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| *Title:* | **CE6.b Report on Short Distance Intra Prediction Method** | | |
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| *Author(s) or Contact(s):* | Xiaoran Cao, Tsinghua  Xiulian Peng, USTC  Changcai Lai, HiSilicon  Yunfei Wang, Tsinghua  Yongbing Lin, HiSilicon  Jizheng Xu, Microsoft  Lingzhi Liu, HiSilicon  Jianhua Zheng, HiSilicon  Yun He, Tsinghua  Haoping Yu, Huawei  Feng Wu, Microsoft | Email: | laichangcai@huawei.com jzxu@microsoft.com  haopingyu@huawei.com |
| Source: | Tsinghua University, University of Science and Technology of China, HiSilicon, Microsoft, Huawei | | |

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# Abstract

This document reports the experimental results of the short distance intra prediction (SDIP) scheme for core Experiment 6 on intra prediction improvement. SDIP was presented in JCTVC-C101 and JCTVC-C270. By dividing the NxN block into lines or non-square blocks, SDIP can reduce the energy of the prediction residuals by reducing the distance of predicted pixel and its reference pixels. When integrated into the TMuC 0.9 (HM) software, it shows 4.3% and 5.7% bit rate saving on average, under all intra high efficiency and low complexity conditions, respectively, with about 50% encoding time increase and no obviously decoding time increase. Up to 8.9% bit rate saving is achieved on sequences with rich textures.

# Introduction

The traditional block-based intra coding in AVC/KTA/HM uses one NxN square block as the reconstruction unit and prediction unit. The pixels inside a square block are all predicted from the boundaries of neighboring reconstructed blocks, producing poor predictions for pixels on the right-bottom part than the others in some regions of sequences. To better exploit spatial correlations, the short distance intra prediction coding scheme is proposed by partitioning one NxN square block into several lines or non-square blocks with rectangle shape. In the block, pixels are predicted and reconstructed line by line or rectangle by rectangle. Therefore, the prediction distance can be obviously shortened.

# Algorithm description

In SDIP, one NxN square block which is smaller than 32x32 is divided into several lines or non-square blocks with rectangle shape. In the block, pixels are predicted and reconstructed line by line or rectangle by rectangle.

## Block Partitions

In SDIP modes, one CU that smaller than 32x32 can be partitioned as lines or non-square blocks with rectangle shape as Fig.1 shows. One 16x16 CU can not only be divided into four 8x8 PU as did in HM, but also be divided into four 4x16/16x4 PU, and a 4x16/16x4 PU can be further split into four 1x16/16x1 partitions. As similar, one 8x8 CU can also be divided into four 2x8/8x2 PU, and every 4x4 PU can be further divided into four 1x4/4x1 partitions.

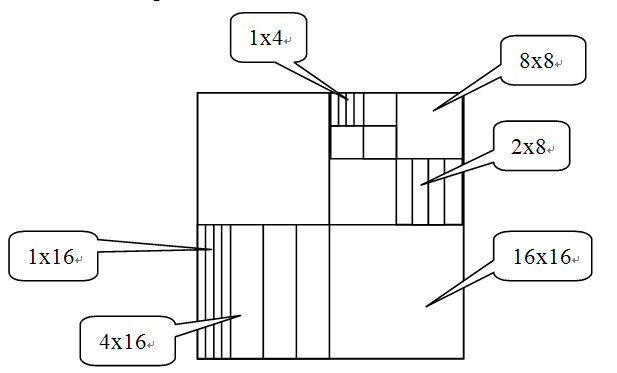


Fig. 1 SDIP block partitions based on HM

## SDIP intra prediction and coding



Fig.2 UDI prediction for 2x8

In the Intra prediction for SDIP partitions, UDI of HM is used as Fig.2 and the UDI modes can be from 9 to 34 and the number of modes is configurable as HM. One UDI mode flag is identified for every 4x16/16x4 or 2x8/8x2 partition. If a 4x16/16x4 is divided into four 1x16/16x1, the 1x16/16x1 partitions used the same modes that identified in 4x16/16x4 and similar for 1x4/4x1 partitions in 4x4 PU. In the prediction of SDIP blocks and square blocks, we used the bidirectional intra prediction for mode 6 as described in JCTVC-D300 [1].

