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3D-HEVC におけるイントラデプスマップの方向性残差信号符号化方式
Angular-based Residual Signal Coding of Intra Depth Map in 3D-HEVC

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Abstract

Coding of depth map data in 3D-HEVC utilizes depth look-up table (DLT) to reduce the residual signal of depth map. The resulting table is then utilized to quantize depth residual data for each of coding units during coding process, thus additional time consumption becomes necessary. To overcome this problem, we propose a method of complementing the DLT with comparable arithmetic function by mapping the residual data in intra mode into two nonzero integer signals according to the area of the prediction mode of the current depth block. Experiment results in HTM10.0 provide BD-rate gain up to 0.03% and running time reduction up to 3%.

1. Introduction

A new video coding standard aims for delivering video with resolution of 4K and beyond have been finalized. The new standard, namely the HEVC (High Efficiency Video Coding), provides technical specification of coding high resolution video with crystal-clear image quality but maintain the low bitrate [1]. Furthermore, the utilization of HEVC in software as well as in hardware has started to grow and make possible for HEVC-capable end-user devices.

Stereoscopic and multi-view devices are the examples of popular end-user devices that let users to experience video beyond 2D. In conjunction with HEVC, to enable such video to be consumed in high resolution, an extension of HEVC for stereoscopic and multi-view video coding has also been developed. The currently developed standards are 3D-HEVC for stereoscopic video coding and MV-HEVC for multi-view video coding, both based on HEVC.

Fig. 1. Depth data (left) and its corresponding video data from *Poznan_Street* sequence.

In 3D-HEVC the process is started by encoding the base video, followed by the depth data [2] which is necessary for 3D image. As shown in Fig. 1, because the depth data is less complex than video data, the coding of depth data requires tools that are developed to reduce the complexity of the coding algorithm by removing unnecessary procedures for depth data. Depth Lookup Table (DLT) is one of the depth coding tools that quantize the depth data to reduce its residual signal.

The main idea of the proposed method in this paper aims for reducing the time consumption that can be caused from using the DLT. To quantize depth residual data for each of coding units, reading the DLT in the memory and then return the mapped data is expected to be considerably time consuming. The brief introduction to DLT is provided in Section 2, the detailed description of the proposed method is provided in Section 3 while the experiment results are presented in Section 4. Section 5 concludes this paper.

2. Depth Lookup Table

Depth look-up table (DLT) is a coding tool developed in 3D-HEVC standard to reduce the amount of bits in the residual signal of depth map. The DLT is constructed in the encoding process based on the spatial structure of the depth map [2]. The DLT is performed when the full available depth range is not utilized, which is valid for most of JCT-3V 3DV test sequences [3]. In straightforward, more complex depth map increases the data allocated in the DLT.

The DLT is constructed before the encoding process of a frame by mapping all depth data values into a set of indexed depth value. This data set, the lookup table, is then stored in picture parameter set (PPS) and then entropy coded along with the media data into a bitstream. In the decoding process, the DLT is obtained by decoding the PPS and remap the decoded depth residue data to finally obtain the reconstructed depth data.

Originally, the DLT is utilized for segment-wise depth coding (SDC), in which the depth residual data is coded without transform and quantization process [2]. However, at the development stage of 3D-HEVC which is implemented in the HTM 10.0 reference software [4], the DLT was also implemented in conventional intra depth coding. Here, the residual signal is calculated as the difference between the original and the prediction data which are mapped into the DLT. However, this calculation is only implemented when the selected prediction mode is DC mode, horizontal mode, and vertical mode. The calculation of residual data for the remaining prediction modes are performed in conventional scheme (i.e. no DLT).

3. Proposed method

Considering that the current DLT consumes computation time usage for each residual depth data, the proposed method aims for simplification of the aforementioned procedure in the HTM 10.0 by two approaches: firstly, the DLT is complemented by simple quantization of residual data using bit-shift operation; and secondly, the operation is performed for all intra prediction modes. The proposed quantization for calculating residual data is based on an assumption that a residual data predicted from a far-located prediction block (which can be determined from the angle of the prediction mode) may have less correlation with the depth data in the current block compared to a residual data that is predicted from a nearby prediction block .

In intra coding, the block partition to be coded is predicted from the previously coded block in the same frame. Based on the rate distortion cost calculation between the current block and each of blocks in the prediction mode, the prediction block with the smallest cost is selected as the reference. HEVC standard specifies 34 angular intra prediction modes available which values are ranging from -32 to +32 for both vertical and horizontal direction [5].

Fig. 2 shows the illustration of the lookup bins that are used to map the depth residual data according to the prediction mode selected for the block. The index m = {0, 1, 2, 3} is determined as the area of block in which prediction modes are within the ranges of [V-32, V-2], [V+2, V+32], [H-2, H-26], and [H+32, H+2] respectively, as shown in Fig 2. In case of DC mode, the angular prediction is assumed to be none, thus the depth residual data mapping is not performed.

