I-033

Inter TU size early determination in HEVC for 8K video

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Summery

The up-to-date video standard, High Efficiency Video Coding (HEVC) supports 8K UHD (4320p). It is a digital video format approved by the ITU-T and ISO/IEC. However, the complexity issues such as variable transform unit (TU) size in HEVC limit the development of both software and hardware video encoder engine. By considering the increasing difficulties for 8K UHD, this paper analyses the 8K video feature from residue and frequency aspects. Meanwhile, the performances differences are illustrated by comparing the proposed algorithm in inter TU size early determination for HEVC, which compared the same video contents in 8K with HD 10bit format. The conclusion is made from the experiment that image quality is guaranteed with the sacrifice of the computational complexity.

Introduction

By adding transform unit, HEVC obtains encoding gains with increased computation complexity [1]. In order to solve this problem, one of the practical schemes [2] proposes an early termination scheme to prune the transform and quantization quadtree. The main ideas of the proposed inter TU size early determination (ITSED) is summarized as follows: 1. the proposal is based on the all zero block (AZB) detection, which detects the to-be-all-zeroed transformed quantized coefficients in the premier residue stage. Therefore, to find the upper SAD limit of the threshold is the main target. 2. The proposal assumes that small residue should not be split into smaller TUs. In these cases, the TU size keeps the same with CU size. Therefore, before entering each TU split loop, the corresponding thresholds are checked under different quantization parameters (QP). Only if the SAD of current block is bigger than the threshold, the TU split encoding is made.

The threshold derivation [2] [3] follows an inverse process of T&Q calculation. First, if the absolute value of all transformed and quantized coefficients is smaller than 1, the input of quantization, transformed coefficients, is limited in a certain range of the corresponding QP. Moreover, the transformed coefficients and the input residues are modeled as Gaussian distribution. By calculating the variance between two Gaussian models, the relationship between sum of absolute difference (SAD) and threshold is constructed. If the SAD is smaller than the threshold, the current block does not calculate the TU split loop.

Proposed inter TU size early determination for HEVC for 8K utilization

By examining the threshold derivation above, it can be discovered that for 8K processing, nothing is changed except the characteristics of UHD images. Therefore, the residue analyses are made for discovering the feature difference between 8K and HD for same video contents. The corresponding HD video contents are generated by bicubic sharper filtering.

Residue analysis comparisons of 8K and HD

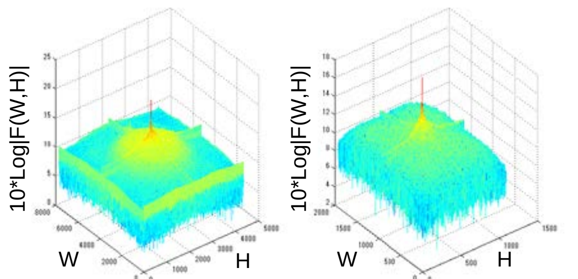

Figure 1. Residue frequency analysis comparison of 8K and HD

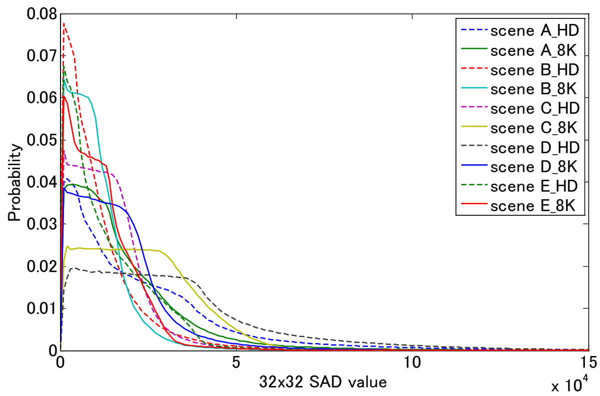

Figure 2. Real residue probability distribution

Fig. 1 shows that high frequency component is more abundant in 8K for same contents. It illustrates that the modeling between the residue and the transformed coefficients should be adjusted for UHD to some extent. In Fig.2, the broken lines which represent HD are outside the corresponding solid lines for the same contents. It means that 8K residue and transform modeling has a better convergence compared with HD modeling, in other words, for the small SAD value the probability of 8K is bigger than HD. Therefore, the threshold for early TU termination should be bigger in 8K for the same contents.

