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| *Title:* | **Chroma intra prediction based on residual luma samples** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

HM3.0 employs LM mode which is reported in JCTVC-E266 as chroma intra prediction. The LM mode predicts chroma samples based on reconstructed luma with linear model. Parameter of the linear model is derived from adjacent blocks with linear least square solution. However, only LM mode is insufficient to predict texture where the correlation among adjacent blocks is low. Inter-channel prediction of chroma intra residuals is thus introduced. Chroma intra direction is derived from luma intra direction. Parameter of inter-channel correlation model is derived and coded on the encoder side. Compared to the HM3.0, the average BD-bitrate gain is 0.1%, 3.4%, 3.9% for intra configuration and the average BD-bitrate gain is 0.0%, 4.6%, 4.6% for random access configuration, respectively for Y, U and V components.

# Introduction

In current Test Model (HM) of High Efficiency Video Coding (HEVC) standards, five modes are defined as chroma intra prediction; Vertical, Horizontal, DC + Planar, LM, and mode derived from luma intra direction.

The LM mode predicts chroma samples based on reconstructed luma with linear model. Parameter of the linear model is derived from adjacent blocks with linear least square solution. Since the parameter is affected by the quantization of adjacent blocks, prediction accuracy is degraded. Furthermore, it is hard to predict texture where the correlation among adjacent blocks is low.

This contribution reports the results about chroma intra prediction as an additional chroma intra mode based on luma residual sample. The key feature of the proposed method is to utilize luma residual block for predicting chroma residual block of intra prediction under the same direction with luma block. A relation between both residual components is the linear model. The proposed coding mode is called RM in the following.

# RM prediction

## Overview

When RM mode is used, the prediction process of chroma samples is summarized as two steps. At the first step, the chroma samples are predicted by the mode derived from luma intra direction. At the second step, residual chroma samples are predicted by residual luma samples of the same block as follows,

where and indicate the predicted residual value of chroma block and the reconstructed residual value of luma block, respectively.

The horizontal and vertical sampling ratio of chroma components is half compared to luma component, and the sampling points have 0.5 pixel phase difference in vertical direction in YUV420 sampling. Reconstructed luma residual is down sampled in vertical direction and sub-sampled in horizontal direction considering the chroma component format, as follows,

Parameter is derived on the encoder side and is then quantized, coded. Quantization step is defined as from the preliminary experimental results, and range of the parameter is set as . Parameter is not coded because it is constant value in a transform unit. It means that parameter is implicitly added to a DC coefficient.

RM mode is newly introduced as chroma prediction modes. As the bitstream syntax, parameter is coded in Prediction Unit of each chroma component.

## Details

Decoding method of the parameter  is described. If parameter  of U is zero, parameter  of V is non-zero. If the decoded parameter  of V is less than or equals to 0, the actual parameter  of V is added to -1/8.

When coding unit selects PART\_NxN, luma CU has four prediction units while chroma CU has only one prediction unit. All luma PU does not have same intra prediction mode. Inter channel correlation between luma intra residual and intra chroma intra residual is broken. Therefore, luma intra residual is re-calculated by using top-left luma intra prediction mode and local decoded luma samples.

When a transform unit depth is greater than zero, it is hard to derive the parameter because an appropriate parameter value is varying for each TU. In this contribution, new regulation is introduced into chroma TU depth, such that one chroma PU has only one chroma TU. The gain coming from this constraint is very small.

LM mode in HM3.0 is controlled by "chroma\_pred\_from\_luma\_enabled\_flag." The proposed RM mode follows this flag for further control in profile.

# Experimental results

The proposed method is integrated in HM3.0 software and compared with it as anchor. The experiments were performed with the common test configuration described in JCTVC-E700.

Table 1 shows average BD-bitrate gain of the proposed RM mode compared to the anchor HM3.0 software for the all intra condition. The average BD-bitrate saving of Y, Cb, and Cr components are 0.1%, 3.4%, 5.9% in all intra / high efficiency condition, and 0.1%, 3.6%, 3.9% in all intra / low complexity condition. While encoding time is increased under ten percent, decoding time is almost same to the anchor. Table 2 shows average BD-bitrate gain for the random access condition.

Table 1 Summary of BD-bitrate by the proposed RM mode for all intra condition.



Table 2 Summary of BD-bitrate by the proposed RM mode for random access condition



# Subjective Comparison

Figure 1and Figure 2 show the coded picture of Cr component by proposed and anchor, respectively. Each figure is the first frame of NebutaFestival coded at QP 37.



Figure 1 A part of first Cr image of the proposed method



Figure 2 A part of first Cr image of the anchor

# Conclusion

In this contribution, intra chroma prediction by residual correlation approach was introduced. Compared to the HM3.0, the average BD-bitrate gain is 0.1%, 3.4%, 3.9% for the all intra configuration.

The proposed method can be easily extended to other YUV sampling format. For YUV 4:2:2 or YUV4:4:4 sequences, the overall gains are expected to be more remarkable.

Since the proposed method achieves solid coding gain without significant complexity increase, the proposed approach should be adopted as the technical issue in CE6: Intra prediction improvements.

# References

1. J. Chen, V. Seregin, S. Lee, W. Han, J. Kim, B.M. Jeon, “CE6.a: Chroma intra prediction by reconstructed luma samples”, JCTVC-E266, Geneva, March, 2011.
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