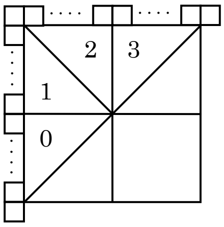

Fig.2. Illustration of angular-based lookup bins employed in the proposed method.

Based on the selected prediction mode of the current intra coding block, residual data is mapped by quantization function Q based on the bit-shift operation which is determined as

$$Q(r)\begin{cases} r>>1, & m=0 \quad or \quad m=3 \\ r>>0, & m=1 \quad or \quad m=2 \end{cases} \qquad (1)$$

where r is the depth residual data and m is the index of lookup bins of the intra prediction modes.

By quantization of Eq. (1), the depth residual data is mapped into either its original value or less, dependent on its correlation with the predicted block according to the selected mode. The more blocks predicted with their less related block (i.e. with index m of 0 or 3), the more residual depth data will be quantized.

4. Experiments results

The proposed method was implemented in HEVC reference software, the HEVC test model (HTM) 10.0, while the experiments were conducted for common test conditions [6]. Table I shows the percentage of BD-rate against the HTM 10.0 anchor. Table I also show the percentage of coding time and synthesized view rendering time ratio from the anchor.

As shown in Table I, the proposed method has performed quite well especially for the sequences with smaller resolutions. By removing the step of reading the DLT in the memory, obtain the corresponding index, and return the mapped residual data, around 2~3% of coding time can be saved in the proposed method. Note that sequences *GT_Fly*, *Poznan_Street* and *Undo_Dancer* are not affected by the quantization of depth residual data. Nevertheless, the reduction of average coding time still can be achieved and no coding loss is reported for those sequences.

In terms of coding gain, up to 0.036% BD-rate in average can be achieved for video PSNR against video + depth bitrate. Since the proposed method is conducted in depth map coding, it does not significantly affect the BD-rate in video data and almost no coding loss is reported.. Note that since a BD-rate of synthesized degradation becomes large whenever there is no subjective loss, degradation in column (3) of Table I for some sequences can be neglected.

Table I. Experimental results

Sequences	**BD-rate (%)**			**Time ratio (%)**		
	(1)	**(2)**	**(3)**	**encoding**	**decoding**	**rendering**
Balloons	0.004	-0.038	0.253	98.626	100.212	94.538
Kendo	-0.004	-0.114	0.023	99.679	98.559	95.119
Newspaper	-0.042	-0.094	0.179	97.968	96.533	94.082
GT_Fly	0.000	0.000	0.044	97.977	91.151	90.112
Poznan_Hall2	0.015	-0.006	-0.108	97.887	99.715	96.065
Poznan_Street	0.000	0.000	0.088	99.100	100.599	91.750
Undo_Dancer	0.000	0.000	0.042	97.416	95.919	88.740
1024x768	-0.014	-0.082	0.152	98.758	98.435	94.580
1920x1088	0.004	-0.001	0.017	98.095	96.846	91.667
Average	**-0.004**	**-0.036**	**0.074**	**98.379**	**97.527**	**92.915**

(1) Video PSNR vs video bitrate

(2) Video PSNR vs video + depth bitrate

(3) Synthesized video PSNR vs video + depth bitrate

5. Conclusions

In this paper we presented the method of calculating residual data in intra depth map coding by complementing DLT with comparable arithmetic function to reduce coding time consumption. The arithmetic function provides bit-rate distortion-rate gain up to 0.03% and reduces coding time as shown in experiments results.

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References

[1] K. Müller, et al., “3D High-Efficiency Video Coding for Multi-View Video and Depth Data,” IEEE Transaction on Image Processing, Vol. 22, No. 9 (2013).

[2] Y. Chen, et al., “Test Model 8 of 3D-HEVC and MV-HEVC,” JCT-3V H1003 (2014).

[3] F. Jäger, “Simplified depth map intra coding with an optional depth lookup table,” IEEE International Conference on 3D Imaging, pp. 1-4, (2012).

[4] Reference software for HEVC, HEVC Test Model (HTM) 10.0 https://hevc.hhi.fraunhofer.de/svn/svn_3DVCSoftware/tags/HTM-10.0/

[5] K. Ugur, “Angular intra prediction in High Efficiency Video Coding (HEVC),” IEEE 13th International Workshop on Multimedia Signal Processing, pp. 1-5 (2011).

[6] D. Rusanovskyy, K. Müller, and A.Vetro, “Common Test Conditions of 3DV Core Experiments,” JCT-3V F1100 (2013).

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