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| **Joint Collaborative Team on 3D Video Coding Extension Development**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  2nd Meeting: Shanghai, CN, 13–19 Oct. 2012 | Document: JCT3V-B0052 |

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| *Title:* | **3D-CE6.h related: Simplification on region boundary chain coding for depth map** | | |
| *Status:* | Input Document | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes a simplification for the region boundary chain coding method in 3D-HEVC. In the current 3D-HEVC design, the number of chains needs to be signalled in the coding unit syntax table. It is proposed that the syntax element edge\_count\_minus\_1, representing the number to be removed. Under common test conditition (CTC) and CTC with VSO turned off, the proposed method achieves average -0.03% and -0.18% BD-rate reduction, respectively.

# Introduction

For the intra coding of depth map in current 3D-HEVC, three techniques are utilized including 1) the intra coding scheme in HEVC, 2) depth modeling modes (DMM) and 3) region-boundary chain coding [1]. One of the three methods is identified for each depth PU and signalled in the bitstream. Different from the first method, the latter two methods represent a depth PU with two regions, which is specified by either pre-defined or generated partition patterns.

The region-boundary chain coding, which partitions a depth PU by signaling the region boundaries with chain codes, is featured by the ability of covering more flexible partition patterns compared to the Wedgelet patition as defined in DMM modes. In region-boundary chain coding, the internal edges within an *N×N* depth PU are found at encoder and the correpsonding partition is explicitly signalled by four syntax elements tabulated in Table 1.

**Table 1 Syntax elements used for region boundary chain coding**

|  |  |  |
| --- | --- | --- |
| syntax element | functionality | number of bins |
| **edge\_start\_left\_flag** | signal whether the chains start from left PU boundary | 1 |
| **edge\_start\_position** | signal the start position of chains | *log*2*N* |
| **edge\_count\_minus\_1** | signal the total number of chain codes | *log*2*N*+1 |
| **edge\_code** | signal each chain code | **edge\_count\_minus\_1**+1 chain codes, each chain code is within 1 and 6 bins |

For example, in Figure 1, an 8*×*8 PU is partitioned using chain coding and 7 chain codes are used to explicitly signal the partition pattern. Each chain code is a connection of one sample and one of its eight-connectivity sample, indexed from 0 to 7.



Figure 1: One depth PU partition pattern and the coded chains in chain coding

To explicitly signal the partition pattern shown in Figure 1, edge\_start\_left\_flag is set as “0” using one bin, edge\_start\_position is set as “3” using 3 bins, edge\_count\_minus\_1 is set as “6” using 4 bins. and a series of 7 edge\_code are sequenctially coded as “3, 3, 3, 7, 1, 1, 1”.

For the parsing process in region-boundary chain coding, it is noted that edge\_count\_minus\_1 is utilized for the decoder to identify the termination of the parsing of edge\_code.

# Proposed Solution

It is noted that the signaling of total number of edges is actually unnecessary and can be implicitly derived by simply adding one more chain which points out of the PU boundary. Specifically, the proposed syntax elements for region boundary chain coding are illustrated in Table 2, and changes from Table 1 are highlighted in red. From Table 2, it is noted that the syntax element edge\_count\_minus\_1is completely removed and one more chain code is added.

**Table 2 Syntax elements used for region boundary chain coding**

|  |  |  |
| --- | --- | --- |
| syntax element | functionality | number of bins |
| **edge\_start\_left\_flag** | signaling whether the chains start from left PU boundary | 1 |
| **edge\_start\_position** | signal the start position of chains at a PU boundary | *log*2*N* |
| **~~edge\_count\_minus\_1~~** | ~~signal the total number of chain codes minus one~~ | *~~log~~*~~2~~*~~N~~*~~+1~~ |
| **edge\_code** | signal all the chains with the depth PU | edge\_count\_minus\_1+2 chain codes, each chain code is within 1 and 6 bins |

During the parsing of edge\_code, the coordinate of current chain is tracked. When the coordinate falls out of the PU boundary, the current chain is identified as the last chain and the parsing of edge\_code terminates.

For example, for the 8*×*8 PU shown in Figure 1, the proposed method is illustrated in Figure 2. To explicitly signal the partition pattern using proposed method, edge\_start\_left\_flag and edge\_start\_position remain unchanged, but edge\_count\_minus\_1 is removed. A series of 8 edge\_code are sequentially coded as “3, 3, 3, 7, 1, 1, 1, 1”, with an additional chain code “1”, which points out of the PU boundary (highlighted in red), added at the end of original chain codes.



