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| *Title:* | **AHG10: Complexity assessment of motion compensation process** | | |
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# Abstract

This proposal reports a complexity assessment of motion compensation process, especially considering the worst case. 3D-HEVC enhances motion compensation process by introducing Sub-block, VSP, ARP and IC methods. This evaluation is carried out by spreadsheet in terms of number of operation and data transfer rate. It is reported that the simplification techniques for the tools, such as horizontal only motion comp in VSP, is useful to reduce the worst case complexity to be comparable to HEVC version1.

It is recommended to retain these simplification techniques and keep complexity in check for further development.

# Introduction

3D-HEVC enhances the motion compensation process with the following way.

* Sub-block uses 8x8 sub-block motion compensation
* VSP uses horizontal only motion compensation with 8x4 or 4x8 sub-block
* ARP uses motion compensation process three times with bi-linear filter (2Nx2N only)
* IC uses linear model filtering after the conventional motion compensation process (2Nx2N only, 4x4 chroma off and subsampling in parameter derivation)

# Report

In either the number of operations or data transfer rate, the worst case in HEVC version1 (Main profile) resides in 8x8 bi-pred case. In this contribution, the worst case in 3D-HEVC tools is compared with the HEVC worst case.

Table 1 shows 3D-HEVC tool’s worst case comparison (% means the ratio to HEVC 8x8 bi-pred case)

As we can see,

* Sub-block doesn’t change the worst case but it may impact average case (average case is not evaluated in this contribution).
* VSP’s worst case complexity is relatively low in this evaluation
* ARP doesn’t increase the number of operation in worst case in this evaluation but it may increase data transfer rate by 22%
* IC increases the number of operation and data transfer rate by 5, 7 and 4 % in mul, add, and data transfer rate respectively, in worst case.

Table 2 shows a tentative evaluation in non 3D-HEVC setting where VSP uses vertical filtering, ARP uses 8/4 taps, IC uses 4x4 chroma and full sampling. The setting shows 3D-HEVC tools without any complexity reduction techniques increase the worst case significantly. On the other hand, the complexity in the current 3D-HEVC as mentioned in Table 1 seems comparable to HEVC version 1.

Table 3 shows the detail of the evaluation.

Table 1 Summary of complexity evaluation (HEVC case and 3D-HEVC Worst case)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | CU | PU | Mult | Add | Bandwidth | Mult [%] | Add [%] | Bandwidth [%] |
| HEVC | MC | 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% |
| 3D-HEVC | Sub-block | 8x8 | 8x8 | 57.0 | 48.5 | 10.1 | 100% | 100% | 100% |
| VSP | 8x8 | 8x8 | 20.0 | 17.0 | 8.0 | 35% | 35% | 79% |
| ARP | 8x8 | 8x8 | 39.0 | 25.5 | 12.3 | 68% | 53% | 122% |
| IC+MC | 8x8 | 8x8 | 59.7 | 51.8 | 10.5 | 105% | 107% | 104% |

Note: In VSP evaluation, depth access is excluded. Green highlight shows the HEVC worst case and Yellow highlight shows over 100% case.

Table 2 Tentative complexity evaluation for non-3D HEVC case (VSP uses vertical filtering, ARP uses 8/4 taps, IC uses 4x4 chroma and full sampling)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| non 3D-HEVC setting |  | CU | PU | Mult | Add | Bandwidth | Mult [%] | Add [%] | Bandwidth [%] |
|  | VSP0 | 8x8 | 8x8 | 74.0 | 63.0 | 14.7 | 130% | 130% | 146% |
|  | ARP0 | 8x8 | 8x8 | 171.0 | 151.5 | 30.3 | 300% | 312% | 300% |
|  | IC0+MC | 8x8 | 8x8 | 62.5 | 56.4 | 11.1 | 110% | 116% | 110% |

Table 3 Detail of complexity evaluation

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | CU | PU | Mult | Add | Bandwidth | Mult [%] | Add [%] | Bandwidth [%] |
| HEVC | MC | 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% |
|  | Sub-block  (8x8) | 64x64 | 64x64 | 57.0 | 48.5 | 10.1 | 100% | 100% | 100% |
| 32x32 | 32x32 | 57.0 | 48.5 | 10.1 | 100% | 100% | 100% |
| 16x16 | 16x16 | 57.0 | 48.5 | 10.1 | 100% | 100% | 100% |
| 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% |
| Sub-block  (16x16) | 64x64 | 64x64 | 48.5 | 41.3 | 6.0 | 85% | 85% | 60% |
| 32x32 | 32x32 | 48.5 | 41.3 | 6.0 | 85% | 85% | 60% |
| 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% |
| VSP | 64x64 | 64x64 | 20.0 | 17.0 | 8.0 | 35% | 35% | 79% |
|  | 32x32 | 32x32 | 20.0 | 17.0 | 8.0 | 35% | 35% | 79% |
|  | 16x16 | 16x16 | 20.0 | 17.0 | 8.0 | 35% | 35% | 79% |
|  | 8x8 | 8x8 | 20.0 | 17.0 | 8.0 | 35% | 35% | 79% |
|  | 8x8 | 8x4 | 10.0 | 8.5 | 2.8 | 18% | 18% | 27% |
|  | 8x8 | 4x8 | 10.0 | 8.5 | 4.0 | 18% | 18% | 40% |
| ARP | 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% |
| IC+MC | 64x64 | 64x64 | 45.3 | 39.1 | 3.8 | 79% | 81% | 37% |
|  | 32x32 | 32x32 | 47.5 | 41.2 | 4.6 | 83% | 85% | 45% |
|  | 16x16 | 16x16 | 52.1 | 45.5 | 6.4 | 91% | 94% | 63% |
|  | 8x8 | 8x8 | 59.7 | 51.8 | 10.5 | 105% | 107% | 104% |