영상 부호화를 위한 주파수 적응형 경판정 양자화

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Frequency Adaptive Hard-Decision Quantization for Video Coding

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요 약

In this paper, we propose a frequency location adaptive hard-decision quantization (HDQ) scheme for video coding. A threshold for zero quantized level is adaptively applied to unquantized transform coefficients based on its frequency location in the transform domain. The proposed method achieves an average of 1.13%, 1.57%, and 1.53% of bit-rate reduction in BDBR sense compared to the conventional HDQ scheme respectively in Y, Cb, and Cr under the all intra encoding configuration.

1. Introduction

As more various video applications start to deal with high-resolution video contents, even more advanced video compression techniques are highly on demand. The newly standardized video coding technology, High Efficiency Video Coding (HEVC) [1] can achieve approximately 50% more bit-rate reduction while maintaining similar or even higher visual quality compared to its predecessor H.264/AVC [2]. Moreover, a future video coding standard known as VVC(Versatile Video Coding) is being developed to provide even higher compression performance than HEVC. In video coding, quantization is one of the most essential parts for lossy compression. HEVC supports a soft-decision quantization scheme, namely, rate-distortion optimized quantization (RDOQ) instead of the conventional hard-decision quantization (HDQ) scheme. RDOQ is known to significantly improve the quantization performance. However, complexity of the encoding process is dramatically increased because RDOQ requires huge computation to decide the optimal quantized level for each transform coefficient. Thus, it is still very meaningful to develop an improved HDQ scheme which can give similar coding performance as RDOQ but at a much low complexity.

In this paper, we investigate an adaptive HDQ scheme considering the property of each transform coefficient at different frequency location. A zero quantized threshold are given differently for transform coefficients based on its frequency location in the transform domain. This study is done for HEVC using its reference software.

2. HDQ Scheme

The scalar quantizer with a dead-zone is simply used to calculate the quantization level in conventional HDQ scheme. The scalar quantized level l_{SQ} is calculated as the following equation:

$$l_{SQ} = \left\lfloor \frac{|c|}{\Delta q} + \theta \right\rfloor, \qquad (1)$$

where c denotes the unquantized coefficient after transform and Δq is the quantization step size. θ is a quantization round offset that controls the dead-zone size. A value 1/3 is used for θ in I slices and 1/6 is used in P and B slices.

3. Frequency Location Adaptive HDQ

Because of the energy compaction property of the DCT transform, the coefficients have much larger magnitudes in the low frequency than in high frequency after the transform. It means that it is not the best to have same quantization

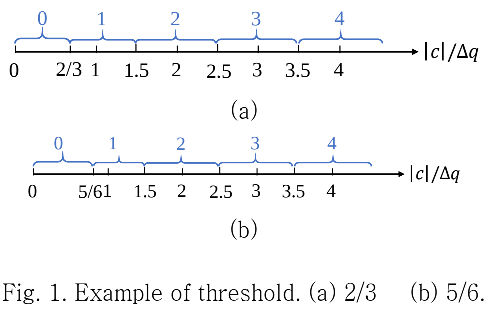

Fig. 1. Example of threshold. (a) 2/3 (b) 5/6.

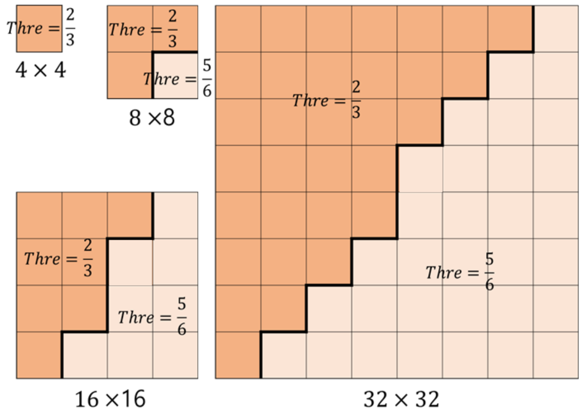

Fig. 2. Threshold assignment at different frequency locations for each TB size.

method for transform coefficient in each different frequency location.

In the entropy coding perspective, having more zero levels at high frequency locations can lead to significant bit-rate saving since the levels are scanned in an inverse scan order, that is, from bottom right to top left, of every transform block (TB). Motivated by this, we suggest to force more transform coefficients quantized to zero at high frequency locations by applying an offset at the dead-zone region to control the range of the transform coefficient values that will be quantized to zero. Except for the dead-zone region, the quantization round offset θ is chosen to be 1/2 in order to achieve the lowest distortion caused by the quantization process. Fig. 1 shows an example of the proposed thresholds 2/3 and 5/6. All the transform coefficients having $|c|/\Delta$ smaller than the threshold will be zero after quantization.

In order to have more zeros after quantization at the high frequency locations, we suggest applying the threshold with a value 5/6. In the contrast, 2/3 is used as a smaller threshold for the transform coefficients at low frequency locations. Fig. 2 show the threshold assignment at different frequency locations for each TB size in a graph format. The small square blocks represents the coefficient groups which always have the size of 4×4.

4. Experimental Results

To evaluate the performance of the proposed frequency location-adaptive HDQ scheme, experiments are carried out using HEVC reference software HM 16.15 [3] with RDOQ tool disabled (RDOQ-Off). Three sequences from class B are tested under the all intra encoding configuration (AI-Main) with four different QP values (22, 27, 32, and 37) following the JVET common test condition [4]. To compare the performance of the proposed HDQ scheme, we choose to use the original HM 16.15 with the conventional HDQ (with RDOQ tool turned off) as the anchor. The Bjontegaard Delta Bit-Rate (BDBR) is utilized to evaluate the coding performance of the proposed method against the anchor.

Table 1. BDBR (%) Comparison of the Proposed Method with Anchor (AI-Main)

Sequences		Y	Cb	Cr
Class B	Kimono	-2.02	-0.86	-0.36
	BasketballDrive	-0.74	-2.73	-3.23
	BQTerrace	-0.64	-1.11	-1.01
Average		**-1.13**	**-1.57**	**-1.53**

The BDBR performance comparison is shown in Table 1 in which we can see that the proposed adaptive scalar quantization scheme achieves 1.13%, 1.57%, and 1.53% bit-rate reduction in the BDBR sense under all intra encoding configuration for Y, Cb, and Cr channel, respectively.

4. Conclusion

A frequency location adaptive HDQ scheme for video coding is addressed in this paper. The proposed HDQ scheme adaptively assigns the dead-zone threshold based on the frequency location of each transform coefficient inside a transform block. The experiments are done on top of HEVC reference software HM 16.15, and the test results illustrate that out proposed frequency location adaptive HDQ scheme can provide -1.13%, -1.57%, and -1.53% gain in BDBR for Y, Cb, and Cr channel, respectively under all intra encoding configuration.

Acknowledgments

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