Efficient Partial Decoding Algorithm for High Efficiency Video Coding

Do-Kyung Lee
Department of Electronics and Computer Engineering
Hanyang Universty
Seoul, Republic of Korea
dky1006@gmail.com

Jechang Jeong
Department of Electronics and Computer Engineering
Hanyang Universty
Seoul, Republic of Korea
jjeong@hanyang.ac.kr

***Abstract*— In this paper, we proposed efficient partial decoding algorithm for high efficiency video coding (HEVC). HEVC is the new video coding standard for next generation video industry. However, it needs massive memory and consumes battery power since the resolution of video sequences became larger. The goal of our approach is to reduce video resolution and memory size for mobile devices. Our algorithm is implemented to HEVC decoder. Experimental results show that the proposed algorithm can efficiently reduce video resolution during decoding process.**

Keywords- HEVC; Video codec; Partial decoding; Low resolution decoding.

I. INTRODUCTION

High efficiency video coding is the latest international video coding standard, which is established by Joint Collaborative Team in Video Coding (JCT-VC) consists of Video Coding Experts Group (VCEG) by ITU-T and Moving Picture Experts Group (MPEG) of ISO/IEC. HEVC achieves half bit-rate reduction compared with H.264/AVC and deals with various video sequence like Ultra High Definition (UHD), High Definition (HD), screen contents and video conferencing sequences. HEVC employs new technologies [2], for instance, quad-tree based block partitioning structure, 35 intra prediction direction, DCT-based interpolation filter for fractional inter prediction, sample adaptive offset (SAO). However, Decoded Picture Buffer (DPB) size and memory bandwidth of encoder and decoder of HEVC is dramatically increased caused by high resolution. In case of mobile devices, memory and battery capacity are very limited resources and important issue for both of customer and engineer. In low resolution decoding for high efficiency video coding (LRD) [3], for reducing battery consumption, authors proposed simple partial decoding algorithm for HEVC. The goal of LRD is to switch on low power decode mode when necessary to saving battery power. However, LRD is implemented only for the encoder and it is not concerned with decoder side. Also, using LRD algorithm, we cannot reduce actual video resolution.

In this paper, we propose partial decoding algorithm with resizing resolution of video sequences for HEVC decoder. In Section II, the conventional algorithm is briefly reviewed. The proposed algorithm is explained in Section III and experimental results and their discussion are presented in Section IV. Finally, we conclude our study in Section V.

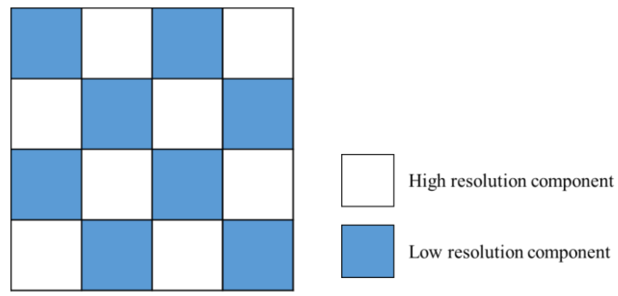

Figure 1. Decomposing image block in LRD

II. CONVENTIONAL ALGORITHM

In [3], authors proposed low power decode mode in HEVC. First, LRD decomposes a video sequence into two components, which are low resolution component (LR) and high resolution component (HR), as shown in Figure 1. When low power decode mode is switched on, only the low resolution component is decoded following LRD algorithm. Also, LRD employs lossless buffer compression algorithm [4] for additional data reduction using absolute moment block truncation.

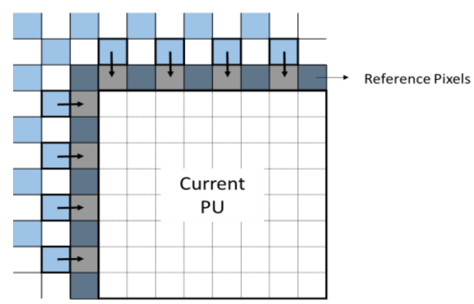

Figure 2. Direct pixel copy for intra prediction

Intra prediction is used to reduce spatial redundancy using high correlation between adjacent pixels. Reference pixels located upper and left of current block is utilized for predicting current pixels. When the low power decode mode is on, HR components do not exist in the reference pixels and it should be interpolated for decoding current Prediction

Unit (PU). The authors proposed the "direct pixel copy" method, which replaces missing pixels to nearby pixels, as shown in Figure 2. Missing HR components are substituted by its left LR pixels or upper LR pixels, which are already decoded for low resolution intra prediction. This method has the similar computational complexity for full decoding and it only need half computing power when the low power decode mode is switched on.

Motion Estimation (ME) and Motion Compensation (MC) using temporal correlation of video sequences are important part for video coding. To utilize MC module in HEVC with LRD, decoder should interpolate HR pixels in reference pictures, like intra prediction. LRD employs bilinear interpolation to keep original MC in HEVC. For full decoding, HR components are brought back from memory and, with LR components, full decoding can be successfully operated in LRD.

