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| *Title:* | **CE 6.h related: Applying Depth Look-up Table to Intra Modes of Depth Map** | | |
| *Status:* | Input Document | | |
| *Purpose:* | Proposal | | |
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# Abstract

DLT shows its advantage in simplified depth coding (SDC), and this contribution further exploits its advantage in other intra modes of depth map. This contribution proposes an alternative residual generation method for all intra modes excluding SDC. Instead of calculating residual as the difference of original pixel value and prediction pixel value directly, both original pixel value and prediction pixel value are firstly mapped to depth index through DLT, and then residual is generated as the difference of these two depth indexes. Rate distortion optimized selection between proposed method and method in 3D-HEVC is performed at encoder and one flag is encoded for each intra coded (excluding SDC) depth CU to indicate which method is used.

It is reported that -0.29% coding gain is achieved on synthesized view in CTC case, and this doubles the gain brought by DLT. In AI case, there is -0.54% coding gain on synthesized view. For sequences using DLT, there is -0.50% and -0.95% coding gain on synthesized view for CTC case and AI case respectively. The encoding time and decoding time is not increased much or even reduced by 3.4% and 1.2% respectively for CTC case, while for AI case, the encoding time is increased by 50% because each intra mode excluding SDC is tested twice and the decoding time is increased by 3.7%.

When combined with JCT3V-E0156, -0.94% coding gain on synthesized view can be achieved and encoding time and decoding time is not increased much.

# Proposed Method

Enlightened by DLT used in SDC [1], this contribution proposes an alternative residual generation method for all intra modes excluding SDC. Instead of calculating residual as the difference of original pixel value and prediction pixel value directly, both original pixel value and prediction pixel value are firstly mapped to depth index through DLT, and then residual is generated as the difference of these two depth indexes. Let *org*[*x*], *pred*[*x*] and *resi*[*x*] be the original value, intra predicted value and residual at position *x* respectively, and let *DLT*[*a*] be the index of depth value *a*. In proposed method, *resi*[*x*] is generated as:

*resi*[*x*] = *DLT*[*org*[*x*]] – *DLT*[*pred*[*x*]] (1)

Rate distortion optimized selection between proposed method and method in 3D-HEVC is performed at encoder and one flag is encoded for each intra coded (excluding SDC) depth CU to indicate which method is used.

At decoder, Let *rec*[*x*], *pred*[*x*] and *resi*[*x*] be the reconstructed value, intra predicted value and residual at position *x* respectively, and let *IDLT*[*a*] be the depth value of index *a*. *rec*[*x*] is constructed as:

*rec*[*x*] = *IDLT*[ *DLT*[*pred*[*x*]] + *resi*[*x*] ] (2)

Of course, there is also one clip operation required for eq. (2). From (2), it can be observed that when compared with decoding method in 3D-HEVC, there is additional two look up table operation required for each pixel. The size of look up table is 256 which is small, therefore the complexity increase caused by look up table is light.

# Results

Proposed method is integrated into HTM 7.0r1 software and compared with it following common test condition [2].

**2.1 Compared with HTM-7.0r1**

Results are shown in Table 1 and Table 2 for CTC case and AI case respectively. As can be seen, there is -0.29% coding gain and -0.54% coding on synthesized view for CTC case and AI case respectively. For sequences using DLT, there is -0.50% and -0.95% coding gain on synthesized view for CTC case and AI case respectively.

The encoding time and decoding time is not increased much for CTC case (or even reduced by 3.4% and 1.2% for encoding time and decoding time respectively), while for AI case, the encoding time is increased by 50% because each intra modes is tested twice and the decoding time is increased by 3.7%.

Table 1: performance comparison with HTM-7.0r1 (CTC)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | video 0 | video 1 | video 2 | video PSNR / video bitrate | video PSNR / total bitrate | synth PSNR / total bitrate | enc time | dec time |
| Balloons | 0.00% | 0.02% | -0.04% | -0.02% | -0.33% | -0.30% | 87.5% | 98.9% |
| Kendo | 0.00% | 0.16% | -0.05% | 0.03% | -0.50% | -0.61% | 108.0% | 98.9% |
| Newspaper\_CC | 0.00% | 0.05% | -0.09% | 0.00% | -0.70% | -0.93% | 90.1% | 99.1% |
| GT\_Fly | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 107.7% | 98.7% |
| Poznan\_Hall2 | 0.00% | 0.01% | 0.21% | 0.01% | -0.14% | -0.17% | 88.5% | 98.8% |
| Poznan\_Street | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 86.7% | 98.5% |
| Undo\_Dancer | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 107.7% | 98.7% |
| 1024x768 | 0.00% | 0.08% | -0.06% | 0.00% | -0.51% | -0.61% | 95.2% | 99.0% |
| 1920x1088 | 0.00% | 0.00% | 0.05% | 0.00% | -0.04% | -0.04% | 97.6% | 98.7% |
| **average** | **0.00%** | **0.03%** | **0.00%** | **0.00%** | **-0.24%** | **-0.29%** | **96.6%** | **98.8%** |

