JCT-VC- I0126: Newer Quantization Matrices for HEVC

Sangoh Jeong and Byeongmoon Jeon

LG Electronics

Fast, Strong & Smart

- **Intra 4x4 QM: Sub-sampled from 8x8 Intra QM**
- **Intra 16x16 QM and Intra 32x32 QM: Up-sampled from 8x8 Intra QM**
- **Inter QM's : Predicted from Intra QM's, using the linear relationship between the Intra QM's and**
  the corresponding inter QM's in AVC/H.264
- **Intra 8x8 QM: Uses the same QM developed for JPEG in 1999, based on an HVS model.**

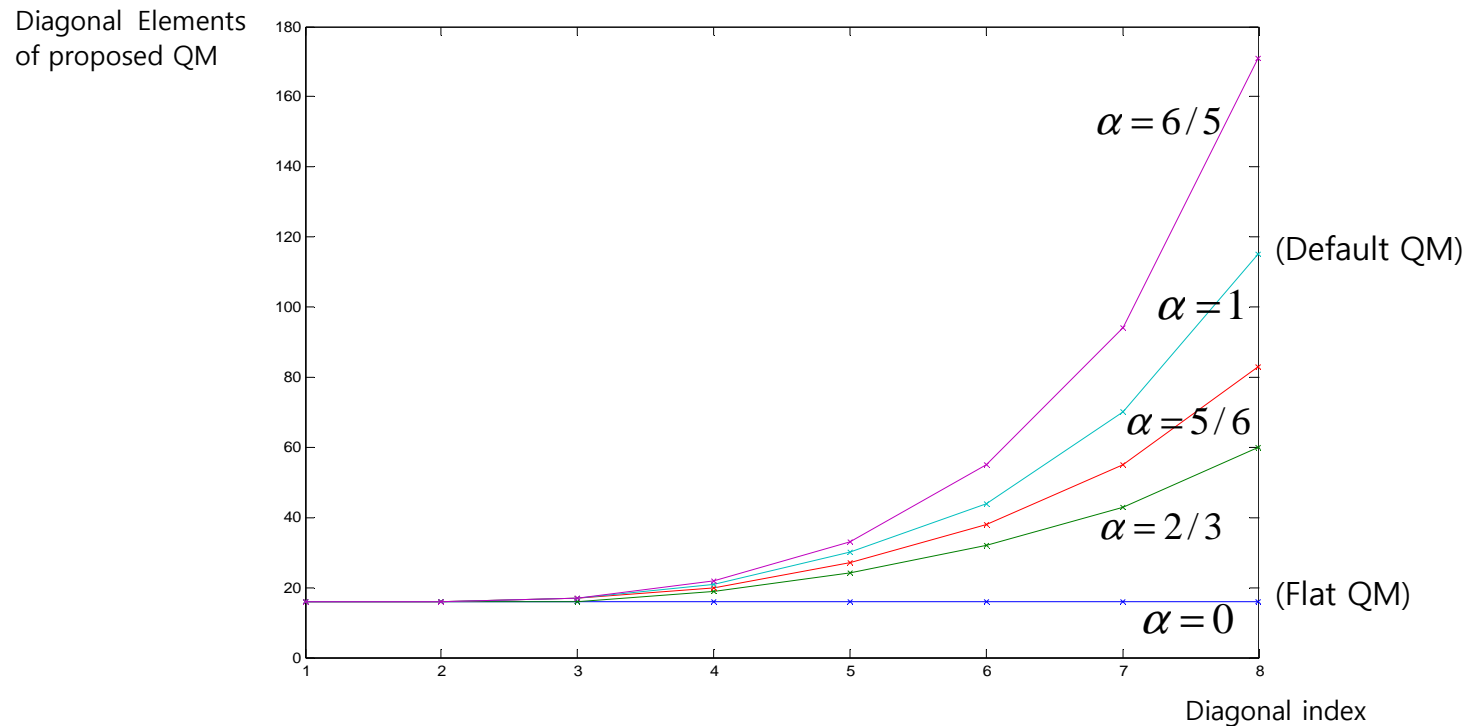- Intra 8x8 QM(i, j) = Round[16 / MTF(i, j)] =   , where MTF(i, j) =