Figure 2: One depth PU partition pattern and the coded chains using proposed method

# Experimental Results

The proposed method is implemented on top of HTM-4.0.1, and simulations were performed under “CTC” [2] and “CTC, VSO off”. The results are summarized in Table 3 and 4, respectively. As it is reported in Table 3 and 4, the proposed method achieves 0.03% and 0.18% BD-rate gain with almost no runtime difference.

Note that since the current encoder with VSO on made the performance of DMM modes and region-boundary chain coding much worse (1.63% BD-rate gain altogether), it is considered that the results generated with “CTC, VSO off” may be more informative. When VSO is turned off, the simplification provides 0.18% BD-rate reduction in average for synthesized views.

Table 3: 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% | -0.07% | -0.05% | 94.4% | 96.3% | 101.7% |
| Kendo | 0.0% | 0.0% | 0.0% | 0.0% | 0.01% | 0.00% | 102.3% | 104.8% | 99.4% |
| Newspapercc | 0.0% | 0.0% | 0.0% | 0.0% | -0.05% | -0.03% | 97.0% | 96.5% | 98.9% |
| GhostTownFly | 0.0% | 0.0% | 0.0% | 0.0% | -0.14% | -0.12% | 94.9% | 93.4% | 94.3% |
| PoznanHall2 | 0.0% | 0.0% | 0.0% | 0.0% | 0.07% | 0.05% | 96.9% | 95.4% | 101.1% |
| PoznanStreet | 0.0% | 0.0% | 0.0% | 0.0% | -0.02% | -0.02% | 105.9% | 102.9% | 99.0% |
| UndoDancer | 0.0% | 0.0% | 0.0% | 0.0% | -0.03% | -0.02% | 100.2% | 94.6% | 101.6% |
| 1024x768 | 0.0% | 0.0% | 0.0% | 0.0% | -0.04% | -0.03% | 97.8% | 99.1% | 100.0% |
| 1920x1088 | 0.0% | 0.0% | 0.0% | 0.0% | -0.03% | -0.03% | 99.4% | 96.5% | 99.0% |
| **average** | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **-0.03%** | **-0.03%** | **98.7%** | **97.6%** | **99.4%** |

Table 4: 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% | 0.00% | 0.00% | 99.7% | 101.4% | 101.1% |
| Kendo | 0.0% | 0.0% | 0.0% | 0.0% | -0.15% | -0.10% | 95.5% | 93.7% | 100.4% |
| Newspapercc | 0.0% | 0.0% | 0.0% | 0.0% | -0.44% | -0.29% | 98.2% | 88.2% | 99.8% |
| GhostTownFly | 0.0% | 0.0% | 0.0% | 0.0% | -0.02% | -0.02% | 102.0% | 101.7% | 103.4% |
| PoznanHall2 | 0.0% | 0.0% | 0.0% | 0.0% | -0.29% | -0.20% | 94.4% | 98.1% | 99.1% |
| PoznanStreet | 0.0% | 0.0% | 0.0% | 0.0% | -0.03% | -0.01% | 101.1% | 104.8% | 100.8% |
| UndoDancer | 0.0% | 0.0% | 0.0% | 0.0% | -0.33% | -0.22% | 106.6% | 107.0% | 107.5% |
| 1024x768 | 0.0% | 0.0% | 0.0% | 0.0% | -0.20% | -0.13% | 97.8% | 94.3% | 100.4% |
| 1920x1088 | 0.0% | 0.0% | 0.0% | 0.0% | -0.17% | -0.11% | 100.9% | 102.8% | 102.7% |
| **average** | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **-0.18%** | **-0.12%** | **99.6%** | **99.1%** | **101.7%** |

# Conclusion

Simplification of the current chain coding design is proposed to remove one redudant syntax element to signal the chain coding in the coding unit of a depth slice. The proposed method achieves in average 0.18% BD-rate gain on 3DV-HTM4.0.1 under CTC when VSO is turned off and introduces no loss for common test condition.

# References

1. J. Heo, E. Son, and S. Yea, “CE6.h Region Boundary Chain Coding for Depth-map,” JCT3V-A0070, Stockholm, SE, 16–20 July 2012.
2. D. Rusanovskyy, K. Müller, A. Vetro, “Common Test Conditions of 3DV Core Experiments,” JCT3V-A1100, Stockholm, SE, 16–20 July 2012.

# Patent rights declaration(s)

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