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| *Title:* | **Chroma intra prediction based on residual luma samples in 4:2:2 chroma format** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution presents an additional chroma intra mode based on inter-channel correlation of residual samples for the 4:2:2 chroma format. Predicted Cb/Cr values are sum of regular prediction (same as DM) and linear equation using reconstructed luma-residual values with a parameter alpha. The parameter alpha is derived and coded on the encoder side. Anchor method is a modified HM7.0 that supports the 4:2:2 chroma format described in JCTVC-J0358. Compared to the modified HM7.0, the average BD-bitrate gains are 0.7%, 3.4%, 2.2%, and 1.4% for all intra HE configuration respectively for Y, U, V, and YUV components.

# Introduction

JCT-VC decides to start standardization of chroma format extension [1]. JCTVC-J0358 provides modification of current HM to support 4:2:2/4:4:4 chroma formats [2]. In the modified HEVC Test Model (modified HM), six modes are defined as chroma intra prediction; Vertical, Horizontal, DC, Planar, LM, and mode derived from luma intra direction. The contribution of an improvement in the field of chroma samples grows because the number of chroma samples increases.

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 sample values around object boundaries 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 [3, 4, 5]. 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. The revised point is to adapt RM to the 4:2:2 chroma format.

# 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, named regular prediction. At the second step, residual chroma samples are predicted by residual luma samples of the same block. Final predicted chroma values are as follows,

Parameters are derived from another linear model, as follows,

Parameter is derived on the encoder side and is then quantized, coded. Quantization step is defined as from the preliminary experiments, 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 introduces two restrictions as follows. A series of chroma processing is performed at coding unit size. TUDepth of coding unit is always set 0. RegularLumaReprediction is always performed in order to produce LumaResidual values which correspond to chroma-coding unit values.

## Syntax

RM mode is additional chroma prediction mode. Position of RM mode is after DM and LM and is before Planar, Horizontal, Vertical and DC.

Parameter is binarized into index in prediction unit of each chroma component. Since signs of Cb-alpha and Cr-alpha are frequently opposite, the index of Cr-alpha depends on the sign of Cb-alpha. Each index is coded by using truncated unary syntax.

## Encoder Optimization

An early termination technique in RDO reduces a lot of encoding runtime. Since RM mode uses the residual luma signals, gain of RM mode is not obtained from low-activity luma units. Based on the size of coding unit and depth of transform unit, a tentative coding of RM mode is skipped in the RDO process.

# Experimental results

The proposed method is integrated in the modified HM7.0 software [2] and compared with it as anchor. The experiments were performed with the common test configuration described in JCTVC-I1100 [6]. Since the gain is obtained from Cb/Cr improvement, YUV BD-bitrate assessment is added to the table. Weighted factor is 0.5:0.25:0.25.

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|  | **All Intra Main** | | | | **All Intra HE10** | | | |
|  | Y | U | V | YUV | Y | U | V | YUV |
| s209 | 0.0% | -1.1% | -1.7% | -0.4% | 0.0% | -0.9% | -1.1% | -0.3% |
| s210 | -2.1% | -7.8% | -4.5% | -3.6% | -0.8% | -4.3% | -2.1% | -1.7% |
| s214 | -0.5% | -3.9% | -2.3% | -1.5% | -0.1% | -2.5% | -1.1% | -0.7% |
| s215 | -1.7% | -4.6% | -3.4% | -2.5% | -1.0% | -3.0% | -2.2% | -1.6% |
| **Overall** | -1.1% | -4.3% | -3.0% | -2.0% | -0.5% | -2.7% | -1.6% | -1.1% |
|  | -1.1% | -4.3% | -3.0% | -2.0% | -0.5% | -2.6% | -1.6% | -1.1% |
| Enc Time[%] | 102.7% | | | | 103.2% | | | |
| Dec Time[%] | 102.4% | | | | 104.3% | | | |

Table Results of all intra/Main and HE10 conditions. The anchor is the modified HM7.0 supporting 4:2:2 chroma format. All sequences are 1920x1080 60p with first 600 frames.

shows average BD-bitrate gains of the proposed RM mode compared to the modified HM7.0 software for the all intra condition. The average BD-bitrate saving of Y, Cb, and Cr components are 1.1%, 4.3%, 3.0% and 2.0% in all intra main condition, and 0.5%, 2.7%, 1.6% and 1.1% in all intra HE10 condition. Since LMChroma is turned off in the AI/Main condition, BD-bitrate gain of the proposed RM mode in the AI/Main is larger than that in HE10.

# References

1. ISO/IEC JTC1/SC29/WG11 N12742, "Responses to NBs on HEVC issues," May 2012.
2. JCTVC-J0358, "AHG12: 4:2:2/4:4:4 chroma format extension for HEVC Version 2," July 2012.
3. JCTVC-F095, "Chroma intra prediction based on residual luma samples," July, 2011.
4. JCTVC-G346, "Chroma intra prediction based on residual luma samples," November, 2011.
5. JCTVC-H0117, "Chroma intra prediction based on residual luma samples," February, 2012.
6. JCTVC-I1100, "Common test conditions and software reference configurations," May 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).**