16	16	16	16	17	18	21	24		1.0000	1.0000	1.0000	1.0000	0.9599	0.8746	0.7684	0.6571
16	16	16	16	17	19	22	25		1.0000	1.0000	1.0000	1.0000	0.9283	0.8404	0.7371	0.6306
16	16	17	18	20	22	25	29		1.0000	1.0000	0.9571	0.8898	0.8192	0.7371	0.6471	0.5558
16	16	18	21	24	27	31	36		1.0000	1.0000	0.8898	0.7617	0.6669	0.5912	0.5196	0.4495
17	17	20	24	30	35	41	47		0.9599	0.9283	0.8192	0.6669	0.5419	0.4564	0.3930	0.3393
18	19	22	27	35	44	54	65		0.8746	0.8404	0.7371	0.5912	0.4564	0.3598	0.2948	0.2480
21	22	25	31	41	54	70	88		0.7684	0.7371	0.6471	0.5196	0.3930	0.2948	0.2278	0.1828
24	25	29	36	47	65	88	115		0.6571	0.6306	0.5558	0.4495	0.3393	0.2480	0.1828	0.1391

- Concerns: Simple adoption of an existing QM without considering much about fine-tuning on
  objective quality and selection criteria.
  → 4 parameters and an assumption of 80 DPI for the MTF(Modulation Transfer Function)
  may not fit with HEVC and a variety of display devices.

■ Motivation: Tuning the 4 parameters and the assumption for a better QM can be difficult.

→ Use a simpler model to find a QM having relatively more objective quality gain than relative bitrate increase.

→ Maintain key properties of using HVS: quantizing low frequency components more than high frequency components.

■ Proposed intra 8x8 QM: Based on a generalized HVS model with one control parameter $\alpha \geq 0$.

.
$$\text{intra 8x8 QM (i, j)= Round } [16 \ / \ MTF(i, j)^{\alpha}]$$

Diagonal Elements of proposed QM

$\alpha = 6/5$

(Default QM)

$\alpha = 1$

$\alpha = 5/6$

$\alpha = 2/3$

(Flat QM)

$\alpha = 0$

Diagonal index

Fast, Strong & Smart

- Proposed intra 8x8 QM: With $\alpha = 5/6$ (0.8333),

- Intra 8x8 QM(i, j) = Round[16 / MTF(i, j)$^{\alpha=0.8333}$] = , where MTF(i, j)$^{\alpha=0.8333}$ =

16	16	16	16	17	18	20	23
16	16	16	16	17	18	21	23
16	16	17	18	19	21	23	26
16	16	18	20	22	25	28	31
17	17	19	22	27	31	35	39
18	18	21	25	31	38	44	51
20	21	23	28	35	44	55	66
23	23	26	31	39	51	66	83

1.0000	1.0000	1.0000	1.0000	0.9665	0.8944	0.8029	0.7047
1.0000	1.0000	1.0000	1.0000	0.9399	0.8651	0.7755	0.6810
1.0000	1.0000	0.9641	0.9073	0.8469	0.7755	0.6958	0.6130
1.0000	1.0000	0.9073	0.7971	0.7135	0.6453	0.5795	0.5136
0.9665	0.9399	0.8469	0.7135	0.6002	0.5201	0.4592	0.4063
0.8944	0.8651	0.7755	0.6453	0.5201	0.4266	0.3614	0.3129
0.8029	0.7755	0.6958	0.5795	0.4592	0.3614	0.2915	0.2426
0.7047	0.6810	0.6130	0.5136	0.4063	0.3129	0.2426	0.1932

- inter 8x8 QM =

16	16	16	16	17	18	19	23
16	16	16	17	18	19	23	23
16	16	17	18	19	23	23	25
16	17	18	19	23	23	25	28
17	18	19	23	23	25	28	34
18	19	23	23	25	28	34	42
19	23	23	25	28	34	42	53
23	23	25	28	34	42	53	66

intra 4x4 QM =

16	16	17	20
16	17	19	23
17	19	27	35
20	23	35	55

inter 4x4 QM =

6	16	17	20
16	17	20	22
17	20	22	31
20	22	31	45

Fast, Strong & Smart

All Intra Main	ΔBD-rate	ΔBitrate	ΔPSNR-Y(DB)	ΔEnc-time
HM6.0 Flat QM	0	0	0	0
HM6.0 Default QM	3.0%, 6.1%(F)	-4.6%, -6.4%(F)	-1.25, -3.17(F)	-2%
HM6.0 Proposed QM	2.3%, 4.3%(F)	-4.0%, -5.6%(F)	-1.04, -2.52(F)	-2%

