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| *Title:* | **Simplified Planar Intra Prediction** | | |
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| *Purpose:* | Proposal | | |
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# Abstract

This document presents two simplified planar Intra prediction methods with lower calculation complexity. One is diagonal-based Intra prediction and other is sub-block based Intra prediction. Both of them can be easily implemented by only using addition and shift operations. Simulation results show the proposed methods reduce encoding time while keeping similar performance as the existing planar Intra prediction.

# Introduction

Planar Intra prediction (PIP) has been investigated in CE6.e since the last JCTVC meeting [1]. As shown in Figure 1, PIP mode firstly predicts the right-bottom corner sample, then the samples at both right border and bottom border. Finally, bilinear interpolation is performed to generate the prediction values of the remained inner samples with the reference of the prediction values in the previous two steps. PIP is suitable to encode smooth texture. It has been also reported that PIP improves objective and subjective performance.



Fig.1. Planar Intra prediction

This document aims to reduce the calculation complexity issue of the existing planar Intra prediction and proposes two simplified planar prediction methods, *i.e.*, diagonal-based Intra prediction and sub-block based Intra prediction.

# Simplified planar Intra prediction

## Diagonal-based Intra prediction

a) Prediction for the samples at diagonal line b) Prediction for other samples

Fig. 2. Diagonal-based Intra prediction

Figure 2 shows the prediction process of diagonal-based Intra prediction. The samples at diagonal line of current block are firstly predicted by using its left and above reference samples. For example, as shown in Figure 2a, the prediction value of sample P is calculated as follows.

*P’* = (*LeftRef* + *AboveRef* +1) >>1 (1)

Where, *P’*denotes the prediction value of sample P, *LeftRef* and *AboveRef* denote the corresponding samples at left and above reference arrays. For the other samples, *e.g.*, the samples of p1 and p2, can be predicted by linear interpolation with reference of the prediction value of its corresponding diagonal sample and its above/left reference sample. For example, as shown in Figure 2b, the prediction value of sample p1 can be calculated by using equation (2) through a linear interpolation.

*p1’* = (*AboveRef*\**d*2 + *P’*\**d*1)/(*d*1+*d*2) (2)

Where, *p1’* is the prediction value of sample p1, *d*1 and *d*2 denote the distances from p1 to *AboveRef* and the sample P, respectively. A look-up table may be required to remove the division operation in the equation (2).

Diagonal-based Intra prediction has lower calculation complexity than the existing planar Intra prediction, since diagonal-based Intra prediction only employs linear interpolation rather than bilinear interpolation which is used in the existing planar Intra prediction.

## Sub-block based Intra prediction

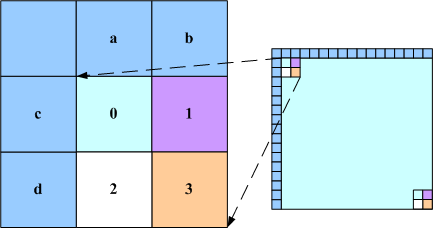


Fig. 3. 2x2-based Intra prediction

A block can be divided into a series of 2x2 or 4x4 sub-blocks, and each sub-block is predicted with reference of the prediction value of its left and above neighbor sub-blocks. The processing order for the divided sub-blocks can be from left to right and from top to bottom.

As shown in figure 3, a block of 16x16 is divided into 64 sub-blocks of 2x2. Each 2x2 sub-block is predicted as follows.

*P3* = (b + d +1) >>1 (3)

*P1* = (b + d + (b<<1) +2) >>2 (4)

*P2* = (b+ d + (d<<1) +2) >>2 (5)

*P0* = (a + c + b + d +2) >>2; (6)

Where *Pn* (*n*=0,1,2,3) is the prediction value of the *n*th sample in current 2x2 sub-block, and a/b/c/d denotes the value of the neighbor reference sample of current 2x2 sub-block. The prediction values of current 2x2 sub-block depend on the prediction values of its neighbor left and above 2x2 sub-blocks. In this way, all sub-block can be predicted, and the residual of current block is also formed.

It is noticed that 2x2 based Intra prediction can be implemented with a simpler way than the existing planar Intra prediction. It only requires 2.5 additions and 1 shift operations per sample. As for the respect of dependency between different 2x2 sub-blocks, it is also possible for the different rows of 2x2 sub-blocks to be processed with pipelining.

