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Low complexity Bi-Partition mode selection for 3D video depth intra coding

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ABSTRACT

This paper proposes a fast mode decision algorithm for 3D High Efficiency Video Coding (3D-HEVC) depth intra coding. In the current 3D-HEVC design, it is observed that for most of the cases, full rate-distortion (RD) cost search of Bi-Partition mode could be skipped since most coding units (CUs) of depth map are very flat or smooth while Bi-Partition modes are designed for CUs with edge or sharp transition. Using the rough RD cost value calculated by HEVC Rough Mode Decision as a selection threshold, we propose a fast Bi-Partition modes selection algorithm to speed up the encoding process. The test result for the proposed fast algorithm reports a 34.4% encoding time saving with a 0.3% bitrate increase on synthesized views for the All-Intra test case and negligible impact under the random access test case. Moreover, by simply varying the selection threshold, we can make a tradeoff between encoding time saving and bitrate loss based on the requirement of different applications.

1. Introduction

With the rapid growing in the three dimensional video market in recent years, research in this field has also been intensified in all areas, from 3D video capture to the 3D display technology. This also includes novel 3D video coding methods for efficient compression and transmission [1].

As the next generation video coding standard, High Efficiency Video Coding (HEVC) achieves superior bitrate and quality performance compared with that of the H.264/MPEG-4 AVC standard. Alluded by the growing 3D video market, Joint Collaborative Team on 3D Video Coding Extension Development (JCT-3V), formed by the ISO/IEC MPEG and the ITU-T VCEG, started the work on developing a new extension, 3D-HEVC, for better 3D video delivery compared with previous generation of depth-based 3D video coding technology [2,4].

We use Fig. 1 [5] to show the fundamental architecture of the 3D-HEVC based coding system. In general, the input signal for the encoder consists of multiple views, associated depth maps, and corresponding camera parameters. Then a 3D video encoder, which represents an extension of HEVC, is used to code the input signal. In this step, the base view is coded using an unchanged HEVC encoder, while the dependent views are coded with new tools developed for 3D-HEVC extension. If the bitstream is decoded using a 3D video decoder, the input videos, the associated depth data, and camera parameters are reconstructed with the given fidelity. To display the 3D content on an auto-stereoscopic display, depth-image-based rendering (DIBR) [3] algorithm is used to generate additional intermediate views. To display the 3D content on a conventional stereo display instead of to an auto-stereoscopic display, the view synthesizer can also generate a pair of stereo views, in case such a pair is not actually present in the bitstream.

Therefore, one of the key components in 3D-HEVC is depth map compression [5]. Depth maps mainly contain two types of areas: sharp edges (which represent object borders) and large areas of nearly constant or slowly varying sample values (which represent object areas) [16]. While the HEVC intra prediction and transform coding are well-suited for nearly constant or regular changing regions, it can result in significant coding artifacts at sharp edges, which are visible in synthesized views. For the coding of depth maps, the same concepts of intra-prediction, motion-compensated prediction, compensated prediction, and transform coding as for the coding of the video pictures are used. However, in contrast to natural video, depth maps are characterized by sharp edges and large regions with nearly constant values [5]. Accordingly, several new intra prediction modes, namely Depth Modeling Mode (DMM) [10] and Region Boundary Chain Coding Mode (RBC) [11], are added for intra depth frame coding. In all these modes, a depth block is approximated by a model that partitions the area of the block into two regions (usually

