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| *Title:* | **AHG5: Objective and subjective evaluations of cross-component decorrelation for range extensions profile** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal and Information | | |
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# Abstract

This contribution reports objective and subjective performance of the cross-component decorrelation tool for the general content (camera captured content).

# Introduction

Range extensions profile was studied at the previous meetings, then the 4:4:4 profile remains under consideration. At the same meeting, the new tool, cross-component decorrelation (CCD), was adopted to the draft specification of the range extensions [1].

Since a correlation of cross components in RGB color space is high, bit-rate reduction ratio by the new tool becomes large in RGB content. Therefore, bit-rate reduction ratio in YCbCr color space is selectively studied. In the same manner, YCbCr color space is used for objective performance measurement and informal subjective assessments in this contribution.

Objective performance evaluation by using only Y BD-rate is not reliable because the cross-component decorrelation tool improves the chroma PNSR value. The proponents of the tool reported an alternative performance measure based on the modified chroma value [2]. This contribution reports the Y BD-rate w/ and w/o CCD under the modified chroma such that an improvement of chroma PSNR value becomes zero while the bit-rate reduction becomes large.

Considering that the purpose of the HEVC range extension is to support high fidelity video signals in the high end consumer and professional environment, it is suggested to include additional coding tools in the set of 4:4:4 generic range extension profiles of a general content.

# Proposal of the cross-component decorrelation inclusion

The cross-component decorrelation (CCD) tool improves the BD-rate for not only screen content but also camera captured content. Since the CCD tool has different characteristics from screen content coding (SCC) tools like intra block copy and intra DPCM, we propose the adoption of the CCD tool to all range extension profile or conformance points which are included in Amd.1 in April 2014. In other word, when two 4:4:4 profiles, like an all tool included profile and a general content profile, are created, it is suggested that the latter profile also adopts the CCD tool. If a constraint flag of SCC tools availability is introduced, it is suggested that the CCD tool is not categorized into SCC tools.

# Test procedure

## Objective evaluation

We perform the following experiment by using HM12.1\_RExt5.0.1 for the objective performance measurement by the cross-component decorrelation tool. The test condition follows the range extensions CTC (common test conditions) [3].

* Test 1: The anchor is HM12.1\_RExt5.0.1 and the target is RExt5.0.1 without CCD.
* Test 2: The anchor is HM12.1\_RExt5.0.1 with modified chroma and the target is RExt 5.0.1 without DCC, which is identical to the target of Test 1.

The multiplier for chroma is selected such that an average chroma-PNSR difference at the same QP becomes zero. 1.3 is then chosen as the chroma multiplier.

Cross component decorrelation is turned on and off by the following configuration setting (default setting is 1).

CrossComponentDecorrelation = 0

Chroma modification is performed by the following patch.

--- source/Lib/TLibCommon/TypeDef.h

+++ source/Lib/TLibCommon/TypeDef.h

@@ -77,6 +77,7 @@

#define DEBUG\_STRING\_CHANNEL\_CONDITION(compID)

#endif

+#define JCTVC\_P0xxx\_CHROMA\_LAMBDA (13)

--- source/Lib/TLibEncoder/TEncSlice.cpp

+++ source/Lib/TLibEncoder/TEncSlice.cpp

@@ -177,6 +177,9 @@

Int qpc=(iQP + chromaQPOffset < 0) ? iQP : getScaledChromaQP(iQP + chromaQPOffset, m\_pcCfg->getChromaFormatIdc());

Double tmpWeight = pow( 2.0, (iQP-qpc)/3.0 ); // takes into account of the chroma qp mapping and chroma qp Offset

m\_pcRdCost->setDistortionWeight(compID, tmpWeight);

+#if JCTVC\_P0xxx\_CHROMA\_LAMBDA

+ tmpWeight = tmpWeight\*10/JCTVC\_P0xxx\_CHROMA\_LAMBDA;

+#endif

dLambdas[compIdx]=dLambda/tmpWeight;

}

## Subjective evaluation

We perform two informal subjective assessments by expert subjects. One is DSCQS method, which is comparison between the original videos and coded videos, and the other is ABAB test, which is comparison between coded video w/ and w/o the cross-component decorrelation (CCD) tool. The goal is to confirm the difference in subjective quality between w/ and w/o the CCD tool.

Modified ABAB test was used. The same sequence and the anchor were shown one after another. The order of w/ and w/o the CCD tool was randomized for respective sequence, and such identification is not notified for subjects. Test subjects were asked to rate each condition on a scale from -50 to 50 (not -2 to 2 as usual). The average scores were later calculated as well as 95-percent confidence intervals for every condition and test sequence.

The following seven sequences are used for the test.

1. Traffic, Qp=37, RA
2. Kimono, Qp=37, RA
3. EBULupoCandlelight, Qp=37, RA
4. EBURainFruits, Qp=37, RA
5. VenueVu, Qp=37, RA
6. BirdsInCage, Qp=37, RA
7. CrowdRun, Qp=37, RA.

The length of one session was about 30 minutes, including the training session. In total, 7 test subjects participated in scoring.

# Test results

## Objective results

Table 1 and Table 2 show the summary BD-rate results of the cross-component decorrelation. Positive value means the gain by the CCD tool because the anchor is results with CCD and the target is that without CCD.

