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An efficient depth modeling mode decision algorithm for 3D-HEVC depth map coding

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ABSTRACT

With the purpose of augmenting immersive perception, 3D video coding extension of High Efficiency Video Coding (3D-HEVC) standard is developed. This extension employs Multiview Video plus Depth (MVD) format in which immediate virtual view texture videos can be rendered by adjacent depth maps, so that bitrates and coding runtime of multiview video are saved. A good preservation of depth map is vital to synthesize high-quality virtual view texture videos. Hence, several new depth map coding tools have been introduced into 3D-HEVC, such as Depth Modeling Mode (DMM) decision. However, the numerous DMM candidates result in a huge computational complexity, which prevents 3D-HEVC for practical use. To this end, we propose an efficient DMM decision algorithm for 3D-HEVC depth map coding, which incorporates unnecessary depth blocks skipping approach and Contour pattern early termination method. Simulated experiment results state that the proposed efficient DMM decision method can save about 31.33% coding time on average with only 0.01 dB of PSNR drop and just 0.60% bitrate increase on average compared to the original 3D-HEVC encoder.

1. Introduction

With the popularity of 3D application, many 3D representation devices have been produced and 3D video services have been investigated in recent years [1,2]. 3D consumer market is increasingly populated by Virtual Reality (VR), Augmented Reality (AR) and Free Viewpoint Television (FTV). All of these stereoscopic displays can absolutely improve immersion for audiences. VR and AR are glasses-based systems, in which audience requires helmet. Different from them, FTV shows people 3D perception without any 3D glasses because it employs Multiview Video plus Depth map (MVD) format which can provide not only a stereo pair, but a multitude of views [3]. In the MVD format, a small number of videos are coded with corresponding depth maps and multiplexed into video bitstream. At the decoder side, texture video and depth data have been decoded and synthesized additional virtual views through using Depth-Image-Based Rendering (DIBR) [2,4]. For conventional single view video, High Efficiency Video Coding encoder (HEVC) is always selected [5]. Note that multiview texture videos in MVD format are encoded by the modified HEVC encoder (3D extension of HEVC, 3D-HEVC), which adds several new tools to perform inter-view and depth map coding [6].

The introduction of depth information contributes to low bitrate for multiview texture video, because additional intermediate views can be synthesized by depth map without extra bitrate, but it is not efficient to encode depth map using

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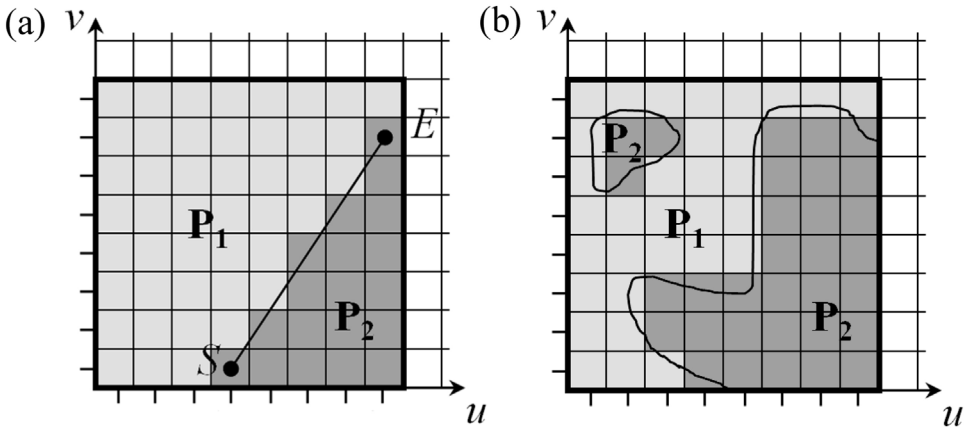

Fig. 1. (a) Wedgelet Pattern; (b) Contour Pattern.

conventional 3D-HEVC encoder. Depth map is characterized by large homogeneous regions and sharp edges, and there are totally two Depth Modelling Modes (DMMs), i.e., Wedgelet pattern and Contour pattern (shown as Fig. 1), and Region Boundary Chain coding (RBC) adopted in 3D-HEVC to preserve sharp edges for depth map. Among these depth map coding tools, each PU can be divided into two non-rectangle areas via DMMs and a Constant Partition Value (CPV) is encoded for each area. DMMs can decrease the distortion of sharp edges and improve the coding efficiency of depth map in 3D-HEVC through matching the numerous candidates one by one. However, these candidates require full Rate-Distortion (RD) cost computation that brings in a huge computational complexity, which obstruct 3D-HEVC for real-time application. Therefore, it is necessary to propose an efficient DMM decision algorithm that can reduce the computational complexity of DMM while keeping the same performance as original 3D-HEVC encoder.

The remaining parts of this paper are organized as follows. Section 2 introduces the related works about current DMM decision algorithms for 3D-HEVC standard. Section 3 represents the proposed an efficient DMM decision algorithm and the experiment results analysis are showed in Section 4. Finally, this paper is concluded in Section 5.

2. The related works about DMM decision

Recently, several fast algorithms have been proposed for 3D-HEVC depth map intra prediction, and we summarize and analyze them as follows. A space exploration over gradient-based algorithm is presented in Ref. [7]. It designs four filters to detect the optimal positions of DMM1 and reduce the coding time of 3D-HEVC. An efficient depth map coding algorithm which is proposed in Ref. [8] takes use of the depth perception sensitivity of humans to skip some unnecessary depth blocks based on Just Noticeable Depth Difference modeling. Ref. [9] proposes a fast depth map intra mode decision algorithm based on content that classifies the spatial distribution of the reference pixels. A down-sampling approach is raised in Ref. [10] that reduces the number of Wedgelet patterns in DMM lookup table. In Ref. [11] an efficient depth map intra mode decision algorithm is developed, and this method make full use of the Low Complexity Rate-Distortion Cost information in the rough mode decision. An efficient method for Wedgelet decision in DMM1 which is proposed in Ref. [12] checks the sharp edges position at first through pre-defined areas, and then decides the best Wedgelet pattern. A constrained depth modeling mode is presented in Ref. [13] based on explicit edge representation. An effective reference sample decision algorithm [14] is proposed to streamline the Constant Partition Value prediction that simplifies reference pixel selection process of 3D-HEVC encoder. A fast depth intra mode decision algorithm is raised in Ref. [15] that adaptively skips some unnecessary DMMs to reduce running time for 3D-HEVC encoder. Ref. [16] proposed a low complexity depth map coding algorithm that adopts depth map edge characteristics and early DMM decision skipping method. A low complexity intra mode decision algorithm is introduced in Ref. [17] that uses the depth map characteristics to reduce 3D-HEVC coding time.

Admittedly, these aforementioned approaches mainly research reducing the computational complexity of DMM decision rather than improving the coding performance for depth map prediction in 3D-HEVC and they either early terminate or omit some unnecessary DMMs decision. However, without combining these two schemes, DMM decision coding efficiency of these algorithms is still low as well as the intrinsic high computational complexity still obstructs 3D-HEVC encoder for real-time application. Therefore, it is essential to develop an efficient DMM decision algorithm for 3D-HEVC depth map coding that not only employs early terminating decision but adopts skipping unnecessary modes decision.