Architecture of Intra Prediction for High Efficiency Video Coding

Jong-sik PARK, Seong-soo LEE

(*School of Electronics Engineering, Soongsil University, Seoul* 156-743, *Korea*)

Abstract – This paper explains intra prediction method for High Efficiency Video Coding (HEVC). Intra prediction removes correlation of adjacent samples in spatial domain. Intra predictor requires reference images which are stored in external memory. Memory access is required frequently in process of intra prediction. The proposed architecture can reduce external memory access by optimized internal buffer.

Key words – ***High Efficiency Video Coding*** (***HEVC***); ***intra prediction***; ***low power***

Manuscript Number: 1674-8042(2011)04-0364-03

doi: 10.3969/j.issn.1674-8042.2011.04.014

1 Introduction

With the development of information technology, multimedia applications such as smart phone, tablet pc, PMP (Potable Multimedia Player) and DMB (Mobile Multimedia Broadcasting) are very popular items for people. Multimedia applications require powerful video codec like H.264/AVC, which is the most international video coding standard and is widely used in various multimedia applications[1]. It was jointly developed by ITU-T and ISO/IEC and provides a more efficient algorithm for compressing video than any other compression methods[2]. But demand for high resolution and high quality video applications, such as High Definition (HD) and Ultra High Definition(UHD) are increasing rapidly. It is difficult to transmit HD/UHD resolution data to end user over current network, because current video coding standards like H.264/AVC have trouble technical problem to provide emerging video services. To resolve this problem, ISO-IEC/MPEG and ITU-T/VCEG recently formed the Joint Collaborative Team on Video Coding (JCT-VC). JCT-VC aims to develop the next-generation video coding standard called High Efficiency Video Coding (HEVC)[3], which can be a low complexity video codec with high coding efficiency.

In this paper, we introduce a intra prediction method and architecture for HEVC. The video codec exploits intra prediction to remove correlation of adjacent samples in spatial domain. Intra predictor requires reference images in external memory for adjacent samples. Memory Access requires a lot of power. To reduce power consumption, the proposed architecture can be implemented by reusing repetitive pixel data.

2 Overview of intra prediction algorithm

2.1 Arbitrary Direction Intra (ADI)

The ADI predicts prediction pixels by directional extrapolation or calculation with the nearest boundary pixels which are reconstructed pixels of H.264/AVC intra prediction. In ADI, reft down boundary pixels are used for reference pixels[4]. ADI are defined by delta value (dx, dy) from current pixel to the corresponding reference pixel. The prediction method with arbitrary direction is shown in Fig. 1.

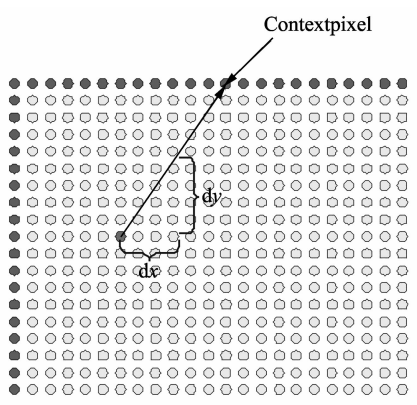

Fig. 1 Arbitrary prediction methods defined by(dx, dy)

* **Received**: 2011-06-15

Project supported: This work was supported by the MKE(The Ministry of Knowledge Economy), Korea, under the ITRC(Information Technology Research Center) support program supervised by the NIPA(National IT Industry Promotion Agency) (NIPA-2011-C1090-1021-0010)

Corresponding author: Jong-sik PARK(tudyy@ssu.ac.kr)

2.2 Angular prediction

To represent directional structure accurately, angular prediction is defined by 33 different directions. The prediction directions is given by displacement of the bottom row of the block and the reference row above the block in case of vertical prediction or displacement of the block rightmost column and reference column left from the block in case of horizontal prediction[4]. Fig. 2 shows available angular prediction directions for 8x8 intra blocks.

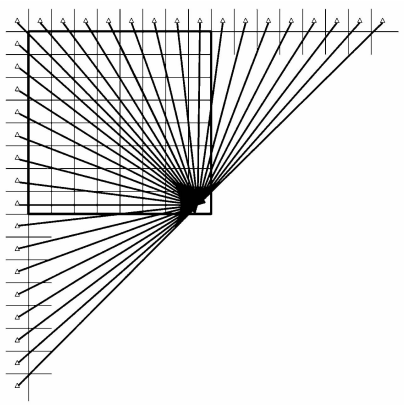

Fig. 2 Angular prediction directions for 8×8 intra blocks

2.3 Unified intra prediction

Unified intra prediction including ADI and Angular Prediction (AP) is adopted at HEVC. Prediction directions are defined angles of $\pm[0,2,5,9,13,17,21,26,32]/32$ by ADI. The number of prediction directions is determined by block size (17 for 4×4, 34 for 8×8, 34 for 16×16, 34 for 32×32, 5 for 64×64)[5]. Tab. 1 shows the number of intra prediction modes. Tab. 2 shows the name of intra prediction mode. Fig. 3 shows mode, order and angle of unified intra prediction for 8x8 intra blocks.