All Intra HE10	ΔBD-rate	ΔBitrate	ΔPSNR-Y(DB)	ΔEnc-time
HM6.0 Flat QM	0	0	0	0
HM6.0 Default QM	2.3%, 5.4%(F)	-4.5%, -6.1%(F)	-1.14, -2.98(F)	-2%
HM6.0 Proposed QM	1.7%, 3.7%(F)	-3.9%, -5.4%(F)	-0.94, -2.36(F)	-2%

Random Access Main	ΔBD-rate	ΔBitrate	ΔPSNR-Y(DB)	ΔEnc-time
HM6.0 Flat QM	0	0	0	0
HM6.0 Default QM	2.3%, 6.8%(F)	-4.3%, -4.7%(F)	-0.66, -2.47(F)	-1%
HM6.0 Proposed QM	1.7%, 4.9%(F)	-3.8%, -4.1%(F)	-0.54, -1.95(F)	-1%

Low Delay B Main	ΔBD-rate	ΔBitrate	ΔPSNR-Y(DB)	ΔEnc-time
HM6.0 Flat QM	0	0	0	0
HM6.0 Default QM	1.5%, 4.8%(F)	-4.0%, -4.0%(F)	-0.55, -1.84(F)	-1%
HM6.0 Proposed QM	1.1%, 3.3%(F)	-3.5%, -3.6%(F)	-0.44, -1.45(F)	-1%

Low Delay B Main	ΔBD-rate	ΔBitrate	ΔPSNR-Y(DB)	ΔEnc-time
HM6.0 Flat QM	0	0	0	0
HM6.0 Default QM	1.5%, 4.8%(F)	-4.0%, -4.0%(F)	-0.55, -1.84(F)	-1%
HM6.0 Proposed QM	1.1%, 3.3%(F)	-3.5%, -3.6%(F)	-0.44, -1.45(F)	-1%

Low Delay B HE10	ΔBD-rate	ΔBitrate	ΔPSNR-Y(DB)	ΔEnc-time
HM6.0 Flat QM	0	0	0	0
HM6.0 Default QM	1.1%, 4.1%(F)	-3.8%, -3.8%(F)	-0.48, -1.67(F)	-1%
HM6.0 Proposed QM	0.7%, 2.9%(F)	-3.2%, -3.2%(F)	-0.39, -1.31(F)	-1%

- α selection: Find the α^* as follows, when the change in y becomes the biggest.

$$\alpha^* = \arg\max_{\alpha} \left(\frac{\Delta y}{\Delta \alpha} - \frac{\Delta y_2}{\Delta \alpha_2} \right)$$

