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| *Title:* | **AHG7: Inter-plane intra coding for residual signals** | | |
| *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.) | | |

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# Abstract

This contribution proposes an intra coding approach based on inter-plane prediction of residual signal as HEVC fidelity range extension. This method reduces correlation of residual signals between two planes based on linear prediction model. Prediction parameter is calculated by the sum of the estimated parameter and the estimation error which is encoded as an additional information. The BD-rate gains for Y/U/V in AI-HE10 configuration achieve 1.5%/4.7%/3.9% in YUV422 case.

# Introduction

HEVC fidelity range extension deals with various chroma formats and color spaces such as YUV422, YUV444, RGB444 and so on. Regarding chroma format, the proportion of main plane pixels like luma and green decreases. In contrast, the proportion of chroma or red/blue pixels increases. Therefore, coding performance in non-main plane should be considered. Regarding color space, a correlation between planes in RGB becomes larger than that in YUV. Consequently reduction tool of inter plane correlation is effective.

The proposed method reduces the correlation between the residual signals of the intra prediction. Though the intra-plane prediction reduces the correlation of neighboring pixels in the same plane, inter plane correlation is remained.

The proposed prediction method consists of three steps. Predicted signal is calculated by the sum of intra-plane prediction and inter-plane prediction. The inter-plane signals are derived by inverse transformation for main plane signals with prediction parameters. These parameters are derived on the encoder side and prediction errors are coded. This parameter prediction scheme overcomes the difference of correlation between planes in color spaces.

# Inter-plane intra coding

## Prediction model

Prediction utilises 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 of reconstructed luma, and is parameter. is result of re-intra prediction of reconstructed luma signals. The re-intra prediction mode of luma is identical to that of chroma. Since the TU correspondence between luma and chroma is not always same, re-calculation techniques is required.

## Parameter derivation

The parameter is derived on an encoder side and 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. Parameters and are derived by using least square equation on our implementation. Parameter is not necessary to be derived because it is not used in prediction. An influence of is included to prediction error of signals and finally included to DC values after transformation.

The parameter is also predicted from neighboring blocks and prediction error is coded. 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 conventional one.

## Binarization of parameters

The new chroma intra mode and the prediction error of parameter are coded. The proposed mode is coded with second shortest code word. The shortest code 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 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 7‑12 ‑ 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 HM8.0/Ahg7.

Common test condition for AHG7 follows as the BoG report of JCTVC-J0581.

