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| *Title:* | **Modifications to CAVLC RDOQ** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

In this contribution, two modifications to CAVLC RDOQ are presented. In the first modification, the encoder skips some locations for “last position” checking based on coefficient levels. The second modification aims at improving the bits estimation. We test the performance of each modification as well as their joint performance. It is observed that combing them together can speed up the encoding process (5% for Intra and 1%-4% for inter) and also slightly reduce the B-D rate (0.1%).

# Introduction

RDOQ is used in HM to adjust quantization levels to achieve good trade-off between encoding bits and reconstruction distortion. RDOQ for CAVLC has two stages. The first stage is estimating the location of the last non-zero coefficients (“last position”). In this stage, the encoder checks every location and calculates the overall cost if this location is the last non-zero one. The second stage estimates the quantization level of each location. At each location, there are several candidates of quantization levels, and the encoder selects the one giving the minimum rate-distortion cost.

In this contribution, we propose two modifications to CAVLC RDOQ process. The first modification (Modification I) reduces the number of locations for the “last position” checking, and the second modification (Modification II) changes bits estimation for quantization level = 0.

# Proposed Modifications

## Modification I - Reduction of Last Position Checking

In current HM RDOQ, last position checking is performed at all the locations with non-zero quantized level. In our modification, only a subset of these locations are checked. Specifically, for an NxN block with coefficients C0, C1, …Ck.…CNxN-1 (the subscript denotes forward scan order index),let C*i* be the first coefficient (smallest index) that has quantization level > 1, the checking is performed only for non-zero coefficients with index >= i.

## Modification II –Bits Estimation for Level = 0

For each location with non-zero coefficient (before RDOQ), a candidate list of quantization levels is constructed. In current HM RDOQ, the bits number of Ci=0 is estimated with the assumption that the next coefficient Ci-1 is a non-zero coefficient. This assumption may not be true and this affects the estimation accuracy.

Our modified bits estimation for Ci=0 is described as follows: Let Ck be the previous non-zero coefficient and Cj be the next coefficient with non-zero level candidate (j < i < k). When Ci!= 0, the bits of encoding Ci and Cj  is Cost\_nz = bits (run=k-i, level = Ci) + bits (run=i-j, level=Cj). When Ci=0, the bits of encoding Ci and Cj is Cost\_z = bits (run=k-j, level=Cj) as only Cj needs to be encoded. The encoder assumes Cj = 1 and compares Cost\_nz and Cost\_z to decide if setting Ci=0.

# Experimental results

We implemented both Modification I and II on top of HM 3.0. The simulations are conducted under Low Complexity Common Conditions as specified in [1]. The coding efficiency is measured by using 4 point BD-Rate. The encoding time is measured on homogeneous CPU cluster, and the decoding time is measured by decoding all sequences on a single PC.

Table I, II, and III present the results of Modification I, Modification II and Modification I+II respectively. The experiments show Modification I achieves 5% encoding time reduction for AI and RA, 3% reduction for LD and 2% for LDP. It does not affect coding efficiency. Modification II achieves 0.07%/0.09%/0.06%/0.03% bit rate reduction for AI/RA/LD/LDP cases without incurring encoding time increase. Combining Modification I and II together, both encoding acceleration and bit rate reduction are achieved. The speed up is 5% for AI, 4% for RA, 1% for LD and 2% for LDP. The B-D rate reduction (Y) is 0.08% for AI, 0.09% for RA, 0.09% for LD and 0.03% for LDP.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | All Intra LC | | | Random Access LC | | |
| Y | U | V | Y | U | V |
| Class A | -0.01 | 0.03 | 0.02 | -0.05 | -0.09 | 0.12 |
| Class B | -0.01 | 0.00 | 0.00 | -0.02 | -0.01 | -0.01 |
| Class C | 0.00 | -0.01 | -0.01 | -0.01 | 0.01 | -0.02 |
| Class D | 0.00 | 0.00 | -0.01 | 0.01 | 0.09 | 0.02 |
| Class E | -0.01 | 0.02 | 0.02 |  |  |  |
| **Overall** | **-0.01** | **0.00** | **0.01** | **-0.02** | **0.00** | **0.02** |
| Enc Time[%] | 95% | | | 95% | | |
| Dec Time[%] | 101% | | | 98% | | |
|  | Low delay B LC | | | Low delay P LC | | |
| Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | 0.00 | -0.03 | -0.14 | -0.01 | 0.11 | 0.03 |
| Class C | 0.00 | 0.06 | -0.15 | 0.01 | 0.03 | -0.02 |
| Class D | 0.00 | 0.03 | 0.06 | 0.01 | 0.07 | 0.03 |
| Class E | 0.01 | -0.15 | -0.12 | -0.03 | -0.24 | -0.03 |
| **Overall** | **0.00** | **-0.02** | **-0.09** | **-0.01** | **0.01** | **0.01** |
| Enc Time[%] | 97% | | | 98% | | |
| Dec Time[%] | 100% | | | 98% | | |