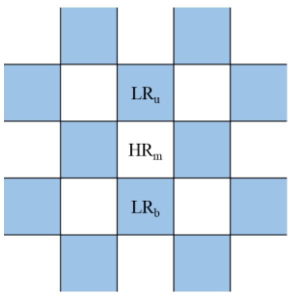

Figure 3. Pixel positions for bilinear filter

The authors proposed cascading structure for LRD de-blocking process. First, as shown in Figure 3, the authors interpolate missing HR component using bilinear filter, $HR_m = LR_u + LR_b$, where HR_m is missing HR component, LR_u and LR_b are upper and bottom low resolution component, respectively. Boundary strength and decision process is applied on LR component and interpolated HR component. Finally, de-blocking filter operates only for LR component and, for full decoding, HR component is fetched from buffer and applied de-blocking filter as well.

In LRD, the authors proposed partial decoding algorithm for memory bandwidth and power saving. Partial decoding is the method for decoder, but LRD algorithm is implemented at encoder. Therefore, we cannot measure partial decoding algorithm properly. Partial decoding algorithm should be applied for decoder since its purpose is to reduce memory and resolution during decoding process. In the next section, we propose partial decoding algorithm for HEVC decoder.

III. PROPOSED ALGORITHM

The goal of proposed algorithm is to reduce resolution and DPB size by 25% of HEVC DPB size during decoding process. Implementing partial decoding algorithm in decoder can cause severe error propagation; therefore, minimizing error is an important issue. First, we decompose pixels into two: Not Decoded Pixel (NDP) and Decoded

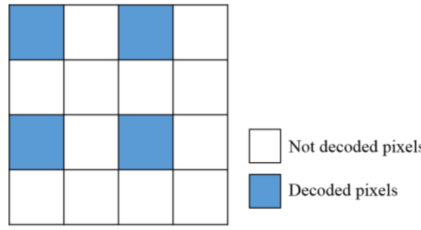

Figure 4. Decoded pixels for proposed algorithm

Pixel (DP), as shown in Figure 4. In our method, DPs that are 1/4 pixels of video sequences will be stored in DPB after reconstructing. The proposed algorithm consists of 3 sub-sections, which are partial decoding method for intra prediction, DCT-based interpolation and modification in de-blocking filter.

A. *Intra prediction for partial decoding*

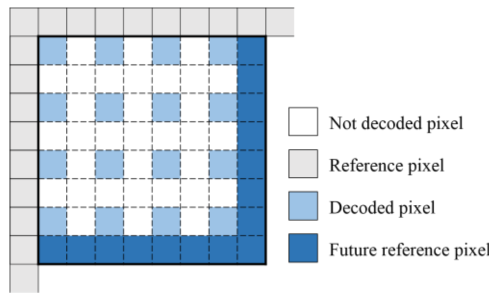

Figure 5. Pixel classification for proposed intra prediction

Intra prediction of HEVC is significantly improved compared with H.264/AVC by employing 35 prediction directions and related techniques for coding efficiency. For decoding intra predicted picture, reference pixels located upper and left PU should be stored in buffer. However, the NDPs in reference line are missing during partial decoding process described in Figure 5. Intra predicted picture would be a most important reference picture since it affects the whole picture in Group of Picture (GOP). To prevent error propagation in intra predicted pictures, we propose full decoding method only for Future Reference Pixel (FRP), as described in Figure 5. Excepting FRPs, the proposed algorithm reconstruct only DPs for reducing DPB size.

B. *DCT-based interpolation for partial decoding*

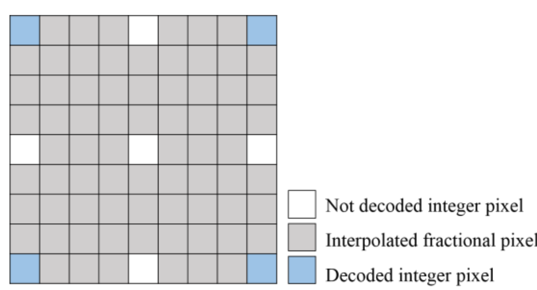

Figure 6. Pixels used for fractional interpolation

DCT-based interpolation filter (DCTIF) in motion compensation process is adopted for HEVC. It has coding efficiency about 4% bitrate reduction for luminance component. The details of calculating DCTIF coefficients is specified in [5].

To reconstruct inter predicted picture by using HEVC standard, reference pictures in reference lists and corresponding motion vectors should be prepared. DCT-based interpolation process is applied for fractional sample position. However, in Figure 6, we do not have some integer pixels causing partial decoding and DCT-based interpolation cannot operate without them. To solve this problem, we consider missing pixels (white pixels) as also fractional pixel to be interpolated, so we calculate filter taps to DCT-based interpolation filter for 8 fractional pixels in Table 1 and 2

TABLE I. INTERPOLATION FILTER FOR LUMA

Sub-pel positions	Filter Coefficients							
0	0	0	0	64	0	0	0	0
0.125	-1	2	-6	62	9	-4	2	0
0.25	-1	4	-10	58	17	-5	1	0
0.375	-2	5	-12	49	30	-10	5	-1
0.5	-1	4	-11	40	40	-11	4	-1
0.625	-1	5	-10	30	49	-12	5	-2
0.75	0	1	-5	17	58	-10	4	-1
0.875	0	2	-4	9	62	-6	2	-1