For the prediction of chroma blocks in SDIP modes, square blocks in HM were used, and all four luma prediction modes in the current CU and the four modes 0-3 are tested in mode decision, among which the four luma modes are mapped to low indices and modes 0-3 are mapped to high ones. Only the first five modes by the new indices are searched in mode decision. The new index is then transmitted in the bitstream instead of the original modes. This approach is also applied to blocks not selecting SDIP mode, where SIZE\_NxN partitions might benefit from it.

The same transform matrices (2x2, 4x4, 8x8 and 16x16) in HM were reused in SDIP modes but only the transform size is partition size related and the quantization scale matrix is modified respectively. The *n*x*m* blocks are transformed by the following steps as described in [2].

**Cnxm = Tm x Bnxm x TnT** (1)

where **Bnxm** denotes a block with *n* pixels *m* rows. **Tn** and **Tm** are the transform matrices of size *n*x*n* and *m*x*m*, respectively. **Cnxm** denotes the transformed *n*x*m* block.

At the entropy coding stage, different scanning orders and contexts are designed for different partitions. Generally, for 2x8, 1x16 and 4x16 partitions, the coefficients are first scanned from high frequency to low frequency into a 1D buffer and then reorganized into a 4x4 or 8x8 block and coded as it does as illustrated in Fig. 3. For 1x16 partitions, since the transform is one dimensional, there is no need to scan from high to low. The coefficients are directly reorganized into 4x4 and coded. For 4x4 using 1x4 transforms, the coefficients of a 4x4 block are coded as a whole. They are scanned from four DC coefficients to other AC coefficients. The significant map is coded using the frequency as a context, i.e. there are four context models for 4x4. The coefficient levels are coded similar to 4x4 in HM. The following figure illustrates the scanning for each case. In SDIP modes, RDOQ is used in CABAC case, in LCEC case, RDOQ was also implemented but turned off considering the tradeoff between the gain and encoding complexity.



Fig. 3 Scanning order for 16x4 partition

# Test conditions and Results

The proposal has been integrated into HM0.9. We have run three sets of results with different SDIP intra prediction modes configurations. All of three sets of results were tested in Intra and Intra LoCo cases under the recommended test conditions of intra-only configuration for CE6 in [3]. The following summarizes the simulation results.

**Results\_1: full configuration**

In this set of configurations, no any fast method was used, 17 modes are used for 1x4/4x1, 2x8/8x2 and 1x16/16x1 partitions，34 modes are used for 4x16/16x4 partitions. The following platform and compiler have been used and results were shown in Table1.

|  |  |  |  |
| --- | --- | --- | --- |
| **Platform** | **CPU** | **Memory** | **Compiler** |
| **Windows Server 2008 R2 64 bits** | **2xIntel Xeon L5420@2.5Ghz** | **16GB** | **VS2010** |

Table1. Results of normal configuration

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Intra | | | Intra LoCo | | |
| Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | -3.7 | -1.9 | -1.7 | -5.2 | -3.4 | -3.7 |
| Class B | -3.5 | -1.4 | -1.6 | -5.3 | -2.2 | -3.1 |
| Class C | -5.8 | -2.7 | -2.9 | -7.8 | -3.7 | -4.6 |
| Class D | -5.8 | -2.8 | -2.9 | -7.4 | -3.9 | -4.3 |
| Class E | -5.2 | -3.2 | -3.1 | -6.4 | -7.0 | -6.1 |
| All | -4.8 | -2.4 | -2.4 | -6.5 | -3.9 | -4.3 |
| Enc Time[%] | 294% | | | 246% | | |
| Dec Time[%] | 102% | | | 106% | | |

