Fast CU Algorithm and Complexity Control for HEVC

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Abstract — *The latest video compression standard HEVC provides the coding unit (CU), defined by quad-tree structures, to achieve high coding efficiency. Compared with previous standards, HEVC encoder increases much computational complexity to levels inappropriate for applications of power-constrained devices. This work thus proposes a fast CU algorithm to improve coding efficiency, and distributes the complexity to the CU layer. Experimental results show that the loss of average BD-PSNR is about 0.1 dB with BD-bitrate 2 % increment as the complexity was reduced to 60%.*

Keywords— *HEVC, complexity control, coding unit*

I. INTRODUCTION

Over past several years, mobile phones have become very popular in consumer electronics. Gradually, people are becoming accustomed to capturing or sharing videos on mobile devices, and the requirement for high-quality and real-time video is increasing. Heavy computations hinder video applications from power-constrained mobile devices. Therefore, it becomes crucial to reduce the complexity for video applications on mobile devices.

The newest video standard HEVC, finalized in 2013, supports better coding efficiency, in particular, for high resolutions of video content than previous standards [1]. HEVC employs quad-tree structures of the coding unit (CU), which increases the computational complexity than pervious standards.

Corrêa et al. adopted the information from the co-located area in the previous encoded frame to predict the coding-tree depths of current encoded CU [2]. Zhao et al. proposed a hierarchical structure to allocate different weighting of the complexity so that the CU depth could be controlled [3]. Zhang et al. created a feature, called motion collision count (MCC), to describe the relation between MV and CU depth, and then determined the number of CU-splitting from the CU depth for complexity control [4].

Some fast algorithms have been proposed for reducing the extent of searching for the optimal prediction unit (PU) located in the CU coding depth [5]. These algorithms can effectively reduce the complexity of the HEVC encoder but involve a slight sacrifice in the transmission quality.

Different to the method in [4], this work applies the MCC for the fast CU algorithm and complexity control in HEVC, separately. We first distribute complexity to the CU layer based on the calculated MCC. Then, the MCC is further applied to form a formula for the CU-depth splitting determination so that the coding efficiency can be improved.

This paper is organized as follows. Section II describes the proposed method for the complexity control and fast CU splitting algorithm. The experimental results are described in Section III. Finally, section IV provides a conclusion.

II. COMPLEXITY ALLOCATION AND FAST CU ALGORITHM

To efficiently control the complexity of HEVC encoder, a fast algorithm to speed CU splitting is required. Zhang et al. created the MCC to determine the number of CU-splitting from the CU depth for complexity control [3]. They recorded all the MVs and related partitions of PUs of the previous frame, and let these PUs move forward with the opposite direction and same distance of their MVs. The number of motion collisions for each CU in the current frame was counted. This number calls motion collision count (MCC).

MCC is applied in this work for the complexity allocation to each LCU in a frame. We assume that an LCU with a larger number of MCC is with a higher probability to be split into its sub-CU depths. Thus, the complexity of each LCU in each frame is allocated proportionally to its MCC value.

The MCC value of the second frame (p-frame) from each test sequence was measured. The relation between average MCC and QP is plotted in Fig. 1, where the average MCC is the MCC divided by total number of LCUs in a frame.

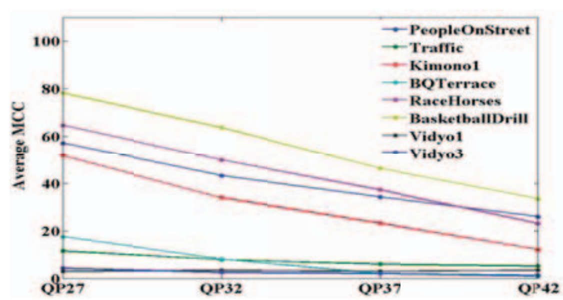

Fig. 1 Relation between average MCC and QP under different sequences

Fig. 1 shows that high motion sequences are with high average MCC values, and vice versus. Also, the average MCC increases as QP decreases. In other words, the MCC depends on sequence and QP. A threshold to determine the LCU depth-splitting can be calculated by (1),

$$T = \frac{MCC}{N}\left(1 - \frac{MCC}{100 \times N}\right) \tag{1}$$

where N is the LCU number in a frame. From Fig. 1, all the average MCC are less than 100, and thus this term $\frac{MCC}{100 \times N}$ is

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always less than 1. For high motion sequences or low QP, this value $(1-\frac{MCC}{100\times N})$ is small, and the threshold is reduced. That is, more LCUs can be split into depth 1. By contrast, for low motion sequence or high QP, the threshold is increased, and less LCUs are split into depth 1.