TABLE II. INTERPOLATION FILTER FOR CHROMA

Sub-pel positions	Filter Coefficients			
0	0	64	0	0
0.0625	-2	63	4	-1
0.125	-2	58	10	-2
0.1875	-4	57	14	-3
0.25	-4	54	16	-5
0.3125	-6	52	23	-5
0.375	-6	46	28	-4
0.4375	-7	43	34	-6
0.5	-4	36	36	-4
0.5625	-6	34	43	-7
0.625	-4	28	46	-6
0.6875	-5	23	52	-6
0.75	-2	16	54	-4
0.8125	-3	14	57	-4
0.875	-2	10	58	-2
0.9375	-1	4	63	-2

C. De-blocking filter for partial decoding

In video codec, de-blocking filter is employed to improve not only visual result but also coding efficiency. Blocking artifact on block boundary caused by quantization is removed by low-pass filtering. There are 6 steps for HEVC-de-blocking filter; first of all, determine Transform Unit (TU) or PU block boundary and then calculate boundary strength. HEVC should decides whether the de-blocking filter is applied or not, and select appropriate filter (strong or weak). In proposed algorithm, for de-blocking filter process in partial decoding algorithm, we use DPs in Figure 4 without NDPs. For instance, when HEVC determines whether filter is applied or not, the first and fourth line of the 4×4 block is used. However, in proposed algorithm, DPs on first and third line of 4×4 block are used for the de-blocking process.

IV. EXPERIMENTAL RESULTS

The proposed algorithm is implemented in decoder of HEVC test model (HM) 15.0 for evaluating its performance. The encoded bit streams of test sequences are used under the HEVC common test conditions [6] and we run the experiment for test sequences of the JCT-VC [7]. We experiment proposed partial decoding algorithm with All-Intra (AI) and Random Access (RA) configuration and compare the performance of proposed algorithm with subsampled and decoded video sequences in Table III.

TABLE III. EXPERIMENTAL RESULTS

	Sub		Proposed Algorithm	
	AI-YPSNR[dB]	RA-YPSNR[dB]	AI-YPSNR[dB]	RA-YPSNR[dB]
Class A	37.98	35.72	37.77	34.30
Class B	37.66	36.38	37.53	33.50
Class C	36.62	35.03	36.47	29.80
Class D	36.05	34.18	35.90	27.71
Class E	39.83	39.72	39.57	38.15
Average	37.63	36.20	37.45	32.69
Differnce	0.00	0.00	0.18	3.51

Experimental results of proposed algorithm are showed in Table III. Luminance Peak Signal To Noise Ratio (Y-PSNR) results are average values when quantization parameters are 22, 27, 32 and 37. We have observed the PSNR loss is more severe when QP is higher because of blocking artifact. Also, in case of small video sequences (class D, E), the blurring effect occurred since the length of DCT-based interpolation becomes longer. The error propagation occurs under RA configuration by inter predicted pictures.

 ISBN: 978-1-61208-439-8

V. CONCLUSIONS

In this paper, we propose partial decoding algorithm for HEVC and this is a new attempt to reduce memory bandwidth and resolution. Experimental results show that the proposed algorithm can yield a promising performance in terms of PSNR. Partial decoding can be a useful tool for decoding video sequences on mobile platform.

ACKNOLWEDGEMENT

This work was supported by the ICT R&D program of MSIP/IITP [R0601-15-1063, Software Platform for ICT Equipments].

REFERENCES

[1] B. Bross, W.-J. Han, G. J. Sullivan, J.-R. Ohm, and T. Wiegand, High Efficiency Video Coding (HEVC) Text Specification Draft 10, document JCTVC-L1003, ITU-T/ISO/IEC Joint Collaborative Team on Video Coding (JCT-VC), Jan. 2013.

[2] G. J. Sullivan, J.-R. Ohm, W.-J. Han, and T. Wiegand, “Overview of the high efficiency video coding (HEVC) standard,” IEEE Trans. Circuits Syst. Video Technol., vol. 22, no. 12, pp. 1649–1668, Dec. 2012.

[3] Z. Ma and A. Segall, “Low resolution decoding for high efficiency video coding,” Signal and Image Processing (SIP 2011), Dallas, USA, Dec. 2011.

[4] Z. Ma and A. Segall, “Frame buffer compression for low-power video coding,” in Proc. of IEEE ICIP, Sept. 2011.

[5] A Alshin, E Alshina, JH Park, WJ Han, “DCT based interpolation filter for motion compensation in HEVC,” in Proceedings of the SPIE 8499 Applications of Digital Image Processing XXXV, San Diego, CA, 2012.

[6] F. Bossen, Common Test Conditions and Software Reference Configurations, document JCTVC-L1100, ITU-T/ISO/IEC Joint Collaborative Team on Video Coding (JCT-VC), 12th Meeting: Geneve, CH 14 - 23 Jan. 2013.

[7] JCT-VC test sequences. [Online] ftp://hevc@ftp.tnt.unihannover.de/testsequences/

 ISBN: 978-1-61208-439-8