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-F118

Title: **CE12: Ericsson's and MediaTek's deblocking filter**

Status: Input document to JCT-VC

Purpose: Proposal

Author(s) or Contact(s): *Andrey Norkin, *Kenneth Andersson, *Rickard Sjöberg, #Qian Huang, #Jicheng An, #Xun Guo and #Shawmin Lei

Tel: +46 10 714 84 02
Email: {andrey.norkin, kenneth.r.andersson, rickard.sjoberg}@ericsson.com
{qian.huang, jicheng.an, xun.guo, shawmin.lei}@mediatek.com

*Färögatan 6
164 80 Stockholm
Sweden

#No. 1, Dusing Rd. 1, Hsinchu Science Park, Hsinchu, Taiwan 30078

Source: *Ericsson, #MediaTek

Abstract

This contribution proposes a deblocking filter based on the current HEVC deblocking filter. The contribution is a combination of earlier proposals on deblocking filtering from Ericsson (E276) and MediaTek (E079). The proposed filter reportedly provides an average BD-rate reduction of 1.2% for luma component, 2.6% for U and 2.7% for V components on the six common test configurations. The decoding time is reported to be similar to HM3.0. The contribution claims that the subjective performance of the proposal is better than that of HM 3.0.

1 Introduction

The HEVC deblocking filter shows good subjective and objective performance and is computationally simpler than the H.264 deblocking filter. Despite its merits, the HEVC deblocking filter has a limited capacity of reducing ringing artifacts as it modifies the first pixel by delta and the second pixel by delta/2. Therefore, small deviations cannot be efficiently smoothed out. Moreover, the same offsets are used for modifying second pixels from both sides of the block border although the structure at each side may be different. The HEVC deblocking filter always modifies at least two pixels from the block border if the deblocking for the block boundary is turned on by the block-based filter decision and the clipping value of the delta is not equal to zero. The HEVC deblocking filter for chroma component also filters only the block boundaries when one of the proposed blocks is intra. The proposal is based on two earlier proposals for deblocking filtering by Ericsson [1] and MediaTek [2].

Simulation results show that the proposal decreases the BD-rate by by 1.2% for luma component, 2.6% for U and 2.7% for V components on average for all six standard configurations [3]. The computational complexity of the decoder is 101% of the HM3.0.

INTEL-1043
9,641,841

2 Algorithm description

The proposed algorithm consists of the following modifications to the HEVC deblocking filter: a modified deblocking filter, the filter length decisions, modified TU block strength computations, modified chroma filtering including a modified deblocking filter for chroma, added conditions for filtering the block boundary, filtering of chroma block boundaries for chroma Bs=2 and filtering on 4x4 chroma grid. The tc_offset for intra blocks has been adjusted.

2.1 Filter description

The proposal modifies input pixels according to the following formulas.

$\Delta = (9*(q_0-p_0)-3*(q_1-p_1))/16$

$p_0' = p_0 + \Delta$

$q_0' = q_0 - \Delta$

$\Delta_{p1} = (p_0 - 2*p_1 + p_2 + 2*\Delta)/4;$

$p_1' = p_1 + \Delta_{p1}$

$\Delta_{q1} = (q_0 - 2*q_1 + q_2 - 2*\Delta)/4;$

$q_1' = q_1 + \Delta_{q1}$

The values p_0 and q_0 are clipped to the range (-tc, tc), while p_1 and q_1 are clipped to the range (-tc/2, tc/2). The implementation of the proposed filtering in the source code is done by using shifts instead of divisions and multiplications by a factor of 2.

The proposed filter attenuates small signal deviations stronger than the HEVC filter. When applied to a signal in the form of a slope (10 20 30 40 50 60), the filter does not modify the signal, since Δ, Δ_p and Δ_q are all equal to zero. When the proposed filter is applied to an unfiltered input signal that has a form close to that of a step function (a blocking artefact), the filter will smooth it. These features are also present in the current HEVC deblocking filter and are kept in the proposal.

2.2 Filtering decisions

The block based filter decision in HEVC is kept and if that allows filtering then two additional conditions are checked.

2.2.1 Check that the artifact is not a natural edge

If a line based decision abs(Δ) < (*thr1*) is fulfilled, pixels p_0, q_0, p_1, q_1 are allowed to be modified. The delta is equal to zero if the signal on the sides of the block border forms a line and increases with the strength of a blocking artifact. This condition helps to differentiate blocking artifacts from natural edges. It also reduces computational complexity of the filter as Δ_p and Δ_q are calculated less often. The value of thr1 is set equal to 10**tc*(QP) and is adapted to the QP.

