Optik 167 (2018) 136–143

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Fast intra coding based on online learning for high efficiency video coding

Yu Lu [a,b,*], Huaping Liu [b], Yameng Lin [a], Yingbiao Yao [a], Haibing Yin [a]

[a] School of Communication Engineering, Hangzhou Dianzi University, Hangzhou 310018, China
[b] School of Electrical Engineering and Computer Science, Oregon State University, Corvallis, OR 97331, United States

ARTICLE INFO

Article history:
Received 30 April 2017
Received in revised form 25 February 2018
Accepted 10 April 2018

Keywords:
HEVC intra coding
Coding unit
Poisson probability distribution
Online learning
Rate distortion cost

ABSTRACT

The state-of-art high efficiency video coding (HEVC) standard attracts much attention as its excellent performances in video compression in recent years. However the inherent coding complexity of HEVC makes it difficult for real-time application. A fast algorithm for HEVC intra coding based on online learning is proposed in this paper. During learning coding, the partition threshold of coding unit (CU) is obtained by learning the random sample set which conforms to Poisson probability distribution. Meanwhile the threshold of rate distortion cost is also obtained by online learning. After that, the acquired thresholds are used for early skip of CU depth or early termination of CU partition in the stage of fast coding. Anchoring the HM16 test model, the proposed algorithm achieves an important improvement of average time-saving 46.02%. In addition, it is also demonstrated that the proposed algorithm gains higher time efficiency when video sequence is encoded with higher compression efficiency.

1. Introduction

It is well known that High Efficiency Video Coding (HEVC) standard is a state-of-art video coding standard [1]. It is developed by the Joint Collaborate Team on Video Coding(JCT-VC) which consists of the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG). Compared with the previous H.264/AVC video standard, HEVC achieves 50% bit-rate coding gains while maintains the similar decoding quality. However, the increased intra prediction modes and flexible coding unit (CU) structure in the intra coding add heavy computational complexity to HEVC [2]. Plenty of fast coding algorithms have been proposed to solve the problem. Some methods are proposed to skip unnecessary CU depth decision. For example in Ref. [3], the texture direction of current CU is decided by the variance of image block, which is used to early finish CU partition. In Ref. [4], a fast CU size decision algorithm is implemented by early determination of CU partition according to texture similarities and bypass method for large CU size based on adjoining CUs. Analogously in Ref. [5], based on exhaust statistical analysis of CU size decision for different videos, the coding texture characteristics detected by Sobel edge operator are utilized to accelerated the intra coding. And in Ref. [6], the HEVC coding complexity is reduced by exploiting the spatial and temporal clues in previous frames to predict the current coding mode and skip trivial CU partition mode. Other algorithms intend to simplify intra prediction mode selection. Such as in Ref. [7], we use the dominant edge assent to simplify the rough mode decision so that the intra coding is accelerated. Furthermore, we

* Corresponding author at: School of Communication Engineering, Hangzhou Dianzi University, Hangzhou 310018, China.
E-mail address: leveny@163.com (Y. Lu).

https://doi.org/10.1016/j.ijleo.2018.04.044
0030-4026/

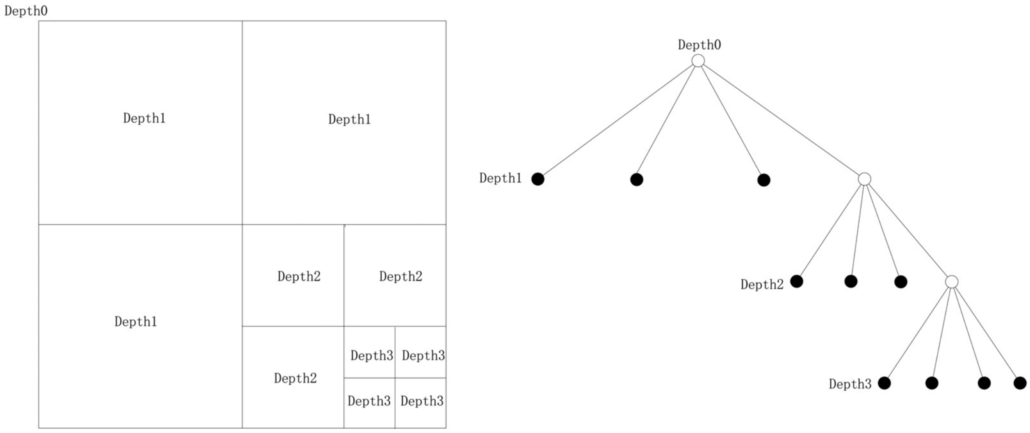

Fig. 1. CU recursive quad-tree structure in HEVC.

