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| *Title:* | **Improvements for HEVC rate control** | | |
| *Status:* | Input document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution provides a HEVC encoder solution of rate control improvements that have been evaluated at the JVET meeting of July 2018 [1]. Implementation details and test results followed by common test condition are provided in the document. Simulation results show that the proposed technique can achieve 2.3%/0.8%/0.5% and 7.8%/6.7%/6.4% coding gain for Y/U/V over HM16.20 at Lowdelay B Main10 (LDB) and Randomaccess Main10 (RA) configuration, respectively.

# Introduction

The R-lambda rate control algorithm for HEVC, JCTVC-K0103 [2] and M0036 [3], were introduced and adopted in HM at JCT-VC. In VVC, the R-lambda rate control is further improved in JVET-K0390 [4] by updating the rate-distortion (R-D) parameters of skip and non-skip CTUs separately with different strategies and employing a solution to handle the case where the GOP size is extended to 16. JVET-K0390 [4] was evaluated and adopted in VTM and BMS software at Ljubljana JVET meeting [1]. This proposal provides an implementation of JVET-K0390 [3] for HM software and reports the test results.

# Proposed method

## Rate-distortion parameters updating strategy

In the default parameters updating strategy, rate-distortion parameters are updated by the least square method. The updating speed is controlled by the learning rate parameters, which may lead to an inaccurate parameter estimation. In this contribution, we choose to update the R-D parameters only from the previous one frame in the same level.

The updating strategy is based on the RD model:



As lambda is the slope of the line tangent to the R-D curve:



where  will be obtained after encoding, two variables  can be estimated with the above two equations. Thus, we can use the updated C and K as the new R-D parameters.

## Updating the parameters of skip and non-skip area separately

In the high-resolution video, the skipped blocks take the majority, leading to a very small average bpp and a flat rate-distortion (R-D) curve. Although the flat curve is indeed the actual average R-D curve of this current frame, it has a bad influence on the non-skip CTU whose R-D curve may be quite different from the frame-level. More specifically, in the current rate control framework, the CTU level lambda and QP is clipped by the frame level parameters for avoiding the quality fluctuation, where the coding parameters of non-skip CTU may be clipped incorrectly.

To solve the problem, we propose to split the skip and non-skip CTU, and only using the average bits and lambda for these CTUs as the data for updating frame level parameters. The proposed picture level updating strategy is:

Step1: collecting the average bits and lambda of non-skip CTUs

Step2: Using the average bits to calculate the bits per pixel (bpp) in the non-skip CTU area

Step3: Using the obtained bpp and lambda to update the parameters of rate-distortion model

When allocating the target bits for each frame, the target bits is calculated by:



## Extend rate control to support random access configuration

Current GOP size in random access configuration is 16, while the default rate control only supports the case where the GOP size equals 8 for random access configuration. The main problem is the target bit allocation strategy. The ratio of bits for each layer in our contribution follows the document of JCT-VC W0062 and JCT-VC X0038, where the QP offset value of each level is indicated. Following the QP offset value, and according to the relations of QP and lambda, we can obtain the ratios of lambda in different levels. And then the target bits of each frame are calculated by:



This allocation scheme only works when the initial QP is estimated. When encoding the first two GOP, the initial QP is not acquired, we simply use a predefined bits ratio table for each layer.

# Experimental results

The proposed rate control improvements are implemented on HM16.20. The test is evaluated using BD rates, encoding time, decoding time according to Common Test Conditions (CTC).

## Test results

The proposed HM rate control improvements test results are summarized in Table 1 - 4. Table 1 and 2 show the results compared to the default rate control in LDB and RA configurations, respectively, while Table 3 and 4 show the comparisons between the proposed method and fixed QP method.

Table 1: Over rate control in HM16.20 (LDB)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Over HM16.20** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A |  |  |  |  |  |
| Class B | -2.9% | -0.2% | 0.4% | 101% | 101% |
| Class C | -1.3% | -0.4% | -0.3% | 100% | 101% |
| Class D | -1.0% | 0.4% | 0.3% | 101% | 102% |
| Class E | -4.3% | -3.8% | -3.2% | 100% | 105% |
| **Overall** | -2.3% | -0.8% | -0.5% | 100% | 102% |

Table 2: Over rate control in HM16.20 (RA)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Over HM16.20** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A | -6.7% | 0.1% | 0.8% | 98% | 98% |
| Class B | -9.7% | -10.7% | -9.1% | 98% | 100% |
| Class C | -6.1% | -7.2% | -7.8% | 99% | 101% |
| Class D | -8.4% | -8.0% | -8.7% | 96% | 97% |
| Class E |  |  |  |  |  |
| **Overall** | -7.8% | -6.7% | -6.4% | 98% | 99% |

Table 3: Over FixQP in HM16.20 (LDB)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Over HM16.20** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A |  |  |  | 100% | 100% |
| Class B | 2.3% | 0.0% | -1.1% | 101% | 99% |
| Class C | -2.0% | -5.0% | -4.1% | 101% | 104% |
| Class D | -0.5% | -1.2% | -0.3% | 100% | 99% |
| Class E | 0.7% | -1.2% | 0.2% | 100% | 100% |
| **Overall** | 0.2% | -1.8% | -1.4% | 100% | 101% |

Table 4: Over FixQP in HM16.20 (RA)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Over HM16.20** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A | 7.3% | 5.1% | 7.9% | 100% | 96% |
| Class B | 7.1% | 10.8% | 13.9% | 100% | 99% |
| Class C | 3.7% | 2.5% | 3.5% | 100% | 103% |
| Class D | 4.6% | 13.3% | 14.3% | 100% | 102% |
| Class E |  |  |  |  |  |
| **Overall** | 5.8% | 8.1% | 10.1% | 100% | 100% |

# Conclusion

In this contribution, we represent the improved rate control method for HEVC. The average coding gain over the default rate control in HM16.20 is 2.3%/0.8%/0.5% and 7.8%/6.7%/6.4% for Y/U/V at Lowdelay B Main10 (LDB) and Randomaccess Main10 (RA) configuration, respectively.

# Patent rights declaration(s)

**Wuhan University and Tencent America LLC do not have any current or pending patent rights relating to the technology described in this contribution.**

# References

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