2.2.2 Choose between filtering one or two pixels on each side of the block boundary

A block based filtering decision is used to decide whether to filter two or one pixels. Pixels p_1, q_1 are modified if there is a lower spatial activity on a side of the block border when the artifact decision in section 2.2.1 is fulfilled. The block based decision is taken separately for p_1, q_1. The condition is as follows: When calculating the value *d* to decide whether to filter the block boundary
$d = |p2_2 - 2*p1_2 + p0_2| + |q2_2 - 2*q1_2 + q0_2| + |p2_5 - 2*p1_5 + p0_5| + |q2_5 - 2*q1_5 + q0_5|$, the values of *d* on the left and the right from the block boundary are saved as

$d_p = |p2_2 - 2*p1_2 + p0_2| + |p2_5 - 2*p1_5 + p0_5|$
$d_q = |q2_2 - 2*q1_2 + q0_2| + |q2_5 - 2*q1_5 + q0_5|$

These values are then reused to decide whether to filter one or two pixels on each side of the block boundary. Pixel p_1 is modified if $d_p < thr2$ and q_1 is modified if $d_q < thr2$. The value of *thr2* is chosen equal to `(Beta(QP)+(Beta(QP)>>1))>>3` and adapts to the QP.

2.3 Modified Bs computations

In the HEVC deblocking filter, the luma boundary could be filtered if one of the two neighboring blocks have non-zero transform coefficients independent of the fact whether the boundary is a PU boundary or a TU boundary. This condition is inherited from the H.264 deblocking filter directly, in which the transform size is always equal to or smaller than the prediction partition size. However, in HEVC, a TU may cover several PUs so that a PU boundary is not always a TU boundary. Therefore, we propose to prohibit setting the Bs=2 if the boundary is only a PU boundary, since when two PU's are covered by one TU, there are no transform artifacts.

2.4 Chroma filtering

The proposed chroma filtering has three major modifications compared with the HEVC deblocking filter: filtering unit, filtering decision and filtering operation.

2.4.1 Filtering unit

Instead of only filtering on a 8x8 chroma grid as in HEVC, the proposal filters on a chroma grid that adapts to the chroma sampling format. For the 4:2:0 format, chroma filtering is performed on a 4x4 grid, which corresponds to a 8x8 luma grid. For the 4:2:2 format, chroma filtering is performed on a 4x8 chroma grid. And for the 4:4:4 format, chroma filtering is done on a 8x8 grid, which is the same as for luma.

2.4.2 Filtering decision

Chroma components can be filtered at the block boundaries with chroma boundary strength BS > 1. For the 4:2:0 sampling format, the filtering decision is done on the 4-pixel block boundary. The 2th and 3rd lines are used in the filtering decision as follows.

$d = |p1_0 - p1_1| + |q1_0 - q1_1| + |p2_0 - p2_1| + |q2_0 - q2_1| < \beta(QP)$

The filtering decisions are made independently for U and V components.

2.4.1 Filtering operation

The proposed chroma filtering operation uses the following formulas.

$\Delta = (12*(q_0-p_0)+3*(q_1-p_1) + 16)>>5$

$p_0' = p_0 + \Delta$

$q_0' = q_0 - \Delta$

3 Compression performance

The compression performance of the proposed method is shown in the tables below. The encoding time is not available as the encoding has been done on heterogeneous cluster. The decoding time on a single computer is shown in the next section. The proposed scheme has been compared against the HM3.0 anchor. The comparison results are given in Table 1-3. One can see that the proposal shows an average BD-rate [4] reduction of 1.2% for luma component, 2.6% for U and 2.7% for V components on average for six test configurations.

Table 1 Comparison of proposed deblocking vs HM3.0 as anchor (All Intra)

	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V
Class A	-1.6	-1.5	-1.2	-1.3	-2.3	-2.1
Class B	-1.2	-1.4	-1.6	-1.0	-2.6	-2.7
Class C	-0.9	-2.5	-2.5	-0.9	-3.4	-3.9
Class D	-0.9	-2.3	-2.4	-0.8	-3.5	-3.8
Class E	-1.3	-0.4	-0.6	-1.1	-2.2	-3.0
Overall	**-1.2**	**-1.7**	**-1.7**	**-1.0**	**-2.8**	**-3.1**
Enc Time[%]	N/A			N/A		
Dec Time[%]	N/A			N/A		

Table 2 Comparison of proposed deblocking vs HM3.0 as anchor (Random Access)

