



JCT-VC- I0126: Newer Quantization Matrices for HEVC

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1. Current Quantization Matrices (QM's or Scaling Lists)

- 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) =

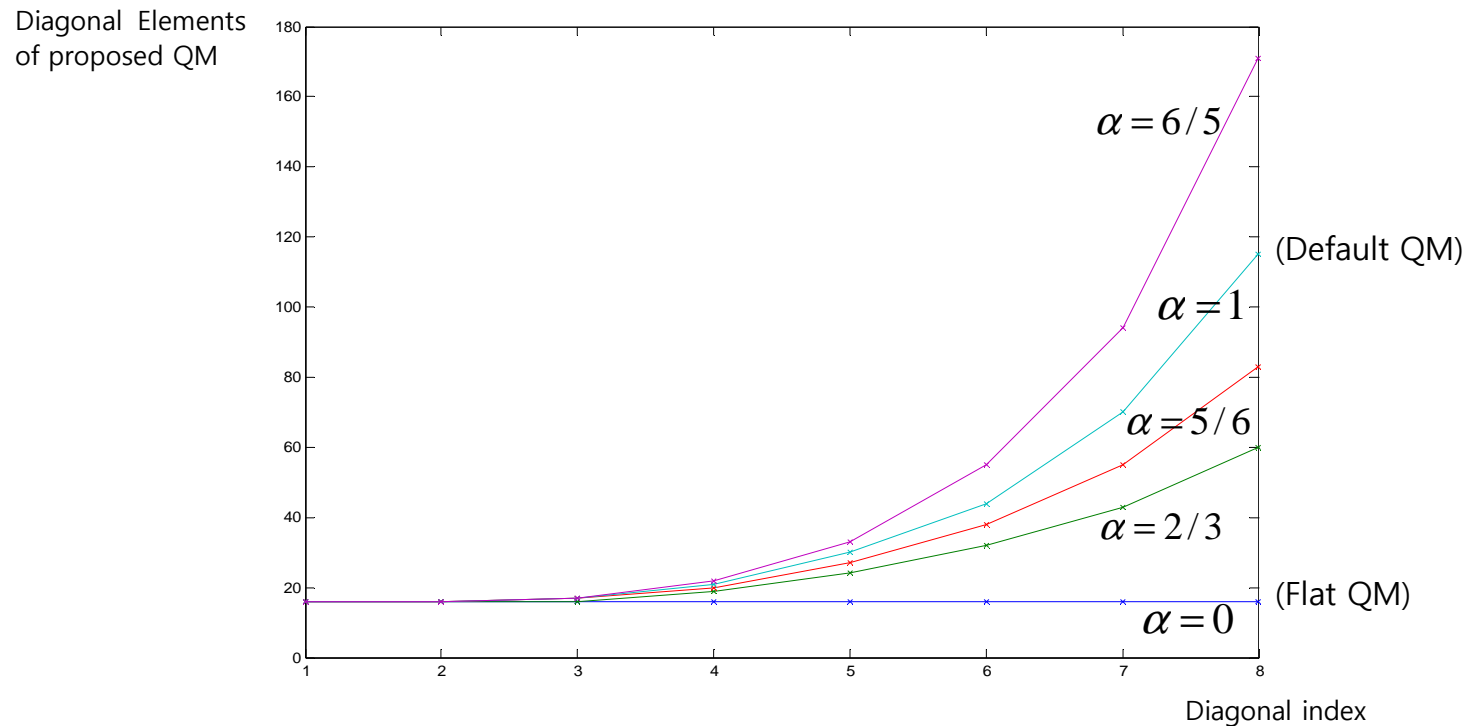
16 16 16 16 17 18 21 24	1.0000 1.0000 1.0000 1.0000 0.9599 0.8746 0.7684 0.6571
16 16 16 16 17 19 22 25	1.0000 1.0000 1.0000 1.0000 0.9283 0.8404 0.7371 0.6306
16 16 17 18 20 22 25 29	1.0000 1.0000 0.9571 0.8898 0.8192 0.7371 0.6471 0.5558
16 16 18 21 24 27 31 36	1.0000 1.0000 0.8898 0.7617 0.6669 0.5912 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.

2. Proposed QM's (Scaling Lists): Motivation and Model



- 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 $\alpha \geq 0$.
intra 8x8 QM (i, j) = Round $[16 / \text{MTF}(i, j)^\alpha]$





2. Proposed QM's (Scaling Lists): Proposed 8x8/4x4 intra and inter QM's

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

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

16 16 16 16 17 18 20 23	1.0000 1.0000 1.0000 1.0000 0.9665 0.8944 0.8029 0.7047
16 16 16 16 17 18 21 23	1.0000 1.0000 1.0000 1.0000 0.9399 0.8651 0.7755 0.6810
16 16 17 18 19 21 23 26	1.0000 1.0000 0.9641 0.9073 0.8469 0.7755 0.6958 0.6130
16 16 18 20 22 25 28 31	1.0000 1.0000 0.9073 0.7971 0.7135 0.6453 0.5795 0.5136
17 17 19 22 27 31 35 39	0.9665 0.9399 0.8469 0.7135 0.6002 0.5201 0.4592 0.4063
18 18 21 25 31 38 44 51	0.8944 0.8651 0.7755 0.6453 0.5201 0.4266 0.3614 0.3129
20 21 23 28 35 44 55 66	0.8029 0.7755 0.6958 0.5795 0.4592 0.3614 0.2915 0.2426
23 23 26 31 39 51 66 83	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