Table 1 lists the correctness for the LCU splitting into depth 1 under the high motion sequence RaceHorses and low the motion sequence Vidyo l. The average correctness is over 90%, which means (1) is applicable.

Table 1 LCU splitting based on proposed method

RaceHorses		Vidyo1	
QP	correctness	QP	correctness
27	0.98	27	0.96
32	0.96	32	0.98
37	0.93	37	0.90
42	0.94	42	0.90
Average	0.95	Average	0.93

The average MCC is also applied to allocate the complexity for each CU if this LCU has been split into depth 1. Four CUs in the depth 1 compose an LCU. The complexity distribution for each CU is proportional to its MCC. In other words, a CU with a large MCC can have more complexity. By contract, a CU with a small MCC may quickly terminate its encoder procedure

The MCC value is also applied to determine whether or not these CUs in depth 1 split into depth 2. The determination formula is similar to (1), except that *N* is replaced by the number of CUs in the depth 1. For the sake of simplicity, we don't control the complexity for the rest depths of CUs.

Finally, the complexity control is applied to the frame layer. Since a GOP (group of pictures) contains four frames. Frames in the same position of a GOP can be assigned the same complexity. A parabolic curve was applied to distribute the complexity to each frame under different QP settings [6]. The complexity control algorithm is plotted in Fig. 2.

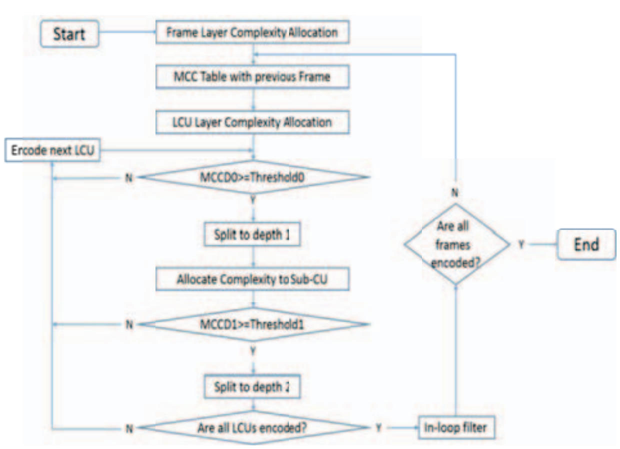

Fig. 2 The complexity control algorithm

III. EXPERIMENTAL RESULTS

Experiments were designed to show the rate-distortion (RD) performance under 80% or 60% of target complexity constraint. This work focused on the low-delay p-frame configuration in the HEVC encoder, and the reference software was HM 12.1 [7]. Experimental results are shown in Table 2. The loss of average BD-PSNR [8] is about 0.1 dB with BD-bitrate 2 % increment as the complexity downscales 60%. Low motion sequences have better RD performance than high motion sequences under complexity constraint.

Table 2 System performances under 80% and 60% of complexity constraint.

	Constraint	BD-BitRate(%)	BD-PSNR(dB)	ΔTime(%)
PeopleOnStreet 2560*1600	80	-0.277	0.014	20.53
	60	4.195	-0.198	39.83
Traffic 2560*1600	80	0.84	-0.032	19.56
	60	2.54	-0.095	39.57
Kimono1 1920*1080	80	-0.005	0.019	19.64
	60	0.003	-0.013	39.62
BQTerrace 1920*1080	80	0.049	-0.002	19.60
	60	1.024	-0.028	39.61
BasketnallDrill 832*480	80	-0.187	0.007	19.85
	60	2.977	-0.1180	39.84
RaceHorses 832*480	80	0.180	0.000	20.55
	60	4.631	-0.169	40.12
Vidyo1 1280*720	80	0.267	-0.01	19.83
	60	0.841	-0.036	39.83
Vidyo3 1280*720	80	0.026	0.001	19.63
	60	0.800	-0.032	39.60
Average	80	0.111	-0.00038	19.89
	60	2.126	-0.086	39.75

IV. CONCLUSION

This work proposes a complexity control mechanism for the HEVC encoder. We proposed a fast CU algorithm to improve the coding efficiency. Then, the complexity in the CU layer is well controlled under complexity constraints. In other words, with the proposed method, the HEVC can be more adequate for the application in the power-constrained device.

V. REFERENCE

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