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| *Title:* | **CE4-related: ARP simplification** | | |
| *Status:* | Input Document to JCT-3V | | |
| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | Tomohiro Ikai  1-9-2 Nakase, Mihama-ku, Chiba-shi, Chiba 261-8520  JAPAN | Tel: Email: | +81-43-299-8526 [ikai.tomohiro@sharp.co.jp](mailto:ikai.tomohiro@sharp.co.jp) |
| *Source:* | Sharp Corporation | | |

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# Abstract

This proposal presents an ARP simplification. In ARP, the number of motion compensation (MC) is three times more than the the number in normal MC. Specifically one MC for predictor and two MC for residual derivation is needed for LX luma, cb and cr component. Although, in pixels basis, the memory access and operation is not so high in courtesy of bi-linier compensation usage, in real case the time of the access / operation is not proportional to the number of pixels. Considering this, it is proposed to omit chroma residual prediction for 4x4 chroma block to reduce the worst case complexity.

The experiment result shows that the BD-rate gain is 0.0 %, 0.0 % and 0.0 % in video, total video and synthesis respectively.

Revision 1 adds a complexity comparison between the proposal and the anchor. It is reported that with the proposed ARP simplification, the worst-case memory bandwidth increase compared to HEVC version1 (8x8 bipred case) is down from 122 % to 105 %. It is asserted that practical impact can be larger since in practical case more data access is needed from the limitation of smallest unit of memory access

Revision2 fixed 8x8 CU computation

# Introduction

In ARP, we need three MC operations per unit, where each MC operation needs external memory access. This MC operation and the associated memory access is carried out for each colour components. By utilizing bi-prediction compensation, the number of memory access in pixel basis or operations is significantly reduced so that the number is comparable to 8 tap / 4tap motion compensation case in HEVC version 1. However, there exists overhead of MC and memory access. For example, loading filter coefficients, request of memory fetch and waiting for requested data. We asserted the worst case should be considered again, considering the practical cost is not the same as the ideal cost (the number of access in pixel and operation) and the cost can be dependent of system

# Proposal

The contribution proposes to omit chroma residual prediction in 4x4 chroma block. Table 1 shows the comparison of number of motion compensation in 8x8 PU.

Table 1 Comparison of number of access / operation in unit in 8x8 PU

|  |  |  |  |
| --- | --- | --- | --- |
|  | Luma | Chroma | Total |
| HTM9 | 3 | 3\*2 | 9 |
| Proposal | 3 | 1\*2 | 5 |

# Proposed Text

If nPbW is greater than 8,the modified prediction samples predSamplesLXCb[ x ][ y ] with x = 0..( nPbW /2 ) − 1 and y = 0..( nPbH /2 )−1 are derived as specified in the following:

* 1. predSamplesLXCb[ x ][ y ] = predSamplesLXCb[ x ][ y ] +   
      ( ( currIvSamplesLXCb[ x ][ y ] − refIvSamplesLXCb[ x ][ y ] )  >>  shiftVal ) (‑242)

If nPbW is greater than 8, the modified prediction samples predSamplesLXCr[ x ][ y ] with x = 0..( nPbW /2 ) − 1 and y = 0..( nPbH /2 ) − 1 are derived as specified in the following:

* 1. predSamplesLXCr[ x ][ y ] = predSamplesLXCr[ x ][ y ] +   
      ( ( currIvSamplesLXCr[ x ][ y ] − refIvSamplesLXCr[ x ][ y ] )  >>  shiftVal ) (‑243)