where, $\quad y = \dfrac{\text{relative BD-rate increase}}{\text{relative bitrate decrease}}, \qquad \Delta\alpha = \alpha - \alpha_1, \qquad \Delta\alpha_2 = \alpha_2 - \alpha,$
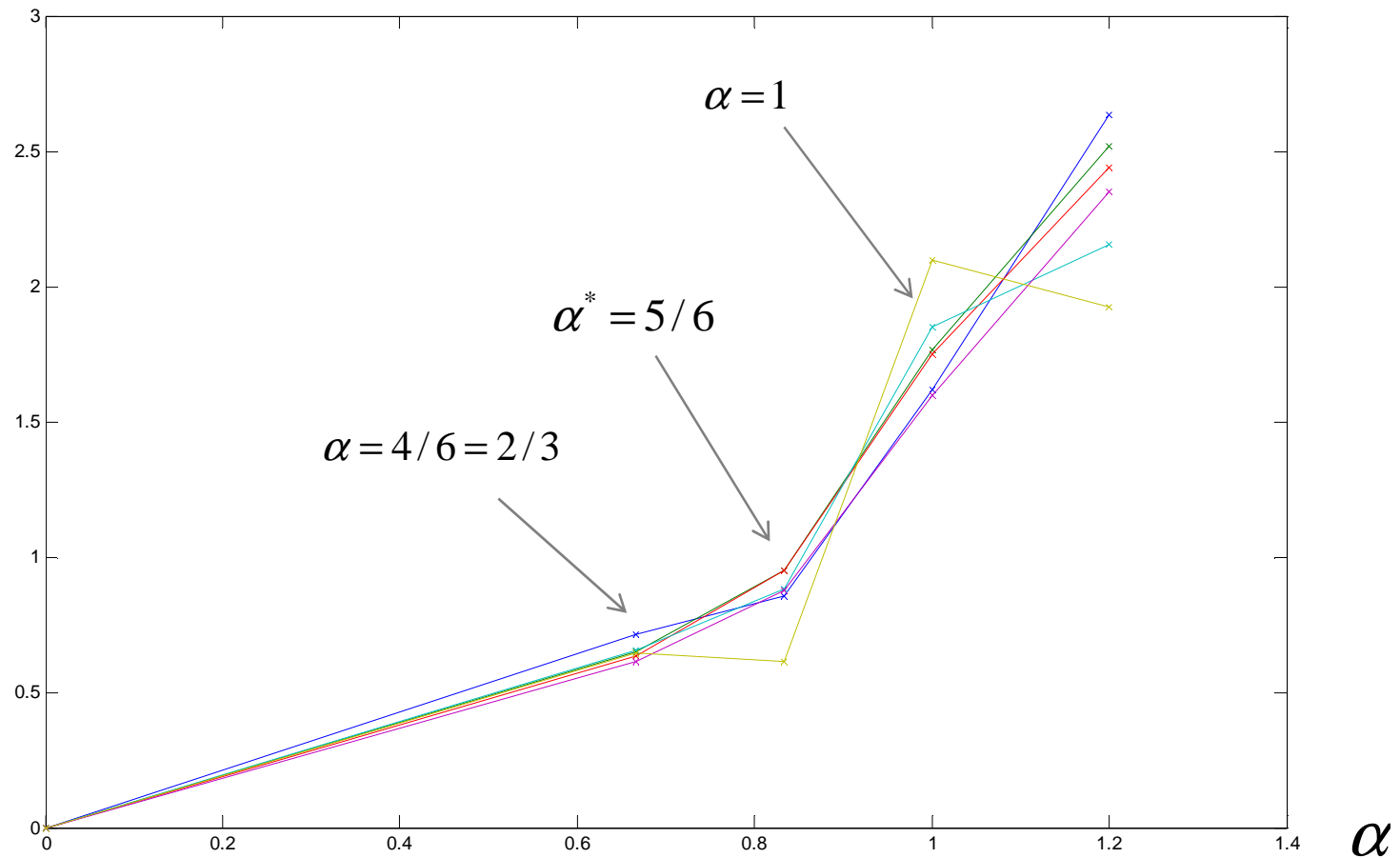
$\alpha_1 \le \alpha \le \alpha_2$: three values are next to each other.

Ex) For "All Intra Main", the relative BD-rate increase = 0.7% / 3.0% = 0.23,

the relative bitrate decrease = 0.6% / 4.6% = 0.13

Fast, Strong & Smart

$$y = \frac{\text{relative BD-rate increase}}{\text{relative bitrate decrease}}$$

- With the proposed QM's, in comparison with the current QM's,
    - → -0.7% ~ -0.4% BD-rate change and 0.4% ~ 0.6% bitrate increase for A,B,C, and D.
    - → -1.9% ~ -1.2% BD-rate change and 0.4% ~ 0.8% bitrate increase for F.
- Provided objective criteria for HVS-based QM selection.
- With the selected $\alpha = 5/6$, the relative benefit in BD-rate is higher than the relative disadvantage in bitrate, in comparison with the current QM's.
- Maintains the HVS property: low frequency components are less quantized than high frequency components.
- Adoption of the proposed QM's as the default QM's is requested.

Fast, Strong & Smart