Adaptive Quantization in DCT Domain for Distributed Video Coding

Chun-Ling Yang[1], Dong-Qin Xiao[1], Lai-Man Po[2], Wang-Hua Mo[1]
[1] *South China University of Technology, Guangzhou, China*
[2] *City University of Hong Kong, Hong Kong, China*

In DCT domain distributed video coding (DVC), the uniform symmetric scalar quantization has been widely implemented, where, coefficients organized into 16 DCT bands are quantized with the given quantization levels [1]. For each sequence has its own contents, the optimal quantization levels should vary with frames. In this paper, a low complexity algorithm for designing adaptive quantization levels (AQL) according to the characteristic of the bands is proposed. It proceeds as follows.

Firstly, similar to the matrices depicted in [1], the basic quantization matrices in AQL are illustrated in Fig.1. The 15 AC bands are separated into 6 groups {1,2}, {3,4,5}, {6,7,8,9}, {10,11,12}, {13,14}, {15} according to frequency. Secondly, coefficients with larger magnitudes are utilized to address the importance of each band. The importance of band b_i is defined as $S_i=\sum|c_j|$ ($c_j\geq T$) with $T=0.5q_i$ and q_i refers to the quantization step when the finest quantizer in [1] is adopted. Then S_i is normalized as $w_i = S_i / S'_{k-1}$, where, S'_{k-1} (k=0, 1, …,5) is obtained by averaging the parameters S_i within the (k-1)th group. Finally, the quantization level for each DCT band is decided. For band b_i, let $2^{M_{0i}}$ and 2^{M_i} stand for its basic quantization level given in Fig.1 and final quantization level respectively and let 2^{M_0} denote the quantization level of group {1, 2}, which doesn't need adjusting. For the other groups except for {15}, M_i is adaptively obtained.

(i) If M_0-M_{0i}=1, M_i remains the same value as M_{0i} or set M_i =0 when $2^{M_{0i}}$ =2.

(ii) If M_0- $M_{0i}\geq 2$ and $w_i\geq T_k$, set $M_i=M_{0i}+1$. Otherwise, $M_i=M_{0i}$ or set M_i=0 when $2^{M_{0i}}$ =2. Threshold T_k is obtained experimentally as T={0.45,0.52,0.5,0.3}. In AQL, each band needs one extra bit (0 or 1) to illustrate the quantization information.

QCIF sequences are employed in our experiments (at 30 frames per second) with even frames encoded as key frames using H.264 reference software JM16.2. Compared to the quantization algorithm in [1], AQL can result in PSNR performance improvements up to 0.8dB. Sample reconstructed frames have also been tested to find that even with fewer bits, AQL can bring about the same or even higher PSNR without visual quality degradation when compared to the quantization method in [1].

[1] C. Brites, J. Ascenso and F. Pereira, "Improving transform domain Wyner-Ziv video coding performance," IEEE International Conference on Acoustics, Speech and Signal Processing, 2006, pp. II-525 – II-528.

0	1	5	6
2	4	7	12
3	8	11	13
9	10	14	15

DCT subbands

16	8	0	0
8	0	0	0
0	0	0	0
0	0	0	0

Q_0

32	8	2	0
8	2	0	0
2	0	0	0
0	0	0	0

Q_1

32	16	2	0
16	2	0	0
2	0	0	0
0	0	0	0

Q_2

64	16	8	2
16	8	2	0
8	2	0	0
2	0	0	0

Q_3

64	32	8	2
32	8	2	0
8	2	0	0
2	0	0	0

Q_4

64	32	8	4
32	8	4	2
8	4	2	0
4	2	0	0

Q_5

64	32	16	8
32	16	8	2
16	8	2	0
8	2	0	0

Q_6

128	64	32	16
64	32	16	8
32	16	8	2
16	8	2	0

Q_7

Fig.1 Basic quantization matrices proposed in AQL

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