Table 1 Summary results w/ and w/o cross-component decorrelation (Test 1)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main-tier** | | | **All Intra High-tier** | | | **All Intra Super-High-tier** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| RGB 4:4:4 | 25.6% | 22.5% | 24.4% | 19.6% | 17.6% | 19.0% | 14.0% | 13.0% | 13.6% |
| YCbCr 4:4:4 | 1.4% | 7.4% | 7.7% | 1.8% | 4.7% | 7.0% | 1.9% | 3.4% | 4.9% |
| Enc Time[%] | 90% | | | 89% | | | 88% | | |
| Dec Time[%] | 102% | | | 103% | | | 104% | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main-tier** | | | **Random Access High-tier** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| RGB 4:4:4 | 18.0% | 15.0% | 17.5% | 14.0% | 10.5% | 13.4% |  |  |  |
| YCbCr 4:4:4 | 0.5% | 9.6% | 8.2% | 0.8% | 6.9% | 8.4% |  |  |  |
| Enc Time[%] | 94% | | | 91% | | |  |  |  |
| Dec Time[%] | 100% | | | 100% | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main-tier** | | | **Low delay B High-tier** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| RGB 4:4:4 | 15.2% | 10.4% | 12.1% | 11.8% | 7.5% | 9.4% |  |  |  |
| YCbCr 4:4:4 | 0.2% | 6.3% | 5.9% | 0.6% | 4.2% | 6.6% |  |  |  |
| Enc Time[%] | 94% | | | 91% | | |  |  |  |
| Dec Time[%] | 101% | | | 101% | | |  |  |  |

Table 2 Summary results w/ and w/o cross-component decorrelation under 1.3 chroma\_lambda (Test 2)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main-tier** | | | **All Intra High-tier** | | | **All Intra Super-High-tier** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| YCbCr 4:4:4 | 5.4% | 0.3% | 2.0% | 5.6% | 1.2% | 4.2% | 4.3% | 3.3% | 4.0% |
| Enc Time[%] | 90% | | | 91% | | | 92% | | |
| Dec Time[%] | 103% | | | 102% | | | 102% | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main-tier** | | | **Random Access High-tier** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| YCbCr 4:4:4 | 5.2% | 3.6% | 5.5% | 3.1% | 6.7% | 4.9% |  |  |  |
| Enc Time[%] | 95% | | | 97% | | |  |  |  |
| Dec Time[%] | 101% | | | 100% | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main-tier** | | | **Low delay B High-tier** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| YCbCr 4:4:4 | 7.1% | -0.5% | 3.8% | 4.5% | 2.8% | 2.6% |  |  |  |
| Enc Time[%] | 94% | | | 96% | | |  |  |  |
| Dec Time[%] | 102% | | | 102% | | |  |  |  |

It is confirmed from the Table 2 that the cross-component decorrelation tool obtains a significant gain for camera captured content in YCbCr color space.

The difference of chroma PNSR values is summarized in Table 3. Negative value means the chroma PSNR improvement by the CCD tool. It is confirmed that the difference of chroma PSNR value w/ and w/o the CCD is suppressed by selecting 1.3 as the multiplier of chroma .

Table 3 Summary results of chroma PSNR difference (w/ and w/o CCD)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | AI-MT | | RA-MT | | LDB-MT | |
|  | cL1.0 | cL1.3 | cL1.0 | cL1.3 | cL1.0 | cL1.3 |
| Traffic | -0.07 | -0.15 | -0.06 | -0.05 | -0.04 | -0.09 |
| Kimono | -0.03 | -0.13 | -0.03 | -0.03 | -0.03 | -0.07 |
| EBULupoCandlelight | -0.20 | 0.08 | -0.19 | 0.13 | -0.15 | 0.07 |
| EBURainFruits | -0.48 | 0.32 | -0.43 | 0.34 | -0.21 | 0.09 |
| VenueVu | -0.20 | -0.03 | -0.19 | 0.04 | -0.17 | -0.02 |
| BirdsInCage | -0.05 | -0.09 | -0.04 | -0.01 | -0.04 | -0.05 |
| CrowdRun | -0.10 | -0.11 | -0.08 | -0.01 | -0.05 | -0.09 |
| **Overall** | -0.16 | -0.01 | -0.15 | 0.06 | -0.10 | -0.02 |

## Results of informal subjective test

The graphs below show the test results. Values with overlapping CI values cannot be rated as distinguishable.

Figure 1 Subjective evaluation by DSCQS. Smaller absolute value means less degradation.

Figure 2 Subjective evaluation by ABAB test. Negative value means that anchor (with CCD) is better than target (without CDD).

Figure 1 shows that significant difference cannot be found by the CCD tool. Figure 2 shows that subjective quality with CCD is better than that without CCD for BirdsInCage content. For the other contents, significant difference cannot be found. These results indicate that CCD tool can reduce the bit-rate without sacrificing the subjective quality.

# Conclusion

This contribution reported objective and subjective performance of the cross-component decorrelation tool for the general content (camera captured content) in YCbCr color space. Furthermore, we proposed the adoption of the cross-component decorrelation tool to all range extensions profiles included in Amd.1 in April 2014. Experimental results indicated that the cross-component decorrelation tool obtained 5.2% gain without sacrificing the subjective quality under the random access main tier condition of RExt CTC with modified chroma value.

# References

1. D. Flynn, J. Sole, G. Sullivan, T. Suzuki, “High Efficiency Video Coding (HEVC) Range Extensions text specification: Draft 5,” ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, Document JCTVC-O1005, Nov 2013.
2. W. Pu, W.-S. Kim, J. Sole, and M. Karczewicz, “RCE1: Descriptions and Results for Experiments 1, 2, 3, and 4,” ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, Document JCTVC-O0202, November 2013.
3. D. Flynn, K. Sharman, and C. Rosewarne, “Common test conditions and software reference configurations for HEVC range extensions,” ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, Document JCTVC-O1006, Nov 2013.

# Patent rights declaration(s)

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