Table Results of Modification I

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | All Intra LC | | | Random Access LC | | |
| Y | U | V | Y | U | V |
| Class A | -0.08 | 0.15 | 0.19 | -0.06 | 0.00 | 0.14 |
| Class B | -0.09 | 0.16 | 0.15 | -0.09 | 0.10 | 0.13 |
| Class C | -0.07 | 0.06 | 0.02 | -0.08 | -0.05 | -0.09 |
| Class D | -0.07 | 0.04 | 0.09 | -0.13 | -0.30 | -0.22 |
| Class E | -0.05 | 0.06 | 0.03 |  |  |  |
| **Overall** | **-0.07** | **0.10** | **0.10** | **-0.09** | **-0.05** | **0.00** |
| Enc Time[%] | 100% | | | 99% | | |
| Dec Time[%] | 101% | | | 100% | | |
|  | Low delay B LC | | | Low delay P LC | | |
| Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | -0.02 | 0.01 | 0.07 | -0.01 | 0.20 | 0.44 |
| Class C | -0.09 | 0.00 | -0.20 | -0.03 | 0.03 | -0.03 |
| Class D | -0.07 | 0.11 | 0.04 | -0.02 | 0.06 | 0.01 |
| Class E | -0.08 | 0.29 | -0.75 | -0.10 | 0.65 | -1.42 |
| **Overall** | **-0.06** | **0.08** | **-0.16** | **-0.03** | **0.21** | **-0.14** |
| Enc Time[%] | 101% | | | 100% | | |
| Dec Time[%] | 100% | | | 98% | | |

Table 2 Results of Modification II

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | All Intra LC | | | Random Access LC | | |
| Y | U | V | Y | U | V |
| Class A | -0.09 | 0.18 | 0.21 | -0.08 | 0.06 | 0.18 |
| Class B | -0.10 | 0.14 | 0.12 | -0.09 | 0.06 | 0.05 |
| Class C | -0.06 | 0.06 | 0.01 | -0.10 | -0.17 | -0.18 |
| Class D | -0.06 | 0.06 | 0.05 | -0.08 | -0.06 | 0.03 |
| Class E | -0.05 | 0.05 | 0.05 |  |  |  |
| **Overall** | **-0.08** | **0.10** | **0.09** | **-0.09** | **-0.02** | **0.02** |
| Enc Time[%] | 95% | | | 96% | | |
| Dec Time[%] | 101% | | | 98% | | |
|  | Low delay B LC | | | Low delay P LC | | |
| Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | -0.06 | 0.01 | 0.07 | -0.02 | 0.12 | 0.25 |
| Class C | -0.09 | 0.09 | 0.06 | -0.02 | 0.19 | -0.10 |
| Class D | -0.05 | 0.19 | -0.02 | -0.01 | 0.08 | -0.18 |
| Class E | -0.18 | -0.23 | -0.84 | -0.06 | -0.18 | -0.52 |
| **Overall** | **-0.09** | **0.03** | **-0.12** | **-0.03** | **0.07** | **-0.09** |
| Enc Time[%] | 99% | | | 98% | | |
| Dec Time[%] | 100% | | | 98% | | |

Table 3 Results of combining Modification I+ II

# Conclusion

In this contribution, we describe two modifications for HM CAVLC RDOQ. It is observed 5% encoding speed up and 0.08% bit rate reduction for All Intra coding, and 1-4% speed up and 0.03%-0.08% bit rate reduction for other cases. We recommend the proposed modifications be integrated into HM software.

# References

1. F.Bossen, “Common test conditions and software reference configurations”, JCTVC-E700, JCT-VC Meeting, Geneva, CH, Mar. 2011.

# Patent rights declaration(s)

**Qualcomm may have IPR 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).**