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| *Title:* | **AHG5 and AHG18: Bypass of the significance and coefficient level flags for higher throughput** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

In JCTVC-O0208, a method is presented for coding the *coeff\_abs\_level\_greaterX\_flags* in bypass mode, reportedly enabling a higher throughput codec. In this contribution the method is extended to code *significance\_coeff\_flags* in bypass mode. The significance and level flags are coded as part of the syntax element *coeff\_abs\_level\_remaining* when the Rice parameter is above a threshold. Therefore, all the bins in a 4×4 sub-block are coded in bypass mode. The method is also combined with the Rice initialization method D1 of RCE2 (JCTVC-O0239). The performance impact of the method is reported to be negligible for the high bit-depth AHG18 settings when applied on top of D1.

# Introduction

HEVC Range Extensions encompasses high bit-depths and extended chroma formats that impose increased demands on the throughput of the codec, especially when the ‘high precision’ process adopted in the 14th JCT-VC meeting is enabled.

The CABAC engine has two operating modes to code the bins: the context mode and the bypass mode. For the context-coded mode, the engine uses the selected context model to code the binary symbol. After each bin is coded, the model is updated. This mode is highly sequential and has strong data dependences.

Meanwhile, the bypass mode assumes an equi-probable model. This mode is simpler and allows a coding speedup and easier parallelization because it does not require context derivation and adaptation. Parallelization is further facilitated when the binary code is regular (e.g., unary or fixed length code).

This proposal targets the reduction of context-coded bins in the residual data. The method is activated when the Rice parameter is above a threshold, which in turn occurs when the residual data values are high. Therefore, the approach improves throughput in the worst-case and average scenarios.

# Technical description

The amount of residual data being coded is highly correlated with the Rice parameter value because a large coefficient magnitude increases the Rice parameter by means of the following update formula:

cRiceParam = Min( cLastRiceParam + ( cLastAbsLevel > ( 3 \* ( 1  <<  cLastRiceParam ) ) ? 1 : 0 ), 4 ) (9‑13)

At high bit-rates, the Rice parameter saturates to its maximum value. Then, all the context-coded bins are used (*coded\_sub\_block\_flag*, *significance\_coeff\_flag*, and *coeff\_abs\_level\_greaterX\_flag*), and large values of *coeff\_abs\_level\_remaining* are coded (in bypass mode).

We propose to code the *significance\_coeff\_flags* and *coeff\_abs\_level\_greaterX\_flags* in bypass mode when the Rice parameter is large. The flags are coded as part of the remaining level. Also, the *coded\_sub\_block\_flag*s are eliminated. This improves throughput and removes coding loops over the 4×4 sub-blocks.

The proposed method can be naturally combined with RCE2 test D1 [1], since that method sets an initial value for the Rice parameter for each 4×4 sub-block which can be used as the condition for bypassing the coding of the significance and level flags.

## Method for the current specification

The Rice parameter at the end of each 4×4 sub-block is stored. At the beginning of the next sub-block (same TU or a different one) that parameter is used to decide whether significance and level flags are coded in bypass mode. If the parameter is equal to 4, then the significance and level flags are bypassed and the *coded\_sub\_block\_flag* is not sent. In this case, the sign flags have to be sent after *coeff\_abs\_level\_remaining.* If the Rice parameter is less than 4, the usual coding process is applied.

Therefore, with the method enabled, all the bins in a 4×4 sub-block are coded in bypass mode. The information contained in the 25 context-coded flags of a sub-block are then sent as part of *coeff\_abs\_level\_remaining*. The process can be summarized as follows:

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| **HEVC** | **Proposed Method** |
| Encode *coded\_sub\_block\_flag*  Loop to encode *significance\_coeff\_flag*  Loop to encode *coeff\_abs\_level\_greater1\_flag*  Loop to encode *coeff\_abs\_level\_greater2\_flag*  Loop to encode *coeff\_sign\_flag*  Loop to encode *coeff\_abs\_level\_remaining* | **If ( previousRiceGolomb < 4 )**  Encode *coded\_sub\_block\_flag*  Loop to encode *significance\_coeff\_flag*  Loop to encode *coeff\_abs\_level\_greater1\_flag*  Loop to encode *coeff\_abs\_level\_greater2\_flag*  Loop to encode *coeff\_sign\_flag*  Loop to encode *coeff\_abs\_level\_remaining*  **Otherwise**  Loop to encode *coeff\_abs\_level\_remaining*  Loop to encode *coeff\_sign\_flag* |

When previousRiceGolomb is equal to 4, the syntax element *coeff\_abs\_level\_remaining* always encodes the absolute level of the coefficient except when the coefficient is the last significant coefficient in the TU. In that case, it encodes the absolute level of the coefficient minus 1.

## Method on top of RCE2 test D1

RCE2 test 1 method derives an initial value of the Rice parameter for each 4×4 sub-block and allows a maximum Rice parameter above 4. In that case, the proposed method can use a threshold larger than 4.

However, the proposal can be implemented even more simply on top of RCE2 test D1 by just using the derived initial Rice parameter as the condition for bypassing the significance and level flags. In this case, the condition

**If ( previousRiceGolomb < 4 )**

is replaced by

**If ( initialRiceGolomb < threshold )**

With this method, there is no need to store the previous Rice parameter. Also, when the threshold is set to 5, the method is equivalent to the current HEVC specification whenever the Rice parameter is within the range of values allowed in HEVC (from 0 to 4).

# Results

The proposal is implemented in HM12.0\_Rext4.1 and in HM12.0\_Rext4.1+Test D1 (setting 1). Simulations are performed under AHG18 test conditions. The performance is compared to the anchor in terms of BD-rate savings.

## Results for AHG18

Tables 1 and 2 show the BD-rate results for the method implemented on top of RCE2 test D1 for the high bit-depth settings for a threshold of 5. The anchors are AHG18 anchor and RCE2 test D1 for tables 1 and 2, respectively.



Table : BD-rate results for threshold = 5 compared to AHG18 anchor



Table : BD-rate results for threshold = 5 compared to RCE2 test D1

Tables 3 and 4 show the BD-rate results for the method implemented on top of RCE2 test D1 for the high bit-depth settings for a threshold of 2. The anchors are AHG18 anchor and RCE2 test D1 for tables 3 and 4, respectively.



Table 3: BD-rate results for threshold = 2 compared to AHG18 anchor



Table 4: BD-rate results for threshold = 2 compared to RCE2 test D1

Table 5 shows BD-rate results for the method implemented on top of HM12.0+RExt-4.1



Table 5: BD-rate results for the method implemented on top of HM12.0+RExt-4.1

# Conclusions

A simple method to encode the significance and level flags based on Rice parameter at the end of previous 4×4 sub-block or the initial Rice parameter for the current 4×4 sub-block is presented. The method enables higher throughput and has no penalty in performance when applied on the top of the Rice initialization method in JCTVC-O0239.

# References

1. L. Guo, J. Sole, R. Joshi, M. Karczewicz, K. Sharman, N. Saunders, J. Gamei, “RCE2: Results of Test D1 on Rice Parameter Initialization”, JCTVC-O0239, Geneva, CH, October 2013.

# Patent rights declaration(s)

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