	36	36	38	38	40	40
25	25	27	27	29	29	31	31	33	33	36	36	38	38	40	40
27	27	29	29	31	31	33	33	36	36	38	38	40	40	42	42
27	27	29	29	31	31	33	33	36	36	38	38	40	40	42	42

Method 3 Result

	symmetry1	symmetry2	symmetry3	symmetry4	symmetry5	symmetry6	asymmetry1	asymmetry2	asymmetry3	asymmetry4	asymmetry5	asymmetry6
Header Bit	1	1	1	1	1	1	1	1	1	1	1	1
Matrix [0][0] Bi	79	59	97	91	79	97	89	65	101	117	89	101
Matrix [0][1] Bi	79	59	97	91	79	97	89	65	101	117	89	101
Matrix [0][2] Bi	79	59	97	91	79	97	89	65	101	117	89	101
Matrix [0][3] Bi	81	45	91	89	81	91	107	55	105	135	107	105
Matrix [0][4] Bi	81	45	91	89	81	91	107	55	105	135	107	105
Matrix [0][5] Bi	81	45	91	89	81	91	107	55	105	135	107	105
Matrix [1][0] Bi	335	261	427	385	261	335	381	281	473	621	281	381
Matrix [1][1] Bi	2	2	2	2	2	2	2	2	2	2	2	2
Matrix [1][2] Bi	335	261	427	385	261	335	381	281	473	621	281	381
Matrix [1][3] Bi	291	141	385	413	141	291	349	177	431	571	177	349
Matrix [1][4] Bi	291	141	385	413	141	291	349	177	431	571	177	349
Matrix [1][5] Bi	291	141	385	413	141	291	349	177	431	571	177	349
Matrix [2][0] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [2][1] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [2][2] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [2][3] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [2][4] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [2][5] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [3][0] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Matrix [3][1] Bi	0	0	0	0	0	0	0	0	0	0	0	0
Total Bit	2026	1260	2576	2552	1428	2110	2400	1456	2860	3714	1684	2430
MaxError	21	14	66	37	62	103	13	11	86	129	55	134
AvgError	1.697835	2.901575	20.649114	5.189715	19.463091	34.440699	1.743356	2.147884	17.99188	16.866142	16.258858	28.908957

Conclusion

- Three methods were examined for handling large size quantization matrices.
  1. Explicit signaling of 4x4, 8x8 and 16x16, derivation of 32x32 from 16x16 by linear interpolation or sample repetition;
  2. Explicit signaling of 4x4, 8x8, derivation of 16x16 from 8x8 by linear interpolation up-sampling, derivation of 32x32 from 16x16 by sample repetition;
  3. Explicit signaling of 4x4, 8x8, derivation of partial16x16 and 32x32 from 8x8 by linear interpolation, the rest by sample repetition.
- Thanks to Motorola Mobility for cross check (JCTVC-H0641)
- Recommend to consider adoption or further study together with other lossless/lossy QM compression methods.

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