present another optimized method in Ref. [8]. The features of coded video are described by the dominant edge assent and its probability distribution, which can accelerate CU partition and prediction mode as well as edge offset class decision. In Ref. [9], a two-step rough mode decision based on the sum of absolute difference and absolute Hadamard transformed difference is applied to simplify the intra mode selection. In Ref. [10], the quantity of uncorrelated prediction directions are decreased according to the texture features of CU. In Ref. [11], the number of prediction modes are decreased in rough mode decision during rate distortion optimization (RDO) process. In Ref. [12], based on the texture characteristic of CU, the relation between the costs of two candidate modes are exploited to enhance the coding efficiency. On the whole, most of the above algorithms use preprocessing procedures including statistical analysis or offline training to acquire necessary parameters for further fast coding.

Different from these algorithms, we propose an fast HEVC intra coding algorithm in this paper. The coding thresholds are obtained by online learning in the first two frames of each frame set, which can be used in the following fast coding frames. The remaining of this paper is organized as follows. In Section 2, the related background and motivation related to our paper is introduced. Then the proposed algorithm is specified in Section 3. The experimental results and analysis are illustrated in Section 4. Finally the conclusions are drawn in Section 5.

2. Related background

In HEVC, each frame is split into a set of slices, which are parts of the frame that can be independently decoded. A slice is composed of sequential coding tree unit(CTU). Each CTU can be divided into CU following a recursive quad-tree structure. CTU is the root of the coding tree. Starting from it, the largest coding unit (LCU) with size 64×64 can recursively be divided into four sub-CUs until the smallest coding unit (SCU) with size 8×8 [13], which is illustrated in Fig. 1. This flexible encoding structure allows large CUs are used for homogenous regions while small CUs for heterogeneous regions.

After CU partition, each CU is split into prediction unit (PU) at the prediction stage. PU is the basic unit involved in intra prediction. It is defined as a region with diverse prediction information. In HEVC intra coding, each CU has one associated PU with the same size except SCU. There are two possible PU modes $2N \times 2N$ or $N \times N$ for a SCU while only $2N \times 2N$ PU mode for other CUs [14], which is shown in Fig. 2. The size of CU ranges from 64×64 to 8×8 while the size of PU for intra prediction ranges from 64×64 to 4×4. In other words, PU is equal to CU when the size of CU larger than 8×8 for the intra coding. In addition, 8×8 PU associated to the same size of CU can be further partitioned into 4×4 PU. To simplify the description in this paper, we assume that CU partition traverses from the size 64×64 to 4×4, which actually includes CU partition and its associated PU partition.

In order to obtain optimal CU partitioning, it evaluates all possibilities by the rate distortion optimization scheme until the smallest CU is reached. The optimal modes for CU and its related PU are selected by the rate distortion cost (RDcost) [15]. RDcost for current mode is calculated as:

$$J_m = SATD + \lambda \cdot R \tag{1}$$

where the sum of absolute transformed differences (*SATD*) denotes an accurate cost measurement. And $\lambda \cdot R$ is associated to the value of QP and the number of total bits during encoding, in which λ is the Lagrangian multiplier and R is the required quantity of bits to encode the prediction information. For a CTU, the RDcost of CU is calculated from 64×64 to 8×8 to select optimal CU mode. At first, the RDcost of 64×64 CU is calculated. And it is split into four 32×32 CUs whose individual RDcost is calculated. The similar processes continue until 8×8 CU. Then it starts the opposite operation for CUs ranging from 8×8 to 64×64. The sum of RDcost of four 8×8 CUs is calculated and compared to the RDcost of 16×16 CU. If the former is less than the latter, the 8×8 CU mode is selected. Otherwise the 16×16 CU mode is chosen. Then the sum of RDcost of four