**Results\_2: Normal configuration**

In this set of configurations, only a simple SDIP early skip method was used to reduce the encoding complexity, in which the SDIP mode was skipped when the RD costs of SIZE\_NxN and SIZE\_2Nx2N are smaller than a threshold value. 17 modes are used for 1x4/4x1, 2x8/8x2 and 1x16/16x1 partitions， 34 modes are used for 4x16/16x4 partitions. The following platform and compiler have been used and results were shown in Table2 and Table3.

|  |  |  |  |
| --- | --- | --- | --- |
| **Platform** | **CPU** | **Memory** | **Compiler** |
| **Windows Server 2008 R2 64 bits** | **2xIntel Xeon L5420@2.5Ghz** | **16GB** | **VS2010** |

Table2. Results of normal configuration

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Intra | | | Intra LoCo | | |
| Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | -3.7 | -1.9 | -1.9 | -4.9 | -3.6 | -3.9 |
| Class B | -3.2 | -1.5 | -1.7 | -4.9 | -2.6 | -3.5 |
| Class C | -5.5 | -2.9 | -3.1 | -7.4 | -4.0 | -4.8 |
| Class D | -5.6 | -3.0 | -3.0 | -7.1 | -4.1 | -4.5 |
| Class E | -4.8 | -3.2 | -3.0 | -5.8 | -7.2 | -6.3 |
| All | -4.6 | -2.5 | -2.5 | -6.1 | -4.1 | -4.5 |
| Enc Time[%] | 200% | | | 182% | | |
| Dec Time[%] | 104% | | | 112% | | |

Table3. Comparison of coding efficiency for test sequences

|  |  |  |
| --- | --- | --- |
|  | **All Intra**  **High Efficiency** | **All Intra**  **Low Complexity** |
| **sequence** | BD-bitrate | BD-bitrate |
| BasketballPass\_416x240\_50 | -5.7% | -8.1% |
| BQSquare\_416x240\_60 | -6.6% | -7.0% |
| BlowingBubbles\_416x240\_50 | -6.0% | -6.9% |
| RaceHorses\_416x240\_30 | -4.3% | -6.4% |
| **Average WQVGA** | **-5.6%** | **-7.1%** |
| BasketballDrill\_832x480\_50 | -6.0% | -9.3% |
| BQMall\_832x480\_60 | -6.4% | -8.3% |
| PartyScene\_832x480\_50 | -5.9% | -6.2% |
| RaceHorses\_832x480\_30 | -3.7% | -5.8% |
| **Average WVGA** | **-5.5%** | **-7.4%** |
| vidyo1\_720p\_60 | -4.9% | -6.2% |
| vidyo3\_720p\_60 | -4.7% | -5.5% |
| vidyo4\_720p\_60 | -4.7% | -5.7% |
| **Average 720P** | **-4.8%** | **-5.8%** |
| Kimono1\_1920x1080\_24 | -1.5% | -2.2% |
| ParkScene\_1920x1080\_24 | -2.3% | -3.7% |
| Cactus\_1920x1080\_50 | -4.1% | -6.0% |
| BasketballDrive\_1920x1080\_50 | -4.5% | -7.2% |
| BQTerrace\_1920x1080\_60 | -3.5% | -5.1% |
| **Average 1080P** | **-3.2%** | **-4.9%** |
| Traffic\_2560x1600\_30\_crop | -3.3% | -4.6% |
| PeopleOnStreet\_2560x1600\_30\_crop | -4.1% | -5.2% |
| **Average 1600P** | **-3.7%** | **-4.9%** |
| **Average** | **-4.6%** | **-6.1%** |

The test results show that 4.6% and 6.1% bit rate saving on average, under all intra high efficiency and low complexity conditions, respectively. Up to 9.3% bit rate saving is achieved on sequences with rich textures.

**Results\_3: faster configuration**

The purpose of this configuration is to further reduce the encoding complexity while maintaining the coding efficiency. In this set of configurations, in addition to the SDIP early skip method, some other fast intra prediction modes search methods were used such as for 4x16 blocks, intra modes 26-33 were skipped and modes 18-25 were skipped for 16x4 partitions, in addition, 1x16/16x1 blocks used the best mode of corresponding 4x16/16x4 partitions.