3. Experimental Results



All Intra Main	Δ BD-rate	Δ Bitrate	Δ PSNR-Y(DB)	Δ Enc-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	Δ BD-rate	Δ Bitrate	Δ PSNR-Y(DB)	Δ Enc-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	Δ BD-rate	Δ Bitrate	Δ PSNR-Y(DB)	Δ Enc-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	Δ BD-rate	Δ Bitrate	Δ PSNR-Y(DB)	Δ Enc-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%

3. Experimental Results



Low Delay B Main	Δ BD-rate	Δ Bitrate	Δ PSNR-Y(DB)	Δ Enc-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	Δ BD-rate	Δ Bitrate	Δ PSNR-Y(DB)	Δ Enc-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, $y = \frac{\text{relative BD-rate increase}}{\text{relative bitrate decrease}}, \quad \Delta \alpha = \alpha - \alpha_1, \quad \Delta \alpha_2 = \alpha_2 - \alpha,$

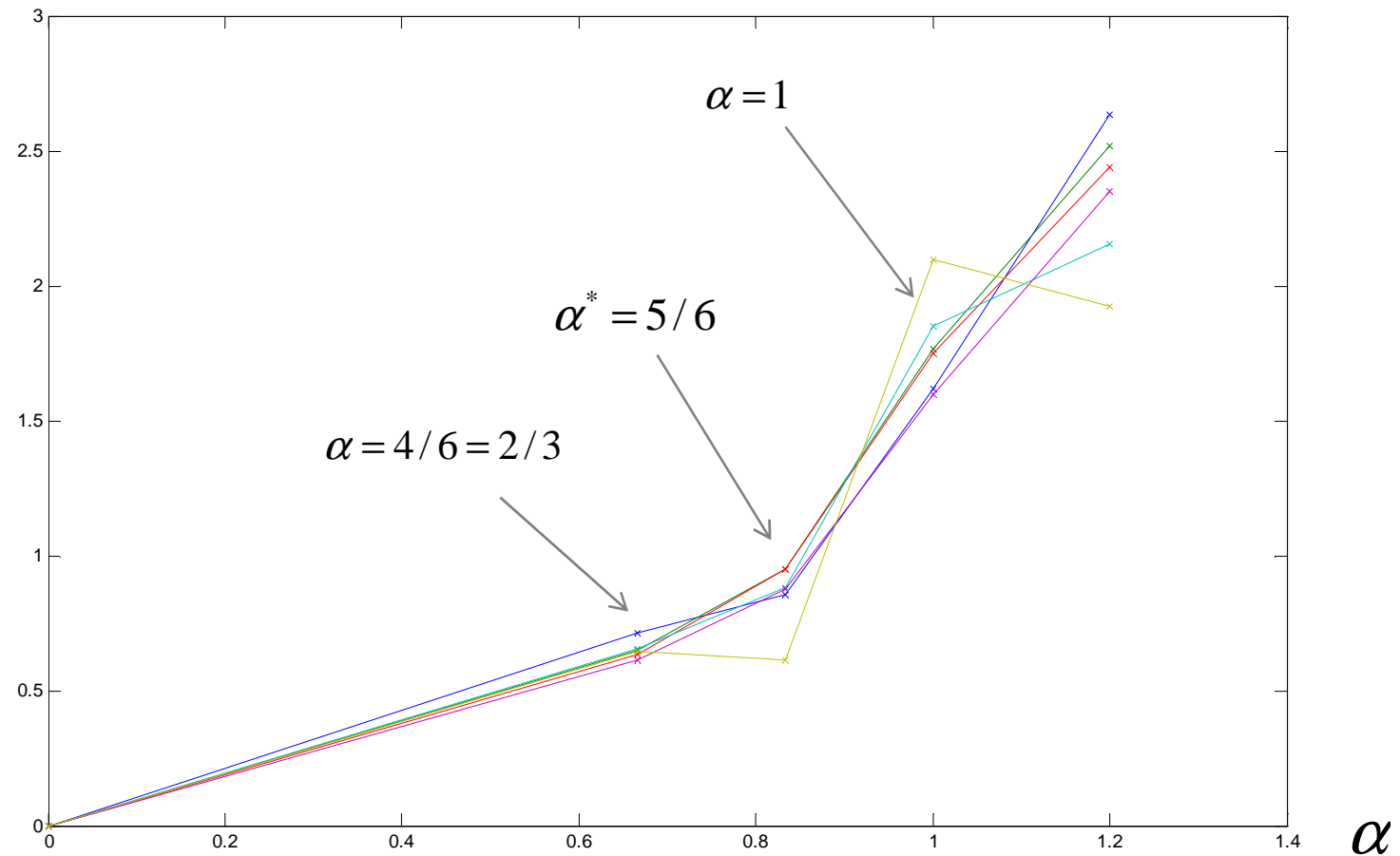
$$\alpha_1 \leq \alpha \leq \alpha_2 \quad : \text{three values are next to each other.}$$

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

3. Experimental Results



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



4. Conclusion



- 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.