Separate Scale for Position Dependent Intra Prediction Combination of VVC

Yong-Uk Yoon, Dohyeon Park, and †Jae-Gon Kim
Korea Aerospace University
{yuyoon, dhpark}@kau.kr, †jgkim@kau.ac.kr

Abstract

The Joint Video Experts Team (JVET) has been working on the development of next generation of video coding standard called Versatile Video Coding (VVC). Position Dependent Intra Prediction Combination (PDPC) which is one of the major tools for intra prediction refines the prediction through a linear combination between the reconstructed samples and the predicted samples according to the sample position. In VVC WD6, nScale which is shift value that adjusts the weight is determined by the width and height of the current block. It may cause that PDPC is applied to regions that do not fit the characteristics of the current intra prediction mode. In this paper, we define nScale for each width and height so that the weight can be applied independently to the left and top reference samples, respectively. Experimental results show that, compared to VTM 6.0, the proposed method gives -0.01%, -0.04% and 0.01% Bjotegaard-Delta (BD)-rate performance, for Y, Cb, and Cr components, respectively, in All-Intra (AI) configuration.

1. Introduction

The Joint Video Experts Team (JVET) has been working on the development of next generation of video coding standard called Versatile Video Coding (VVC) since 2015 [1-2]. Until recently, VVC Committee Draft (CD) [2] and test model of VVC named VTM6.0 [3] have been released, and various techniques for improving coding efficiency have been adopted. Especially, the intra-prediction technology has effectively improved encoding efficiency by adopting various techniques such as matrix-based intra prediction (MIP), position dependent intra prediction combination (PDPC), etc [4].

PDPC is one of the major tools for intra prediction. PDPC refines the prediction block through a linear combination between the reconstructed samples and the predicted samples according to the sample position of the predictive block. PDPC is a technology that showed high coding efficiency from Joint Exploration Model (JEM) [5], which is the exploration model of VVC, and is now adopted in VTM through a number of optimization processes [4].

The structure of this paper is as follows. A brief description of the current PDPC is given in Section 2, and Section 3 describes the problems and proposed method address them. In Section 4, the experimental results of the proposed method are shown, and Section 5 concludes this paper.

2. PDPC in VTM

PDPC refines the prediction samples of the current block by linear combination of the unfiltered boundary samples and the intra predicted samples with the filtered reference samples according to sample position. PDPC has a role of smoothing the boundary between the prediction samples and the neighboring reconstructed reference samples as well as refining the predicted samples by giving a planar effect on the directional predicted samples.

PDPC is applied to the intra modes which are planar, DC, horizontal, vertical, some angular modes without signaling. The sample at the position of (x,y) is predicted as follows:

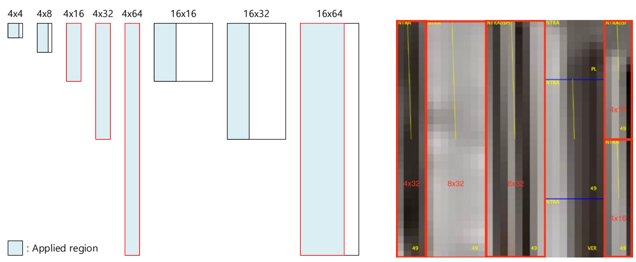
$$pred'(x,y) = (wL \times R_{-1,y} + wT \times R_{x,-1} - wTL \times R_{-1,-1} + (64 - wL - wT + wTL) \times pred(x,y) + 32) >> 6, \quad (1)$$

where $R_{-1,y}$, $R_{x,-1}$, and $R_{-1,-1}$ represent the reference samples located at the left, top, and top-left of current block, respectively. wL, wT, and wTL represent the weight for each reference sample.

The weights are defined to vary depending on the height and width of current block and the position of the current sample. Table 1 shows how the weights are defined. nScale is shift value defined by the shape of current block and intra prediction mode.

Table 1. *wL*, *wT*, and *wTL* definition

Mode	*wL*	*wT*	*wTL*
Planar/DC	$32 \gg ((x \ll 1) \gg nScale)$	$32 \gg ((y \ll 1) \gg nScale)$	0
HOR (18)	0	$32 \gg ((y \ll 1) \gg nScale)$	*wT*
VER (50)	$32 \gg ((x \ll 1) \gg nScale)$	0	*wL*
Ang (<18)	0	$32 \gg ((y \ll 1) \gg nScale)$	0
Ang (>50)	$32 \gg ((x \ll 1) \gg nScale)$	0	0



(a) (b)

Figure 1. (a) Examples of regions where PDPC is applied, (b) Examples of prediction mode of long vertical blocks.

