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| *Title:* | **CE6.e: Mode-Dependent Intra Smoothing Modifications** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes modifications to mode-dependent intra smoothing (MDIS), which is studied in CE6.e. The decision mapping table is updated and planar mode is included. On average the BD-rate gain is -0.1% for both intra-coding test conditions, while execution times are unchanged. For the BasketballDrill (class C) sequence, the coding gains are -0.9% (HE) and -1.8% (LC). It is proposed to adopt the MDIS modifications into the HM.

# Introduction

The MDIS scheme [1] determines the smoothing filter type according to the prediction unit (PU) size and the intra prediction mode. MDIS orders the intra prediction modes in a hierarchy that is mapped to the PU size. For increasing PU sizes, additional intra modes are filtered according to the predetermined hierarchy.

In [2] an RD loss was observed mainly for the Class C “BasketballDrill” sequence. This proposal addresses this RD loss by modifying the MDIS decision mapping table between intra prediction mode and PU size, resulting in a generally applicable MDIS scheme. In addition, this proposal includes the planar mode [3] into MDIS.

# MDIS Modifications

The modified MDIS described in this contribution, is based on the statistics of the rate-distortion optimized IS filtering mode decision ([1 2 1] filter is applied or not) by the video encoder as a function of the intra prediction modes and PU sizes. Table 1 enumerates the HM3 intra prediction modes [4]. Figure 1 illustrates the intra prediction directions and the intra prediction modes. Modes 0 and 34 are respectively the DC mode and the planar mode [3], which are non-directional.

Figure 1 and Table 2 illustrate the modified decision mapping between intra prediction modes and PU sizes. Statistics indicate that the vertical (mode 0) and horizontal (mode 1) prediction directions are not candidates for IS filtering at any PU size. The main diagonal intra prediction directions (modes 3, 6, 9) are candidates for IS filtering at PU levels 32x32 down to 8x8. The statistics further indicate that the intra prediction directions in between the horizontal or vertical intra prediction directions and the main diagonal directions are candidates for IS filtering at progressively smaller PU sizes. For the DC mode the statistics indicate that it is not a candidate for IS filtering, while the planar mode is a candidate for IS filtering at PU sizes 8x8, 16x16, and 32x32.

Table 1 Intra prediction modes in HM3

|  |  |
| --- | --- |
| **PU Size** | **Intra Prediction Modes** |
| 4x4 | 0-16, 34 |
| 8x8 | 0-34 |
| 16x16 | 0-34 |
| 32x32 | 0-34 |
| 64x64 | 0-2, 34 |

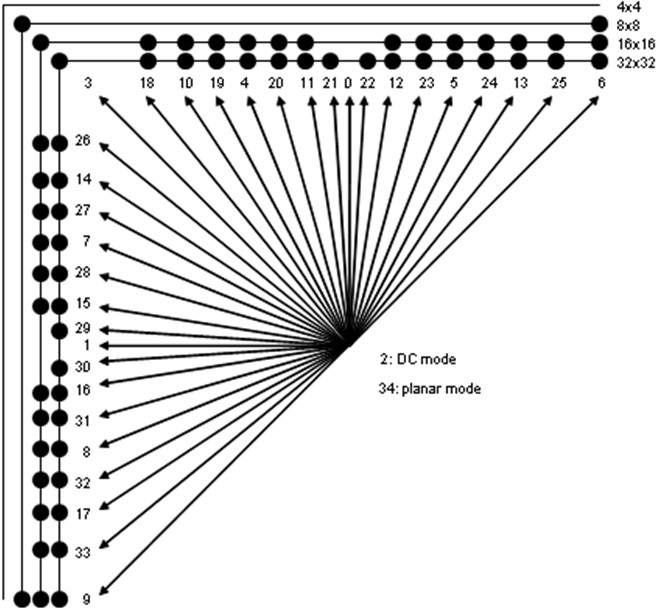


Figure 1 IS filtering is indicated with a marker as a function of intra prediction direction and PU size. When the marker is absent, no filtering is applied.

Table 2 Modified decision mapping table for MDIS

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **PU\Mode** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** | **31** | **32** | **33** | **34** |
| **4x4** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **8x8** |  |  |  | 1 |  |  | 1 |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| **16x16** |  |  |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  |  | 1 | 1 | 1 | 1 | 1 | 1 |  |  | 1 | 1 | 1 | 1 |
| **32x32** |  |  |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

# Results

Table 3 contains the BD-rate performance results of the proposed modified MDIS compared to the HM3 anchor, which has the present MDIS [1] enabled. In particular for Class C, the gain is -0.2% for “All Intra HE” and -0.4% for “All Intra LC”. This is mainly attributable to the rate reduction for the Class C “BasketballDrill” sequence (see Table 4): -0.9% and -1.8% for respectively “All Intra HE” and “All Intra LC”.

Table 5 enumerates BD-rate results for modified MDIS compared to HM3 with the present MDIS disabled (QC\_MDIS=0). This data illustrates that the overall gain is -0.3% and -0.4% for respectively “All Intra HE” and “All Intra LC”. For the higher resolution sequences (classes A, B, E), the gain is -0.4% and -0.6% on average.