Following tables show the summary of BD-rate for YUV422/YUV444 sequences.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE10 (YUV422)** | | | **All Intra HE10 (YUV444)** | | |
|  | Y | U | V | Y | U | V |
| Kimono | -1.3% | -2.6% | -2.2% | -2.0% | -2.0% | -2.6% |
| Parkscene | -2.4% | -6.0% | -2.9% | -3.5% | -4.6% | -3.2% |
| BirdsInCage | -0.8% | -1.7% | -4.9% | -1.6% | -1.9% | -8.0% |
| DucksAndLegs | -0.3% | -0.7% | -0.6% | -0.5% | -0.6% | -1.0% |
| Traffic | -0.9% | -1.6% | -3.7% | -1.0% | -1.6% | -5.0% |
| CrowdRun | -0.9% | -6.0% | -4.3% | -2.1% | -5.8% | -5.2% |
| OldTownCross | -0.8% | -3.8% | -2.6% | -1.4% | -2.8% | -2.1% |
| Seeking | -4.5% | -15.4% | -10.2% | -7.8% | -13.3% | -9.8% |
| **Overall** | -1.5% | -4.7% | -3.9% | -2.5% | -4.1% | -4.6% |
| Enc Time[%] | 104% | | | 105% | | |
| Dec Time[%] | 103% | | | 103% | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access HE10 (YUV422)** | | | **Random Access HE10 (YUV444)** | | |
|  | Y | U | V | Y | U | V |
| Kimono | -0.5% | -4.7% | -1.8% | -0.7% | -3.2% | -1.8% |
| Parkscene | -0.9% | -8.5% | -2.0% | -1.6% | -6.3% | -1.8% |
| BirdsInCage | -0.5% | -3.2% | -5.7% | -0.8% | -1.5% | -8.4% |
| DucksAndLegs | -0.2% | -0.6% | -0.5% | -0.2% | -0.4% | -0.8% |
| Traffic | -0.3% | -2.6% | -4.4% | -0.4% | -1.6% | -4.9% |
| CrowdRun | -0.2% | -6.0% | -3.5% | -0.6% | -5.8% | -4.0% |
| OldTownCross | -0.3% | -8.0% | -5.2% | -0.9% | -3.5% | -3.8% |
| Seeking | -1.5% | -17.1% | -9.3% | -3.5% | -15.1% | -8.9% |
| **Overall** | -0.5% | -6.4% | -4.1% | -1.1% | -4.7% | -4.3% |
| Enc Time[%] | 100% | | | 100% | | |
| Dec Time[%] | 101% | | | 101% | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B HE10 (YUV422)** | | | **Low delay B HE10 (YUV444)** | | |
|  | Y | U | V | Y | U | V |
| Kimono | 0.0% | -1.8% | -0.6% | -0.2% | -0.9% | -0.5% |
| Parkscene | -0.2% | -1.6% | -0.3% | -0.3% | -1.4% | -0.4% |
| BirdsInCage | -0.2% | -1.3% | -3.2% | -0.1% | 0.0% | -5.5% |
| DucksAndLegs | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.2% |
| Traffic | 0.0% | -1.7% | -2.2% | -0.2% | -0.9% | -2.5% |
| CrowdRun | 0.0% | -1.7% | -0.8% | -0.1% | -1.9% | -1.1% |
| OldTownCross | -0.1% | -1.3% | -1.0% | -0.1% | -0.4% | -0.6% |
| Seeking | -0.3% | -6.7% | -4.0% | -1.2% | -6.7% | -4.3% |
| **Overall** | -0.1% | -2.0% | -1.5% | -0.3% | -1.5% | -1.9% |
| Enc Time[%] | 100% | | | 100% | | |
| Dec Time[%] | 102% | | | 101% | | |

Following table shows the summary of BD-rate for additional RGB444 sequences, which are obtained from VQEG web site.

Table 4 Results of RGB444 sequences

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE10** | | | **Random Access HE10** | | | **Low delay B HE10** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| CrowdRun | -15.8% | -13.8% | -14.4% | -7.0% | -5.7% | -6.2% | -2.9% | -2.0% | -2.1% |
| ParkJoy | -7.6% | -7.7% | -8.3% | -8.8% | -6.8% | -8.7% | -5.9% | -3.5% | -5.0% |
| DucksTakeOff | -9.3% | -10.6% | -8.9% | -2.3% | -3.5% | -2.3% | -0.5% | -0.7% | -0.4% |
| InToTree | -5.6% | -6.8% | -6.1% | -1.0% | -0.9% | -1.0% | -0.4% | -0.2% | -0.2% |
| OldTownCross | -13.1% | -12.1% | -12.2% | -5.9% | -4.9% | -5.4% | -2.7% | -1.9% | -1.8% |
| **Overall** | -10.3% | -10.2% | -10.0% | -5.0% | -4.3% | -4.7% | -2.5% | -1.7% | -1.9% |
| Enc Time[%] | 107% | | | 101% | | | 101% | | |
| Dec Time[%] | 98% | | | 99% | | | 99% | | |

# Conclusion

This contribution proposed the inter-plan intra coding based on residual signals.

Experimental results showed that the proposed method achieved 1.5%, 4.7%, and 3.9% BD-rate reduction respectively for Y, U, and V of all intra configuration with HE10 for YUV422 sequences. The BD-rate gain was 2.5%, 4.1%, and 4.6% for Y, U, and V of all intra configuration with HE10 for YUV444 sequences.

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

# References

1. K. Kawamura, et.al, “CE6.a: Chroma intra prediction based on residual luma samples”, JCTVC-H0117, San José, February, 2012.
2. D. Flynn, “BoG report: Extended chroma formats,” JCTVC-J0581, Stockholm, July 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).**