3. Proposed Separate Scale for PDPC

In VVC CD, nScale for the modes of vertical, horizontal, DC, and Planar is determined purely by the width and height of current block as in Equation (2). Figure 1-(a) shows an example of applying PDPC to the current block according to the shape of the block when the intra prediction mode is the vertical mode. Since nScale is defined by the width and height of the block, even if the block has the same width, the regions where PDPC is applied are different. Therefore, PDPC may be applied to regions that do not fit the characteristics of the current intra prediction mode. In other words, long vertical blocks such as blocks having a width of 4 and a height of 16 or more are likely to have a vertical prediction mode. Such empirical observations are shown in Figure 1-(b) which shows the prediction modes of long vertical blocks. In other words, if the block having vertical mode has a high vertical correlation. However, in the current PDPC, the influence of the left reference samples is reflected to more regions as shown in Figure 1-(a).

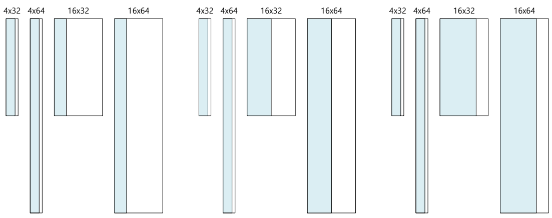
nScale = (Log2(Width) + Log2(Height) – 2) >> 2. (2)

In this paper, we define nScale for each width and height so that the weight can be applied independently to the width and height of the current block. In other words, nScale of *wL* and *wT* defined in Table 1 is separated into nScaleL and nScaleT which are shift values determined only by width and height, respectively, as follows:

nScaleL = (Log2(Width) – a) >> b,
nScaleT = (Leg2(Height) – a) >> b, (3)

where a and b are variables that can adjust nScale.

In this paper, we compared and analyzed the performance by adjusting two variables to adjust the regions where PDPC is applied. Figure 2 shows the regions where PDPC is applied when the current mode is vertical mode according to a and b. Because of separate nScale, PDPC is applied to the same regions for the blocks with the same width. In this paper, three tests are performed according to the variable set (a, b). The sets of (a, b) are (1, 2), (1, 1) and (2, 0) for Test 1, Test 2 and Test 3, respectively. Compared to the existing PDPC shown as Figure 1, it can be seen that Test 1 applies PDPC to less areas, Test 2 applies similarly, and Test 3 applies more regions.



(a) Test 1 (b) Test 2 (c) Test 3

Figure 2. Examples of regions where PDPC is applied with the proposed method.

4. Experimental Results

The proposed method is implemented on top of VTM6.0 and evaluated in the All-Intra (AI) encoding configuration according to the JVET common test conditions [6]. In this paper, three tests are performed according to the variables a and b mentioned in Section 2. Table 2-4 show the performance results of the proposed method over VTM 6.0. The proposed method gives -0.01%, -0.04%, and 0.01% Bjotegaard-Delta (BD)-rate performance in Test 1, 2, and 3, respectively. As shown in Table 2-4, the more PDPC is applied, the lower the coding efficiency. Therefore, it may be inefficient to increase the PDPC region as the block gets larger.

Table 2. Experimental results of Test 1

	All Intra Main10		
	Y	U	V
Class A1	0.06%	0.13%	0.19%
Class A2	-0.03%	0.02%	0.00%
Class B	0.00%	-0.06%	-0.05%
Class C	-0.02%	-0.15%	-0.02%
Class E	-0.04%	-0.08%	0.00%
Overall	**-0.01%**	**-0.04%**	**0.01%**

Table 3. Experimental results of Test 2

	All Intra Main10		
	Y	U	V
Class A1	0.00%	0.01%	0.09%
Class A2	0.01%	0.05%	-0.03%
Class B	0.00%	0.06%	0.00%
Class C	0.00%	-0.10%	-0.05%
Class E	-0.04%	-0.02%	0.03%
Overall	**0.00%**	**0.00%**	**0.01%**

Table 4. Experimental results of Test 3

	All Intra Main10		
	Y	U	V
Class A1	0.10%	0.03%	0.05%
Class A2	0.18%	0.16%	0.11%
Class B	0.05%	0.16%	0.12%
Class C	0.05%	0.04%	0.10%
Class E	0.13%	0.22%	0.25%
Overall	**0.09%**	**0.12%**	**0.12%**

5. Conclusions

This paper proposed a method of scaling for adjusting the regions to which PDPC is applied to improve the performance of the existing PDPC in VVC. In the proposed method, the scale determined by the width and height of the block was separated to two scales each of which is defined by the width and height, respectively, so that PDPC was applied to more appropriate regions. Experimental results demonstrated that the proposed method gives -0.01%, -0.04% and 0.01% BD-rate performance in average over VTM 6.0, for Y, Cb and Cr components, respectively. Since PDPC is a promising coding tool for intra prediction, it is necessary to devise ways to increase the performance of PDPC while keeping complexity.

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