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| *Title:* | **3D-CE6.h related: Distortion calculation simplification for Depth Modeling Mode (DMM) 3** | | |
| *Status:* | Input Document | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes further simplifications of Depth Modeling Mode (DMM) 3. In DMM 3, the decoder needs to access the reconstructed Co-located Texture Luma Block (CTLB) to identify a Wedgelet pattern, and for each Wedgelet candidate, a prediction block is generated and Sum of Absolute Difference (SAD) between the CTLB and prediction block is calculated, thus a block has to be predicted and each pixel of the CTLB block has to be accessed. In this contribution, it is proposed that for a given Wedgelet pattern, no SAD of whole blocks is calculated, instead, only the calculation of differences of two sample pairs is needed. It is reported that almost no BD Rate difference is observed using this proposed method.

# Introduction

In 3D-HEVC, DMM is utilized together with the intra coding scheme of HEVC for intra coding of depth map. In DMM, a depth prediction unit (PU) is partitioned into two regions using either pre-defined Wedgelet or generated Contour partitioning pattern, and each region is predicted by a constant value. Four sub-modes are defined in DMM, and one of them, namely DMM 3, utilizes the CTLB to identify a Wedgelet pattern. Given a list of Wedgelet pattern candidates, the DMM 3 will evaluate the performance of each candidate by applying it on CTLB and calculate the SAD between reconstructed and predicted CTLB, then the Wedgelet pattern with least SAD will be selected.

Due to the large set of pre-defined Wedgelet pattern candidates, DMM 3 has significant impact on the decoder complexity for intra coding, and fast Wedgelet search methods are proposed in [1] and [2]. In [1], it is proposed to apply DMM 3 only for cases that the CTLB is intra coded, and it is also proposed that the decoder search is limited to a fixed range around the intra direction of the CTLB. Although the fast Wedgelet search methods can skip a large portion of unnecessary Wedgelet searches, DMM 3 still needs to access reconstructed texture samples and perform block-based SAD calculation for each Wedgelet pattern candidate, which is relatively high-complexity for decoder.

# Proposed Solution

To remove the dependency of accessing CTLB during the decoder search in DMM 3, it is proposed to use the neighboring depth reference samples to identify a Wedgelet pattern.

## Extending of PU boundary

An example of the method to extend the PU boundary is illustrated in Figure 1. While the top and left (boundary) reference samples (denoted as P+1 to P+4 and P-1 to P-4) are always available, the right and bottom (boundary) reference samples are not available. To solve this problem, the extended reference samples in the top/left (denoted as P+5 to P+8 and P-5 to P-8) are rotated clockwise 90/-90 degrees to form the new boundary reference samples for the right/bottom PU boundary.



Figure : Mapping of right/bottom reference samples to the boundary of a depth PU

The new reference samples are denoted as Q+1 to Q+4 and Q-1 to Q-4 respectively for right and bottom boundaries of the current depth PU.

## Difference of the reference sample pairs

For a Wedgelet pattern, assume the partition boundary line intersects the PU reference samples with two pairs of sample values (Si, Si+1) and (Rj, Rj+1), wherein S or R belongs to one of P+, P-, Q+, and Q-, and 0 ≤ i, j < N (N is the width of the square PU).

The distortion of this Wedgelet pattern is calculated as follows:

***D*** = | Si - Si+1 | + | Ri - Ri+1 |.

The Wedgelet pattern with the maximum value of ***D*** is chosen for the current PU which is coded with DMM 3.

For example, in Figure 2, given the Wedgelet pattern, the partition boundary line intersects the PU reference samples with two sample pairs of (P+4, P+5) and (P-4, P-5), then the distortion of this given Wedgelet pattern is calculated as ***D*** = | P+4 - P+5 | + | P-4 - P-5 |.



Figure 2: Example of calculating the difference of reference sample pairs

It is noted that the proposed method avoids accessing the reconstructed CTLB during each of the decoder searches in DMM 3 mode. Also the distortion calculation only involves two absolute difference calculations, which is much simpler than the original block-based SAD which needs *N*×*N* absolute difference calculations. The steps illustrated above for 4x4 PU can also be directly applied to 8x8, 16x16 and 32x32 cases.