Tab. 1 Intra prediction mode number

Block size	Intra prediction mode number
4×4	17
8×8	34
16×16	34
32×32	34
64×64	5

Tab. 2 Name of intra prediction mode

Intra prediction mode	Name of intra prediction mode
0	Intra_Vertical
1	Intra_Horizontal
2	Intra_DC
Otherwise (3~33)	Intra_Angular

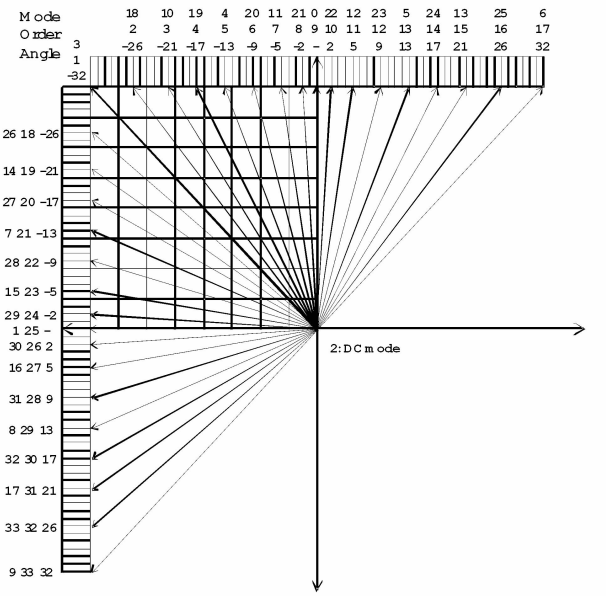

Fig. 3 Unified prediction directions for 8×8 intra blocks

3 Proposed architecture

Intra prediction removes correlation of adjacent samples in spatial domain. Therefore, intra predictor requires reference images which are stored in external memory. In intra prediction for HEVC, two arrays (refMain and refSide array) are used for reference image. In vertical prediction, an above line is refMain, and a left line is refSide. In Horizontal prediction, a left line is refMain, and an above line is refSide. But refSide value can be copied to refMain array. So only one refMain is used in intra prediction[6]. Fig. 4 shows refMain arrays and refSide arrays.

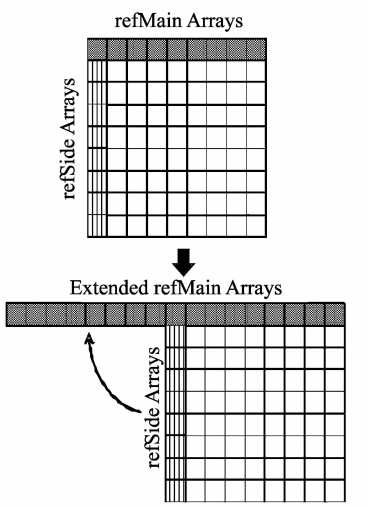

Fig. 4 RefMain arrays and refSide arrays

RefMain arrays and reference images are stored in external memory. Memory access is required frequently in process of intra prediction. Frequent external memory access is not the desirable power consumption. To resolve this problem, this paper prop-

oses optimized internal buffer. The refMain arrays are stored in internal buffer. A number of refMain arrays are determined by block size. Internal buffer size is the fixed maximum block. In small block size, numbers of refMain arrays are small. So an internal buffer has empty space. By storing repetitive reference pixel data in empty space, external memory access can be minimized. Furthermore, it reduces external memory size. Fig. 5 shows architecture of intra prediction for HEVC.