Figure 4 also shows the prediction process of 4x4 sub-block divided from a block of 16x16, where each 4x4 sub-block employs the existing planar Intra prediction. Each sub-block is predicted with reference of the prediction value of its left and above neighbor sub-blocks.



Fig. 4. 4x4-based Intra prediction

**Prediction for right and bottom borders**

*P15* = ( D + H +1) >>1

*P3* = ( P15 + 3\*D +2) >>2

*P7* = ( P15 + D +1) >>1

*P11* = ( 3\*P15 + D +2) >>2

*P12* = ( P15 + 3\*H +2) >>2

*P13* = ( P15 + H +1) >>1

*P14* = ( 3\*P15 + H +2) >>2

**Prediction for Inner Samples**

*P0* = (P12 + 3\*A + P3 + 3\*E + 4) >>3

*P1* = (P13 + 3\*B + 2\*P3 + 2\*E + 4) >>3

*P2* = (P14 + 3\*C + 3\*P3 + E + 4) >>3

*P4* = (2\*P12 + 2\*A + P7 + 3\*F + 4) >>3

*P5* = (2\*P13 + 2\*B + 2\*P7 + 2\*F + 4) >>3

*P6* = (2\*P14 + 2\*C + 3\*P7 + F + 4) >>3

*P8* = (3\*P12 + A + P11 + 3\*G + 4) >>3

*P9* = (3\*P13 + B + 2\*P11 + 2\*G + 4) >>3

*P10* = (3\*P14 +C + 3\*P11 + G + 4) >>3

It is noted that multiplying by 2 or 3 can be easily implemented with shift and addition operations.

For a block of 16x16, the number of bilinear interpolation can be calculated as follows.

• 3x3x16=144 of bilinear interpolations for 4x4-based Intra prediction.

• 15x15 = 225 of bilinear interpolations for the existing planar Intra prediction.

Therefore, the number of bilinear interpolation is reduced to 64% of the existing planar Intra prediction.

# Test conditions and Results

The proposed Intra prediction methods have been integrated into the reference software provided by CE6.e. HM2.0 is used as anchor for the simulation.The following running environment and compiler have been used for running simulations.

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| **Running environment** | **Compiler** |
| Intel Xeon X7560 @2.27GHz, 256G RAM  Windows Server 2003, 64 bits | VS2005 |

We have run both Intra HE and LC cases using the same computer to make sure coherent encoding and decoding time. Common testing conditions are used for simulation [2][3]. In our simulation, the proposed Intra prediction mode is used as an additional Intra mode. The following tables summarize the simulation results. The detail of test results can be found from attachments.

Table 1. Performance of the existing Planar Intra prediction (JCTVC-D235)



Table 2. Performance of Diagonal-based Intra prediction



Table 3. Performance of 2x2-based Intra prediction



Table 1 shows the performance of the existing planar Intra prediction as described in JCTVC-D235, which achieves 0.7% bit-rate reduction over HM2.0 for both all Intra HE and LC configurations. Table 2 and Table 3 show the performance of the proposed diagonal and 2x2 based Intra prediction methods, respectively. It can be observed that the proposed Intra prediction methods achieve the reduced encoding time and similar performance as the existing planar prediction. The reduction of encoding time can be explained by the simplification on calculation complexity.

Table 4. Performance of 4x4-based Intra Prediction



Table 4 shows the performance of the 4x4 based Intra prediction methods, It is observed that the proposed 4x4 based Intra prediction reduces encoding time while keeps almost the same performance as the existing planar Intra prediction.

# Conclusion

This document presents two simplified planar Intra prediction methods. Simulation results show that the proposed methods have lower calculation complexity and similar performance compared with the existing planar Intra prediction method.

# References

1. Sandeep Kanumuri, TK Tan, Frank Bossen, "Enhancements to Intra Coding", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-D235, 4th Meeting, Daegu, KR, Jan., 2011.
2. Ali Tabatabai, Keiichi Chono, Muhammed Coban, etc. "Core Experiment 6: Intra Prediction Improvement", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-D606, 4th Meeting, Daegu, KR, Jan., 2011.
3. F. Bossen., “Common conditions and software reference configurations”, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-D600, 4th Meeting, Daegu, KR, Jan., 2011.

# Patent rights declaration(s)

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