The following platform and compiler have been used and Table4 and Table5 show the results of faster configurations.

|  |  |  |  |
| --- | --- | --- | --- |
| **Platform** | **CPU** | **Memory** | **Compiler** |
| **Windows Server 2008 R2 64 bits** | **2xIntel Xeon L5420@2.5Ghz** | **16GB** | **VS2010** |

Table 4. Resutls of faster configuration

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Intra | | | Intra LoCo | | |
| Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | -3.5 | -1.9 | -1.9 | -4.5 | -3.3 | -3.4 |
| Class B | -3.0 | -1.4 | -1.7 | -4.4 | -2.5 | -3.2 |
| Class C | -5.2 | -2.8 | -3.1 | -7.0 | -3.8 | -4.4 |
| Class D | -5.4 | -2.9 | -2.9 | -6.8 | -3.9 | -4.2 |
| Class E | -4.5 | -3.0 | -2.7 | -5.3 | -6.3 | -5.6 |
| All | -4.3 | -2.4 | -2.5 | -5.7 | -3.8 | -4.1 |
| Enc Time[%] | 161% | | | 146% | | |
| Dec Time[%] | 100% | | | 105% | | |

Table5. Comparison of coding efficiency for test sequences

|  |  |  |
| --- | --- | --- |
|  | **All Intra**  **High Efficiency** | **All Intra**  **Low Complexity** |
| **sequence** | BD-bitrate | BD-bitrate |
| BasketballPass\_416x240\_50 | -5.4% | -7.7% |
| BQSquare\_416x240\_60 | -6.3% | -6.9% |
| BlowingBubbles\_416x240\_50 | -5.6% | -6.6% |
| RaceHorses\_416x240\_30 | -4.1% | -6.1% |
| **Average WQVGA** | **-5.4%** | **-6.8%** |
| BasketballDrill\_832x480\_50 | -5.7% | -8.9% |
| BQMall\_832x480\_60 | -5.9% | -7.6% |
| PartyScene\_832x480\_50 | -5.7% | -6.0% |
| RaceHorses\_832x480\_30 | -3.4% | -5.4% |
| **Average WVGA** | **-5.2%** | **-7.0%** |
| vidyo1\_720p\_60 | -4.6% | -5.7% |
| vidyo3\_720p\_60 | -4.6% | -5.0% |
| vidyo4\_720p\_60 | -4.5% | -5.1% |
| **Average 720P** | **-4.5%** | **-5.3%** |
| Kimono1\_1920x1080\_24 | -1.4% | -2.0% |
| ParkScene\_1920x1080\_24 | -2.1% | -3.2% |
| Cactus\_1920x1080\_50 | -3.7% | -5.5% |
| BasketballDrive\_1920x1080\_50 | -4.2% | -6.8% |
| BQTerrace\_1920x1080\_60 | -3.4% | -4.8% |
| **Average 1080P** | **-3.0%** | **-4.4%** |
| Traffic\_2560x1600\_30\_crop | -3.1% | -4.1% |
| PeopleOnStreet\_2560x1600\_30\_crop | -4.0% | -4.8% |
| **Average 1600P** | **-3.5%** | **-4.5%** |
| **Average** | **-4.3%** | **-5.7%** |

The test results show that 4.3% and 5.7% bit rate saving on average, under all intra high efficiency and low complexity conditions, respectively. Up to 8.9% bit rate saving is achieved on sequences with rich textures.

# Conclusion

This document reports the experimental results of SDIP scheme for core Experiment 6 on intra prediction improvement. When integrated into the TMuC 0.9 software, it shows 4.3% and 5.7% bit rate saving on average, under all intra high efficiency and low complexity conditions, respectively, with about 50% encoding time increase and no obviously decoding time increase. Up to 8.9% bit rate saving is achieved on sequences with rich edges.

# References

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