Table 2: performance comparison with HTM-7.0r1 (AI)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | video 0 | video 1 | video 2 | video PSNR / video bitrate | video PSNR / total bitrate | synth PSNR / total bitrate | enc time | dec time |
| Balloons | 0.00% | 0.00% | 0.00% | 0.00% | -0.79% | -0.96% | 185.0% | 106.7% |
| Kendo | 0.00% | 0.00% | 0.00% | 0.00% | -0.92% | -1.07% | 189.7% | 105.9% |
| Newspaper\_CC | 0.00% | 0.00% | 0.00% | 0.00% | -0.94% | -1.15% | 180.2% | 110.0% |
| GT\_Fly | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 100.2% | 99.6% |
| Poznan\_Hall2 | 0.00% | 0.00% | 0.00% | 0.00% | -0.37% | -0.61% | 190.9% | 104.0% |
| Poznan\_Street | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 102.6% | 99.6% |
| Undo\_Dancer | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 100.4% | 99.9% |
| 1024x768 | 0.00% | 0.00% | 0.00% | 0.00% | -0.88% | -1.06% | 185.0% | 107.6% |
| 1920x1088 | 0.00% | 0.00% | 0.00% | 0.00% | -0.09% | -0.15% | 123.5% | 100.8% |
| **average** | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **-0.43%** | **-0.54%** | **149.9%** | **103.7%** |

**2.2 Compared JCT3V-E0156 + JCT3V-E0157 with HTM-7.0r1**

Because both proposals are extensions of SDC, we also show the combined influence of them.

Results are shown in Table 3 for CTC case (Since JCT3V-E0156 does not influence AI case, the results for AI case is not shown). As can be seen, there is -0.94% coding gain on synthesized view. The encoding time and decoding time are not increased much.

Table 3: performance comparison with HTM-7.0r1 (CTC)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | video 0 | video 1 | video 2 | video PSNR / video bitrate | video PSNR / total bitrate | synth PSNR / total bitrate | enc time | dec time |
| Balloons | 0.00% | 0.00% | -0.07% | -0.02% | -0.23% | -0.71% | 86.9% | 101.7% |
| Kendo | 0.00% | 0.15% | -0.27% | -0.03% | -0.38% | -1.16% | 115.1% | 100.9% |
| Newspaper\_CC | 0.00% | -0.02% | 0.03% | 0.01% | -0.37% | -1.33% | 87.0% | 101.6% |
| GT\_Fly | 0.00% | -0.98% | -1.06% | -0.25% | 0.06% | -1.10% | 105.4% | 102.1% |
| Poznan\_Hall2 | 0.00% | -0.22% | 0.20% | -0.02% | 0.19% | -1.14% | 89.8% | 101.5% |
| Poznan\_Street | 0.00% | -0.19% | -0.08% | -0.04% | 0.06% | -0.26% | 88.1% | 102.0% |
| Undo\_Dancer | 0.00% | -0.42% | -0.40% | -0.09% | 0.15% | -0.86% | 105.1% | 101.8% |
| 1024x768 | 0.00% | 0.04% | -0.10% | -0.02% | -0.33% | -1.07% | 96.3% | 101.4% |
| 1920x1088 | 0.00% | -0.45% | -0.33% | -0.10% | 0.12% | -0.84% | 97.1% | 101.9% |
| **average** | **0.00%** | **-0.24%** | **-0.24%** | **-0.07%** | **-0.07%** | **-0.94%** | **96.7%** | **101.7%** |

# Conclusion

This contribution proposes to further exploit advantage of DLT. For CTC case, -0.29% coding gain is achieved. Meanwhile, when combined with JCT3V-E0156, -0.94% coding gain can be achieved. Therefore, we recommend adopting both JCT3V-E0156 and JCT3V-E0157 into 3D-HEVC.

# Reference

[1] G. Tech, K. Wegner, Y. Chen, S.Yea, “3D-HEVC Test Model 3”, Doc. JCT3V-C1005, Geneva, Swizerland, 17–23 Jan. 2013.

[2] D. Rusanovskyy, K. Müller, A. Vetro, “Common Test Conditions of 3DV Core Experiments”, Doc. JCT3V-D1100, Inchon, KR, 20–26 Apr. 2013.

# Patent rights declaration(s)

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