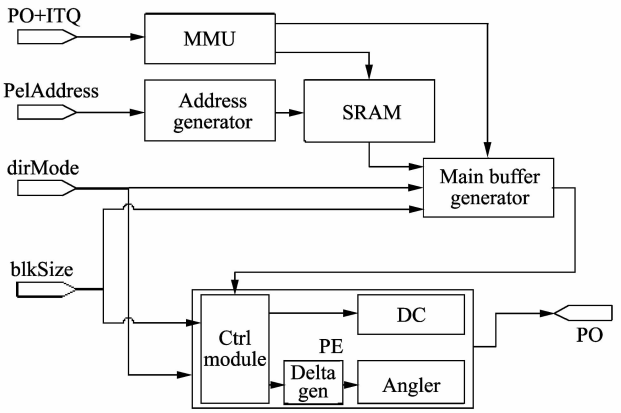

Fig. 5 Proposed architecture of intra prediction for HEVC

The MMU (Memory Management Unit) block and Main Buffer Generator (MBG) block are used for reusing repetitive pixel data. DC block is used for mode 1 (Intra_Vertical), mode 2 (Intra_Horizontal) and mode 3 (Intra_DC). An Intra Vertical mode is extrapolation from upper samples. An intra Horizontal mode is extrapolation from left samples. A DC mode is mean of upper and left-hand samples. Fig. 6 shows mode 1, mode 2 and mode 3. Fig. 7 shows block diagram of PE (Processing Element) for DC block. DC block consists of several PEs for variable block size. An Angular block is used for mode 3. In angular mode, delta value is necessary. Delta Gen block is used for calculating delta value. Ctrl module is used for selecting DC an Angular block.

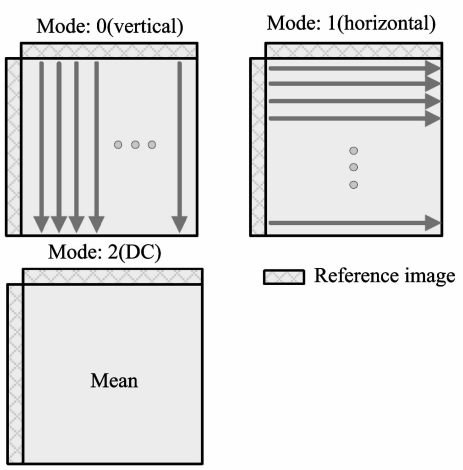

Fig. 6 Intra prediction mode 1, mode 2 and mode 3

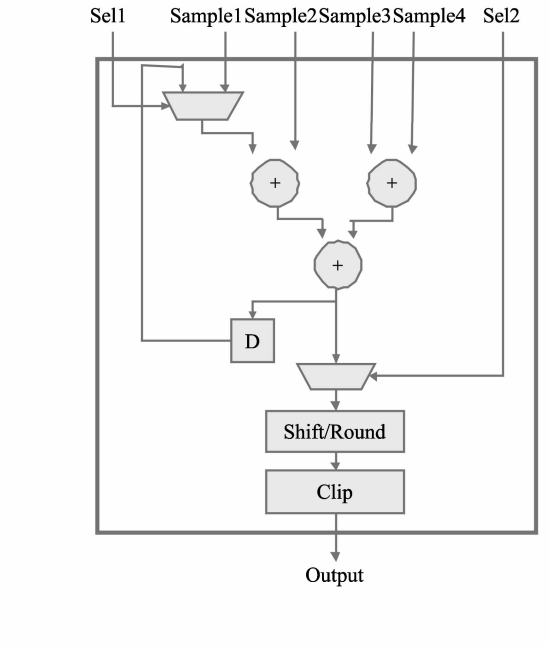

Fig. 7 Block diagram of PE for DC block

4 Conclusions

In this paper, we introduce intra prediction method and architecture for HEVC. Intra prediction is an effective method for higher compression efficiency from correlation removal of adjacent samples in spatial domain. It has an external memory for reference samples. As frequent memory access consumes power, in order to minimize memory access, this paper proposes an architecture with optimized internal buffer by reusing repetitive reference pixel data.

References

[1] ITU-T, 2003. Draft ITU-T recommendation and final draft international standard of joint video specification.

[2] E. G. Iain, Richardson, 2003. H. 264 and MPEG-4 video compression, video coding for next-generation multimedia, Wiley.

[3] K. Ugur, K. R. Andersson, A. Fuldseth, 2010. High performance, low complexity video coding and the emerging HEVC standard. *IEEE Trans. on Circuits and Systems for Video Technology*, 20(12): 1688-1697.

[4] Joint Collaborative Team -Video Coding, 2010. Test model under consideration. JCTVC-A205 output document, Germany: Dresden.

[5] Joint Collaborative Team -Video Coding, 2010. Unification of the directional intra prediction methods in TMuC. JCTVC-B100, Geneva.

[6] Joint Collaborative Team -Video Coding, 2010. Simplified angular intra prediction. JCTVC-B093, Geneva.