|  |  |
| --- | --- |
| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  12th Meeting: Geneva, CH, 14–23 Jan. 2013 | Document: JCTVC-L0370 |

|  |  |  |  |
| --- | --- | --- | --- |
| *Title:* | **AHG7: Inter-plane intra coding of residual signals for range extensions** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | Kei Kawamura Tomonobu Yoshino Sei Naito  2-1-15, Ohara, Fujimino-shi, Saitama, JAPAN | Tel: Email: | +81 49 278 7411 ki-kawamura@kddi.com |
| *Source:* | KDDI Corp. (KDDI R&D Laboratories, Inc.) | | |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Abstract

This contribution proposes an intra coding approach based on inter-plane prediction of intra residual signals for the HEVC range extensions. This method reduces a correlation of residual signals between two planes by using the linear model. Prediction parameter of the model is derived on the encoder. Resulting parameter is also predicted from neighboring parameters. Only the error value is encoded as additional information. The YUV BD-rate gains of the All Intra / Random Access / Low delay B are 8.2% / 4.5% / 1.5% for the HE Main-tier and 6.7% / 3.2% / 1.0% for the High-tier, respectively.

# Introduction

HEVC range extensions deals with various chroma formats and color spaces such as YUV 4:2:2, YUV 4:4:4, RGB 4:4:4 and so on. Regarding chroma format, the ratio of the luma / green pixels is decreased. On the other hand, the ratio of the chroma / blue & red pixels is increased. Therefore, coding performance in non-main planes (chroma / blue & red) should be considered. Regarding color space, a correlation between planes in RGB becomes larger than that in YUV. Consequently it is effective to reduce inter plane correlation. In the following section, “chroma” means not only U & V components but also B & R components.

# Inter-plane intra coding

## Prediction model

Prediction employs a linear model with one parameter as follows,

where is predicted signals of chroma, is regular intra-predicted signals of chroma, is reference residual signals from the reconstructed luma, and is the parameter. is result of re-intra prediction of the reconstructed luma signals. The re-intra prediction mode of luma is identical to that of chroma. Since the TU correspondence between luma and chroma in not always same, re-calculation techniques is required. For the case of 4:2:2 chroma format, reference pixels are down-sampled as follows,

,

where is reconstructed luma signals and is regular intra prediction of luma signals.

## Parameter derivation

The parameter is derived on an encoder side and then coded. Prediction model of signals is slightly different from derivation model of parameter. The derivation model is linear model as follows,

,

where is original signal of chroma on the encoder side. Parameter and are derived by using the least square equation on our implementation. Parameter is not necessary to be derived because it is not used in the prediction on both the encoder and decoder side. An impact of , which affects the prediction error signals, is included to DC values after transformation.

The parameter is also predicted from neighboring blocks. The parameter is derived as follows,

where and are values of upper and left block, respectively. Although every block has values whatever chroma intra prediction mode is, is estimated from predicted values when chroma intra prediction mode is one of the existing modes.

## Binarization of parameters

The new chroma intra mode and the prediction error of the parameter are coded. The proposed mode is coded with second shortest code word. The shortest coded word of chroma intra-prediction mode indicate that actual intra mode of chroma is same as that of luma. Other chroma intra modes are plane, horizontal, vertical, and DC by this order.

The prediction error of the parameter is coded with truncated unary code.

The variable Intra IntraCrAlphaDiff[ x0 ][ y0 ] is specified as

* If ( ( intra\_chroma\_pred\_rm\_cb\_diff[ x0 ][ y0 ] % 2 ) ) = = 0, IntraCrAlphaDiff[ x0 ][ y0 ] is derived from the value of intra\_chroma\_pred\_rm\_cb\_diff as defined in Table 7-8(a).
* Otherwise, IntraCrAlphaDiff[ x0 ][ y0 ] is derived from the value of intra\_chroma\_pred\_rm\_cb\_diff as defined in Table 7-8(b).

Table Parameter association to prediction mode and partitioning type

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| (a) | 0 | -1 | +1 | -2 | +2 | -3 | +3 | -4 | +4 | -5 | +5 | -6 | +6 | -7 | +7 | -8 |
| (b) | 0 | +1 | -1 | +2 | -2 | +3 | -3 | +4 | -4 | +5 | -5 | +6 | -6 | +7 | -7 | -8 |

# Experimental results

The proposed mode is implemented to HM-range-extensions (r3055). A test condition follows the common test condition for HEVC range extensions [3]. Following tables show the summary of BD-rate gain and codec runtime.

