|  |  |
| --- | --- |
| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11**  6th Meeting: Torino, IT, 14-22 July, 2011 | Document: JCTVC-F184\_r1 |

|  |  |  |  |
| --- | --- | --- | --- |
| *Title:* | **Evaluation of PU-level vs TU-level Intra Prediction** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Information | | |
| *Author(s) or Contact(s):* | Andrea Gabriellini and Marta Mrak | *Email:* | andrea.gabriellini@bbc.co.uk |
| *Source:* | British Broadcasting Corporation | | |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Abstract

This contribution reports on the evaluation of intra prediction carried out at the prediction unit (PU) vs default HM setting where it is carried out at the transform unit (TU) level. In order to show what performance penalty, if any, is associated with restricting intra prediction to the PU-level, support for PU-level intra prediction has been added to the HM for all intra coding modes (directional prediction, planar, chroma from luma prediction). PU level intra prediction allows a decoder to compute a prediction signals for all TUs belonging to a PU at once. On the encoder side, all TU configurations can be evaluated at once, in parallel. The tests have been performed for intra configurations only. It is shown that on average there is a compression performance loss of 0.2% and 0.4% BD-rate for the luma component for intra high efficiency and low complexity test configurations, respectively. For chrominance components, there is no difference for the high efficiency configuration, while for the low-complexity configuration the gain is 0.4%. The running times are close to standard HM times, with the only noticeable difference a reduction of average decoding times for intra low complexity (92% of reference).

Introduction

Intra prediction is selected at PU level. However, the selected prediction is applied at TU level, i.e., each TU forms its own intra prediction signal, using the same prediction choice as the other TUs in the PU. In Figure 1 an example is shown where a directional prediction is used. TU-level prediction tends to deliver better compression performance, as it enables prediction from nearer pixels. A possible drawback of this approach is the dependency introduced in the coding and decoding process at TU level. In fact, TUs in a PU must be processed serially.

This contribution evaluates default HM set up with TU-level prediction vs intra prediction carried out at PU level only. Multiple TUs are still allowed to be picked for each PU, within the same constraints as before, but intra prediction is carried out on the whole PU block only, i.e. the prediction signal is formed on the whole PU, regardless of underlying TU structure.

The benefit of this different approach is the removal of the coding/decoding dependency at TU level; once the intra prediction signal is generated at PU level all TUs can be processed at once. Note that now only transform of the residual and quantisation are carried out at TU level. The drawback is that intra prediction is likely to be less effective, as it is now generally performed on larger blocks. Thus this contribution aims to evaluate the extent of this drawback on compression performance.



Figure - Intra prediction in HM (TU-level) and the evaluated PU-level prediction approach

# Test set up and results

The tests have been based on HM 3.1. No modifications have been made to the syntax of the codec. Also, the same configuration files defined in [1] have been used for these tests.

The encoder has been modified to perform intra prediction at PU level. A new buffer has been added to store the prediction signal for both luma and chroma components. The pre-calculated prediction signal is then passed to the RQT search stage of the encoder. In HM each TU calculates a prediction signal for a given prediction direction; in this test each TU uses the prediction signal stored in the above mentioned buffer.

On the decoder side a buffer is added to store the intra prediction signal generated at PU level. The buffer, used for both luma and chroma components, is passed to the RQT functions that would normally generate the signal in HM.

The tests have used two test points, intra high efficiency and intra low complexity.

Table 1 and Table 2 show the test results. A compression performance drop of 0.2% BD-rate for luma component is recorded for intra high efficiency test configuration. No change for chroma components, although the test modifies intra prediction handling for those components too. A slightly higher compression performance drop of 0.4% BD-rate is recorded for the luma component of the intra low complexity test configuration. In this case the chroma components show an improvement of 0.4% and 0.3% BD-rate for U and V components, respectively. Running times are close to HM 3.1 times and mostly within the variability expected of the cluster system used for the test. The average decoding time for low complexity test point is however noticeably lower, as it stands at 92% of HM 3.1.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Intra High Efficiency | | |
| Y BD-rate | U BD-rate | V BD-rate |
| Class A | 0.2 | -0.7 | -0.8 |
| Class B | 0.2 | 0.1 | 0.4 |
| Class C | 0.2 | 0.1 | 0.1 |
| Class D | 0.1 | 0.1 | 0.2 |
| Class E | 0.4 | 0.4 | 0.5 |
| All | 0.2 | 0.0 | 0.0 |
| Enc Time[%] | 98% | | |
| Dec Time[%] | 96% | | |

Table - Test results for intra high efficiency

|  |  |  |  |
| --- | --- | --- | --- |
|  | Intra Low Complexity | | |
| Y BD-rate | U BD-rate | V BD-rate |
| Class A | 0.3 | -1.2 | -1.1 |
| Class B | 0.6 | -0.2 | -0.1 |
| Class C | 0.3 | 0.1 | 0.0 |
| Class D | 0.2 | 0.1 | 0.1 |
| Class E | 0.8 | -1.0 | -0.8 |
| All | 0.4 | -0.4 | -0.3 |
| Enc Time[%] | 97% | | |
| Dec Time[%] | 92% | | |

Table - Test results for intra low complexity

# Conclusions

This contribution reports the evaluation of intra prediction carried out at PU level vs TU level. Limiting intra prediction to PU level can allow the parallel processing of all TUs at that level but it may affect the compression performance of the codec. This contribution shows that a compression performance drop of 0.2% and 0.4% BD-rate of the luma component is recorded for intra high efficiency and low complexity configurations, respectively.

# Patent rights declaration(s)

**BBC 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).**

# References

1. Frank Bossen, “Common test conditions and software reference configurations”, JCTVC-E700, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T VCEG and ISO/IEC MPEG, Geneva, CH, March. 2011.