Adjustment factor for 8K utilization

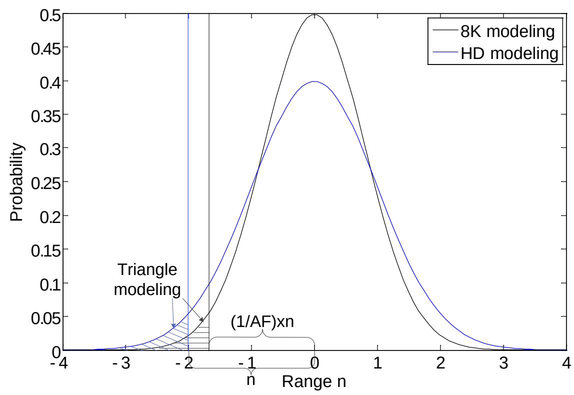

Figure 3. Gaussian modeling comparison between 8K and HD

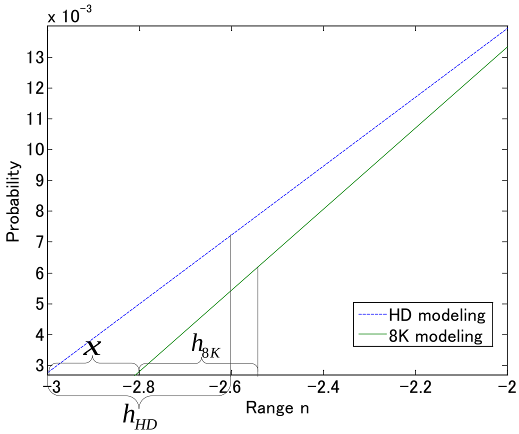

Figure 4. Triangle modeling for adjustment factor calculation

Based on the instruction of the real residue probability distribution, Fig.3 displays the general view of Gaussian modeling comparison between 8K and HD. Where, the horizontal axis represents the range n factor, the vertical axis represents the probability value. From the assumption of ITSED, the target area is marked by the shadow. For simplification, the target area is modeled as triangle area shown as Fig.4. In order to keep the same accuracy for a certain video content, the AZB detection accuracy (DA) should keep the same by using adjustment factor (AF).

$$TH_{8K} = AF \times TH_{HD} \tag{1}$$

$$DA = \frac{AZBNumber_{total} - AZBNumber_{false}}{AZBNumber_{total}} \tag{2}$$

$$PA_{HD} = \frac{1}{2}\tan\theta_1 \times h_{HD}^{\ 2} \tag{3}$$

$$PA_{8K} = \frac{1}{2}\tan\theta_2 \times h_{8K}^{\ 2} \tag{4}$$

TH_{HD} is the threshold which is set for HD contents in ITSED. TH_{8K} is the target threshold after adjustment for 8K utilization. $AZBNumber_{total}$ is the total number of the real AZB. $AZBNumber_{false}$ is the number of false detected AZB. θ_1, θ_2 is the angle of the HD and 8K probability line with horizontal axis, and h_{HD}, h_{8K} is the bottom length of the target triangle area, respectively. Assume that $\theta_1 \approx \theta_2$, the probability area (PA) ratio between 8K and HD is calculated as formula (5). Therefore, the AF is obtained as (6) and calculated as Table1. From Table 1, in most cases, AF is bigger than 1, which confirms the observation in Fig.2.

$$\frac{h_{8K}}{h_{HD}} = \sqrt{\frac{PA_{8K}}{PA_{HD}}} = p \tag{5}$$

$$AF = \frac{1}{1 - \dfrac{p \times h_{HD} + x - h_{HD}}{n}} \tag{6}$$

Table1 Calculated Adjustment Factors

contents	scene A	scene B	scene C
AF	1.01	1.18	2.01
contents	scene D	scene E	Average
AF	0.84	1.52	1.31

Evaluations

The proposed algorithm is implemented in HM 12.1 software and tested under the random access default configuration. NHK Super Hi-Vision sequences are used for 8K contents. For the video compression performance, BD bitrate (BDBR) [4] is employed, which is the average difference in the bit rate between the proposed algorithm and the default HM respectively, to measure video quality as Table.2 shows. The total encoding time reduction (TR) is calculated as below:

$$TR = \frac{TIME_{HEVC} - TIME_{proposal}}{TIME_{HEVC}} \times 100\% \tag{8}$$

At the beginning, the performance of the existing proposal without AF (AF=1) is tested. In this case, although the BDBR-Y makes almost no difference with HM, HD achieves 4% TR averagely, however, 8K obtains only 0.39% TR averagely. Therefore, the threshold adjustment becomes a must. The average AF (AF=1.3) and the biggest AF (AF=2) in Table 1 are then checked here. Compared with the biggest AF, by adjusting the threshold with the average AF, the encoding performance of 8K is increased, and also the time reduction can be achieved with larger AF.

Table 2 Performance comparison (%)

contents		AF=1.3		AF=2	
		8K	HD	8K	HD
BDBR-Y	scene A	-0.5	0.0	0.0	0.1
	scene B	0.0	0.0	0.1	0.1
	scene C	0.0	0.0	0.0	0.1
	scene D	0.0	0.1	0.1	0.0
	scene E	0.0	0.0	-0.1	0.0
	Average	-0.1	0.02	0.02	0.1
TR	scene A	6.33	0.97	10.22	0.98
	scene B	7.61	7.39	11.39	6.81
	scene C	3.98	8.21	7.22	11.45
	scene D	5.81	5.91	9.89	8.90
	scene E	7.64	8.62	11.71	8.86
	Average	6.28	6.22	10.08	7.40

Conclusion

This paper makes adjustment to utilize a fast quadtree based transform and quantization early termination algorithm to 8K video contents. It mainly consists of two contributions. First, residue analysis comparisons of 8K and HD have been made for same video contents. Second, the adjustment scheme for 8K video is proposed.

References

[1] B. Bross et al “High Efficiency Video Coding (HEVC) text specification draft 7,” JCTVC-I1003, 27 April – 7 May 2012.
[2] Jia Su, Takayuki Onishi, Mitsuo Ikeda, Atsushi Shimizu, “Inter TU partition early termination for HEVC”, PCSJ2013, Nov.6-8
[3] Jia Su, Koyo Nitta, Mitsuo Ikeda, Atsushi Shimizu: “Residue role assignment based transform partition predetermination on HEVC”, ICIP 2013: 2019-2023.
[4] G. Bjøntegaard, “Improvements of the BD-PSNR model”, VCEG-AI11, ITU-T SG16 Q.6, 35th VCEG meeting, July 2008.