# Experimental Results

The proposed method is implemented on top of HTM-4.0.1, and simulations were performed under “CTC” [3] and “CTC, VSO off”.

The results are summarized in Table 1 and 2, respectively. As it is reported, for both “CTC” and “CTC, VSO off”, the proposed method introduces 0.01% BD-rate increase.

Table 1: BD rate results for 3-view case under CTC

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | video 0 | video 1 | video 2 | video only | synthesized only | coded & synthesized | enc time | dec time | ren time |
| Balloons | 0.0% | 0.0% | 0.0% | 0.0% | -0.05% | -0.04% | 93.3% | 91.8% | 94.8% |
| Kendo | 0.0% | 0.0% | 0.0% | 0.0% | 0.08% | 0.06% | 102.7% | 96.1% | 95.6% |
| Newspapercc | 0.0% | 0.0% | 0.0% | 0.0% | -0.08% | -0.05% | 101.3% | 99.6% | 96.6% |
| GhostTownFly | 0.0% | 0.0% | 0.0% | 0.0% | -0.01% | -0.01% | 97.9% | 99.0% | 95.8% |
| PoznanHall2 | 0.0% | 0.0% | 0.0% | 0.0% | 0.01% | -0.01% | 97.5% | 95.3% | 99.9% |
| PoznanStreet | 0.0% | 0.0% | 0.0% | 0.0% | -0.05% | -0.04% | 102.2% | 96.0% | 98.8% |
| UndoDancer | 0.0% | 0.0% | 0.0% | 0.0% | 0.12% | 0.11% | 101.2% | 95.2% | 99.7% |
| 1024x768 | 0.0% | 0.0% | 0.0% | 0.0% | -0.02% | -0.01% | 99.0% | 95.8% | 95.7% |
| 1920x1088 | 0.0% | 0.0% | 0.0% | 0.0% | 0.02% | 0.01% | 99.7% | 96.4% | 98.5% |
| **average** | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **0.01%** | **0.00%** | **99.4%** | **96.1%** | **97.3%** |

Table 2: BD rate results for 3-view case under CTC, VSO off

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | video 0 | video 1 | video 2 | video only | synthesized only | coded & synthesized | enc time | dec time | ren time |
| Balloons | 0.0% | 0.0% | 0.0% | 0.0% | 0.03% | 0.03% | 102.9% | 100.6% | 103.8% |
| Kendo | 0.0% | 0.0% | 0.0% | 0.0% | -0.20% | -0.14% | 97.9% | 100.8% | 105.8% |
| Newspapercc | 0.0% | 0.0% | 0.0% | 0.0% | -0.39% | -0.24% | 100.6% | 93.9% | 100.1% |
| GhostTownFly | 0.0% | 0.0% | 0.0% | 0.0% | 0.26% | 0.17% | 103.4% | 99.5% | 97.5% |
| PoznanHall2 | 0.0% | 0.0% | 0.0% | 0.0% | -0.30% | -0.21% | 102.5% | 102.0% | 99.5% |
| PoznanStreet | 0.0% | 0.0% | 0.0% | 0.0% | 0.08% | 0.06% | 107.6% | 103.6% | 101.9% |
| UndoDancer | 0.0% | 0.0% | 0.0% | 0.0% | 0.58% | 0.39% | 101.0% | 99.9% | 101.0% |
| 1024x768 | 0.0% | 0.0% | 0.0% | 0.0% | -0.19% | -0.12% | 100.4% | 98.4% | 103.2% |
| 1920x1088 | 0.0% | 0.0% | 0.0% | 0.0% | 0.16% | 0.10% | 103.6% | 101.3% | 100.0% |
| **average** | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **0.01%** | **0.01%** | **102.2%** | **100.0%** | **101.3%** |

# Conclusion

Further simplification of depth modeling mode 3 for 3D-HEVC is proposed. The proposed method avoids accessing co-located texture luma block and simplifies the distortion calculation during the decoder size Wedgelet pattern search. It is reported that there is almost no BD Rate difference using the proposed method on HTM-4.0.1.

# References

1. X. Zhao, Y. Chen, L. Zhang, M. Karczewicz, “3D-CE6.h related: Depth Modeling Mode (DMM) 3 simplification for HTM,” JCT3V-A0098, Stockholm, SE, 16–20 July 2012.
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# Patent rights declaration(s)

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