Table 3 BD-rate results and execution timings for modified MDIS compared to the HM3 anchor

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | All Intra HE | | | All Intra LC | | |
| Y | U | V | Y | U | V |
| Class A | -0.1 | -0.3 | -0.2 | -0.1 | -0.1 | -0.2 |
| Class B | -0.1 | -0.2 | -0.2 | -0.1 | -0.1 | -0.1 |
| Class C | -0.2 | -0.3 | -0.3 | -0.4 | -0.3 | -0.5 |
| Class D | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 | -0.1 |
| Class E | -0.1 | -0.3 | -0.2 | -0.1 | -0.3 | -0.3 |
| **Overall** | **-0.1** | **-0.2** | **-0.2** | **-0.1** | **-0.2** | **-0.2** |
| Enc Time[%] | 100% | | | 99% | | |
| Dec Time[%] | 100% | | | 99% | | |

Table 4 BD-rate result detail for Class C “BasketballDrill” sequence, in case of modified MDIS compared to the HM3 anchor

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | Y-BD Rate | U-BD Rate | V-BD Rate |
| Class C | BasketballDrill | All Intra HE | -0.9 | -1.2 | -1.1 |
| WVGA |  | All Intra LC | -1.8 | -1.3 | -1.6 |

Table 5 BD-rate results for modified MDIS compared to the HM3 anchor with MDIS disabled (QC\_MDIS=0)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | All Intra HE | | | All Intra LC | | |
| Y | U | V | Y | U | V |
| Class A | -0.5 | -0.7 | -0.9 | -0.8 | -0.6 | -0.9 |
| Class B | -0.3 | -0.5 | -0.4 | -0.4 | -0.3 | -0.2 |
| Class C | -0.1 | -0.3 | -0.3 | -0.1 | -0.2 | -0.3 |
| Class D | -0.1 | -0.2 | -0.2 | -0.1 | -0.1 | -0.1 |
| Class E | -0.4 | -0.8 | -0.7 | -0.6 | -0.8 | -0.7 |
| **Overall** | **-0.3** | **-0.5** | **-0.5** | **-0.4** | **-0.4** | **-0.4** |

# Conclusion

This proposal presented modifications to MDIS, which improve its RD performance by updating the decision mapping table between intra prediction modes and PU sizes, and by including planar mode. On average, the BD-rate performance of the modified MDIS tool is respectively -0.3% and -0.4% for “All Intra HE” and “All Intra LC”. In particular, the BD-rate gain is -0.9% (HE) and -1.8% (LC) for the BasketballDrill sequence (class C).

It is proposed to adopt the modified MDIS into the HM.

# Appendix: Working Draft Description

The following changes to the WD3 [5] reflect the modifications to MDIS from this proposal.

**8.3.3.1.2 Filtering process of neighbouring samples**

Inputs to this process are:

– neighbouring samples p[ x, y ], with x, y = -1..2\*nS-1,

– a variable nS specifying the prediction size.

Output of this process is:

– filtered samples pF[ x, y ], with x, y = -1..2\*nS-1.

**Table 8-6 – Specification of intraFilterType[ nS ][ IntraPredMode ] for various prediction unit sizes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **IntraPredMode** | **intraFilterType**  **for nS = 4** | **intraFilterType**  **for nS = 8** | **intraFilterType**  **for nS = 16** | **intraFilterType**  **for nS = 32** |
| 0-2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 1 | 1 | 1 |
| 4, 5 | 0 | 0 | 1 | 1 |
| 6 | 0 | 1 | 1 | 1 |
| 7, 8 | 0 | 0 | 1 | 1 |
| 9 | 0 | 1 | 1 | 1 |
| 10-20 | 0 | 0 | 1 | 1 |
| 21, 22 | 0 | 0 | 0 | 1 |
| 23-28 | 0 | 0 | 1 | 1 |
| 29, 30 | 0 | 0 | 0 | 1 |
| 31-33 | 0 | 0 | 1 | 1 |
| 34 | 0 | 1 | 1 | 1 |
| 35 | n/a | n/a | n/a | n/a |

Filtered sample array pF[ x, y ] with x = -1..nS\*2-1 and y = -1..nS\*2-1  are derived as follows:

– When intraFilterType[ nS ][ IntraPredMode ] is equal to 1, the following applies:

pF[ -1, nS\*2-1 ] = p[ -1, nS\*2-1 ] (8‑17)

pF[ nS\*2-1, -1 ] = p[ nS\*2-1, -1 ] (8‑18)

pF[ -1, y ] = ( p[ -1, y+1 ] + 2\*p[ -1, y ] + p[ -1, y-1 ] + 2 ) >> 2 for y = nS\*2-2..0 (8‑19)

pF[ -1, -1] = ( p[ -1, 0 ] + 2\*p[ -1, -1] + p[ 0, -1 ] + 2) >> 2 (8‑20)

pF[ x, -1 ] = ( p[ x-1, -1 ] + 2\*p[ x, -1 ] + p[ x+1, -1 ] + 2 ) >> 2 for x = 0..nS\*2-2 (8‑21)

# References

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