Table Results of the All Intra HE conditions

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE Main-tier** | | | | **All Intra HE High-tier** | | | |
|  | Y | U | V | YUV | Y | U |  | V |
| RGB 4:4:4 | -18.3% | -17.0% | -17.5% | -17.5% | -14.2% | -13.8% | -14.1% | -14.1% |
| YCbCr 4:4:4 | -1.7% | -7.0% | -7.2% | -3.3% | -1.9% | -4.7% | -6.4% | -3.2% |
| YCbCr 4:2:2 | -1.3% | -5.7% | -5.0% | -2.5% | -1.1% | -2.8% | -2.9% | -1.7% |
| **Overall** | -7.6% | -10.2% | -10.2% | -8.2% | -6.1% | -7.4% | -8.1% | -6.7% |
|  | -7.6% | -10.2% | -10.3% | -8.2% | -6.2% | -7.6% | -8.2% | -6.7% |
| Enc Time[%] | 106.4% | | | | 107.0% | | | |
| Dec Time[%] | 101.2% | | | | 100.7% | | | |

Table Results of the Random Access HE conditions

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access HE Main-tier** | | | | **Random Access HE High-tier** | | | |
|  | Y | U |  | V | Y | U |  | V |
| RGB 4:4:4 | -9.0% | -8.6% | -10.0% | -9.1% | -6.4% | -5.5% | -7.2% | -6.2% |
| YCbCr 4:4:4 | -0.6% | -7.1% | -5.9% | -2.2% | -0.6% | -4.9% | -5.0% | -1.9% |
| YCbCr 4:2:2 | -0.5% | -6.7% | -5.1% | -1.5% | -0.4% | -2.6% | -3.0% | -1.1% |
| **Overall** | -3.6% | -7.5% | -7.1% | -4.5% | -2.6% | -4.4% | -5.2% | -3.2% |
|  | -3.6% | -8.0% | -7.1% | -4.5% | -2.7% | -5.2% | -5.4% | -3.4% |
| Enc Time[%] | 100.3% | | | | 100.6% | | | |
| Dec Time[%] | 99.9% | | | | 100.3% | | | |

Table Results of the Low delay B HE conditions

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B HE Main-tier** | | | | **Low delay B HE High-tier** | | | |
|  | Y | U |  | V | Y | U |  | V |
| RGB 4:4:4 | -2.7% | -2.7% | -3.1% | -2.7% | -2.0% | -1.5% | -2.2% | -1.8% |
| YCbCr 4:4:4 | -0.1% | -3.4% | -2.2% | -0.8% | -0.1% | -2.0% | -1.7% | -0.6% |
| YCbCr 4:2:2 | -0.1% | -3.8% | -3.0% | -0.7% | -0.1% | -1.3% | -1.7% | -0.5% |
| **Overall** | -1.1% | -3.3% | -2.8% | -1.5% | -0.8% | -1.6% | -1.9% | -1.0% |
|  | -1.1% | -2.6% | -2.8% | -1.6% | -0.8% | -1.9% | -1.8% | -1.0% |
| Enc Time[%] | 100.3% | | | | 100.6% | | | |
| Dec Time[%] | 100.4% | | | | 100.6% | | | |

# Conclusion

This contribution proposed the inter-plane intra coding based on residual signals with the linear model.

Experimental results showed that the proposed method achieved 8.2%, 4.5%, and 1.5% BD-rate reduction respectively for the All Intra, Random Access and Low delay B of HE Main-tier.

Since the inter-plane intra coding method achieves solid coding gain with inter-plane correlation, we recommend adopting it in HEVC range extensions.

# References

1. K. Kawamura, et al, “CE6.a: Chroma intra prediction based on residual luma samples”, JCTVC-H0117, San José, February, 2012.
2. K. Kawamura et al. “AHG7: Inter-plane intra coding for residual signals”, JCTVC-K0191, Shanghai, Oct. 2012.
3. D. Flynn, “Common test conditions and software reference configurations for HEVC range extensions,” JCTVC-K1006, Shanghai, Oct. 2012.

# Patent rights declaration(s)

**KDDI 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).**