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0141-9382/

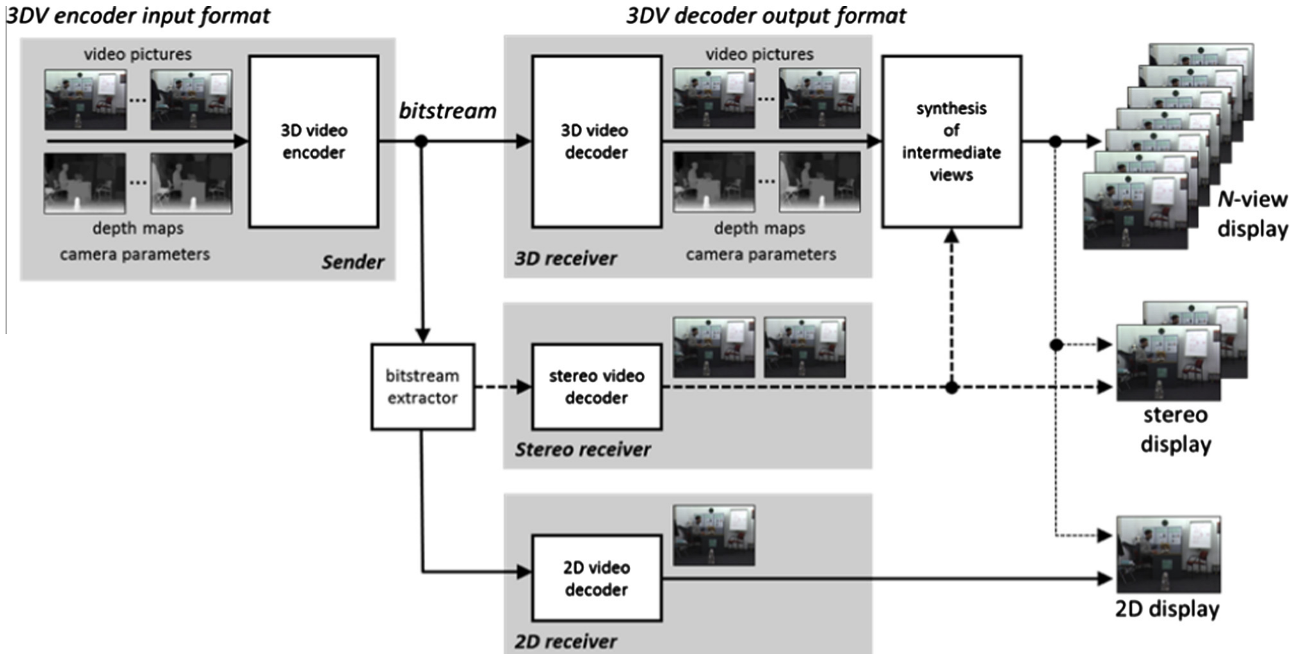

Fig. 1. Overview of the system structure and the data format for the transmission of 3D video [5].

non-rectangular). Therefore, these new modes are also named as Bi-Partition modes [8]. The information required for such a model consists of two elements, namely the partition information, specifying the region each sample belongs to, and the region value information, specifying a constant value for the samples of the corresponding region. The Bi-Partition modes are integrated as an alternative to the conventional intra prediction modes specified in HEVC. For these modes, a residual representing the difference between the approximation and the original depth signal can be transmitted via transform coding. In Ref. [5], it is reported that Bi-Partition modes show a bitrate reduction of up to 6% for intra depth frame coding and achieve a much better subjective quality for synthesized views.

In 3D-HEVC intra depth coding, the CU encoding process, which contains the partition size determination and prediction mode selection for each prediction unit (PU), involves large computational cost and plays a crucial role. This is also true for Bi-Partition modes selection since in the current 3D-HEVC model, all these new Bi-Partition modes are added to full-RD calculation list for mode selection which is very time-consuming.

Several fast depth intra coding algorithms [12,13,19,20] have been proposed to reduce the encoding complexity. In Ref. [12], irrational operations of DMM are analyzed and a simplified DMM Wedgelet Partition search method is proposed by using the correlations between the mode and Wedgelet Partition. Although significant encoding time is saved for several selected sequences, this method incurs very big BD-bitrate loss (1.6–5% according to different settings). In Ref. [13], a fast DMM selection algorithm is proposed depending on the first mode in full-RD cost calculation list. If the first mode in full-RD cost calculation list is not a planar mode, all the DMM modes are added to the full-RD cost calculation list. Otherwise, a full-RD cost calculation of DMM modes is skipped. In Ref. [13], a 27.8% encoding time saving was reported with only a 0.5% bitrate loss on synthesized views. However, the method proposed in Ref. [13] lacks of the flexibility of trading off between the bitrate loss and encoder speedup. In this paper, we propose a fast Bi-Partition mode selection algorithm to speed up encoding process by using RD cost value calculated in HEVC intra Rough Mode Decision as a threshold. Considerable encoding time saving is achieved with negligible performance loss. By varying the selection threshold, we can simply make a tradeoff between encoding time saving and bitrate loss based on the requirements of different applications.

The rest of the paper is organized as follows. In Section 2, the existing 3D-HEVC intra depth coding is introduced with a focus on Bi-Partition mode RD cost calculation. In Section 3, a fast Bi-Partition mode selection algorithm is proposed. Experiment results for both intra coding scenario are shown in Section 4. Section 5 concludes this paper.

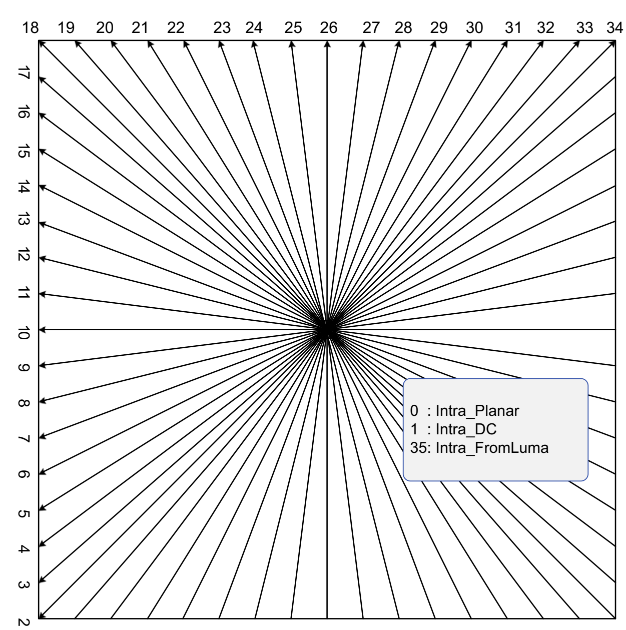

Fig. 2. Conventional HEVC intra prediction modes [18].