# Simulation results

Experiment result based on HTM90r1 is shown in Table 2

Table 1 Experimental results (anchor: HTM90r1)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | video 0 | video 1 | video 2 | video PSNR / video bitrate | video PSNR / total bitrate | synth PSNR / total bitrate | enc time | dec time | ren time |
| Balloons | 0.0% | 0.4% | 0.4% | 0.13% | 0.12% | 0.05% | 100.5% | 98.6% | 100.1% |
| Kendo | 0.0% | 0.2% | 0.1% | 0.03% | 0.02% | 0.02% | 98.3% | 103.2% | 101.1% |
| Newspaper\_CC | 0.0% | 0.2% | 0.1% | 0.05% | 0.03% | 0.04% | 98.4% | 98.5% | 99.3% |
| GT\_Fly | 0.0% | 0.0% | 0.1% | 0.00% | 0.00% | -0.03% | 99.9% | 99.1% | 99.9% |
| Poznan\_Hall2 | 0.0% | -0.1% | 0.1% | 0.02% | 0.01% | 0.07% | 99.9% | 99.1% | 99.4% |
| Poznan\_Street | 0.0% | 0.0% | 0.0% | -0.01% | -0.01% | -0.01% | 100.4% | 99.4% | 100.0% |
| Undo\_Dancer | 0.0% | -0.1% | -0.1% | -0.01% | -0.01% | -0.03% | 100.1% | 100.8% | 100.4% |
| Shark | 0.0% | 0.1% | 0.1% | 0.02% | 0.00% | 0.02% | 99.6% | 101.3% | 100.4% |
| 1024x768 | 0.0% | 0.2% | 0.2% | 0.07% | 0.06% | 0.04% | 99.1% | 100.1% | 100.2% |
| 1920x1088 | 0.0% | 0.0% | 0.0% | 0.00% | 0.00% | 0.01% | 100.0% | 99.9% | 100.0% |
| **average** | **0.0%** | **0.1%** | **0.1%** | **0.03%** | **0.02%** | **0.02%** | **99.6%** | **100.0%** | **100.1%** |

# Complexity comparison

Table 2 shows that worst case complexity comparison in terms of number of operations and memory bandwidth.

With the proposed method, the worst case bandwidth increases is down from 22 % to 5 % compared to HEVC version1 worst case (8x8 bipred). And the worst case changed from 8x8 PU case to 16x16 PU case.

It is noted that this estimation doesn’t care about memory access pattern (smallest unit of memory access). If memory access pattern is considered, the worst case memory bandwidth can be larger especially in small block.

Table 2: Complexity comparison between HEVC normal MC and 3D-HEVC ARP (the anchor and the proposal)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| HEVC Main profile  (MC) | CU | PU | Mult | Add | Bandwidth | Mult [%] | Add [%] | Bandwidth [%] |
| 64x64 | 64x64 | 42.1 | 35.8 | 3.7 | 74% | 74% | 36% |
| 32x32 | 32x32 | 44.3 | 37.6 | 4.4 | 78% | 78% | 43% |
| 16x16 | 16x16 | 48.5 | 41.3 | 6.0 | 85% | 85% | 60% |
| 8x8 | 8x8 | 57.0 | 48.5 | 10.1 | 100% | 100% | 100% |
| 8x8 | 8x4 | 37.0 | 31.5 | 7.3 | 65% | 65% | 73% |
| 8x8 | 4x8 | 28.5 | 24.3 | 7.3 | 50% | 50% | 73% |
| anchor (3D-HEVC ARP) | CU | PU | Mult | Add | Bandwidth | Mult [%] | Add [%] | Bandwidth [%] |
| 64x64 | 64x64 | 36.4 | 24.2 | 9.4 | 64% | 50% | 93% |
| 32x32 | 32x32 | 36.8 | 24.4 | 9.8 | 64% | 50% | 97% |
| 16x16 | 16x16 | 37.5 | 24.8 | 10.6 | 66% | 51% | 105% |
| 8x8 | 8x8 | 39.0 | 25.5 | 12.3 | 68% | 53% | 122% |
| proposal (3D-HEVC ARP) | CU | PU | Mult | Add | Bandwidth | Mult [%] | Add [%] | Bandwidth [%] |
| 64x64 | 64x64 | 36.4 | 24.2 | 9.4 | 64% | 50% | 93% |
| 32x32 | 32x32 | 36.8 | 24.4 | 9.8 | 64% | 50% | 97% |
| 16x16 | 16x16 | 37.5 | 24.8 | 10.6 | 66% | 51% | 105% |
| 8x8 | 8x8 | 25.5 | 15.8 | 7.6 | 45% | 32% | 75% |

# Conclusion

This proposal omits residual prediction for 4x4 chroma block. Because it removes the worst case concerns with negligible impact, it is recommended to adopt this method in 3D-HEVC.

# Patent rights declaration(s)

**Sharp Corporation may have current or pending patent rights relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**