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-1.4	-2.3	-1.8	-1.4	-2.6	-2.0
Class B	-1.2	-2.6	-2.3	-1.3	-2.8	-2.3
Class C	-1.0	-3.5	-3.3	-1.0	-3.5	-3.8
Class D	-0.8	-2.9	-3.3	-0.8	-2.9	-3.0
Class E						
Overall	**-1.1**	**-2.8**	**-2.6**	**-1.1**	**-2.9**	**-2.8**
Enc Time[%]	N/A			N/A		
Dec Time[%]	N/A			N/A		

Table 3 Comparison of proposed deblocking vs HM3.0 as anchor (Low Delay)

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-1.4	-2.7	-2.8	-1.4	-2.4	-2.3
Class C	-1.1	-2.9	-2.8	-1.0	-2.3	-3.0
Class D	-0.9	-1.7	-1.8	-0.8	-1.7	-2.3
Class E	-2.8	-3.1	-3.7	-2.4	-6.6	-6.2
Overall	**-1.5**	**-2.6**	**-2.7**	**-1.3**	**-3.0**	**-3.2**
Enc Time[%]	N/A			N/A		
Dec Time[%]	N/A			N/A		

4 Complexity considerations

In order to evaluate the complexity of the proposed deblocking, the decoding time on a single computer has been measured for both the proposal and the anchor with only one thread. The time has been obtained without writing decoded pictures on the disk in order to minimize the influence of the I/O time.

Table 4 Decoding time of the proposal vs HM3.0 decoding time

Configuration	Dec. time proposal [%] first version	Dec. time proposal [%] updated version
Random access	101%	100%
Low delay	100%	99%
All intra	100%	100%
Random access loco	103%	102%
Low delay loco	103%	102%
All intra loco	102%	101%
Average	**101%**	**100.7%**

The decoding time results for the first version sent to the cross-verifiers and for the updated version of the source code are provided in Table 4. The updated version of the source code has a bit-exact match with the first version. However, it has shorter decoding times due to more efficient implementation of the proposed deblocking algorithm. The updated source code has also been sent to the cross-checkers and cross-verifications results for decoding time obtained.

Table 4Table 4 indicated that the proposal has similar complexity compared to HM3.0 anchor. One can see from the table that the decoding time for the low-complexity configurations is slightly increased. However, one should take into account that the proposed solution filters more chroma boundaries than the HM3.0 anchor. The proposed deblocking performed filtering of chroma components on the 4x4 grid, which corresponds to the 8x8 luma grid, while the anchor filters on the 8x8 chroma grid, which corresponds to the 16x16 luma grid. Moreover, the anchor filters chroma block boundaries only if one of the adjacent blocks is intra while the proposal filters also block boundaries where at least one of the adjacent blocks have coefficients, which has a certain impact on filtering of B and P pictures. The impact of this chroma boundary filtering is seen in the chroma BD-rate decrease.

5 Subjective quality

After informal subjective viewing it was found that the proposal was slightly better subjectively than the HM3.0 anchor.

6 Software

Attached to the contribution is the software for Ericsson's and MediaTek's deblocking filter. The software package contains three files:

TComLoopFilter.h, *TComLoopFilter.cpp and TypeDef.h*.

The proposed software modifications are turned on by the following statement in *TComLoopFilter.h*.

```
define ERMTK_DEBLOCKING           1
```

7 Conclusions

The contribution proposes a harmonized solution based on the two earlier contributions from Ericsson [1] and MediaTek [2]. The solution proposes modifications to the HEVC deblocking filter. These modifications comprise the modification of the "weak filter", adding a check for the natural edges and deciding between filtering one or two pixels from the block boundary dependent on the spatial activity. Regarding chroma deblocking, filtering of the the chroma block boundary is added for block boundaries with Bs = 2 and on the 4x4 sampling grid. The filtering conditions checking the structure on the sides of the block boundary are added. The filter achieves a BD-rate reduction of 1.2% for luma component, 2.6% for U and 2.7% for V components on average for six test configurations with similar decoding time. We suggest adoption of this proposal to the next version of HM.

8 References

[1] A. Norkin, K. Andersson and R. Sjöberg, "Development of HEVC deblocking filter", JCTVC-D276, Geneva, Mar. 2011.

[2] J. An, Q. Huang, X. Guo, Y.-W. Huang, S. Lei, "CE12 Subtest 1: Improved Deblocking Filter", JCTVC-E079, Geneva, Mar. 2011.

[3] F. Bossen, "Common test conditions and software reference configurations", JCTVC-E700, JCT-VC Meeting, Geneva, Mar. 2011.

[4] G. Bjontegaard, "Calculation of average PSNR differences between RD curves," ITU-T SC16/Q6, VCEG-M33, Austin, USA, Apr 2001.

9 Patent rights declaration(s)

Ericsson 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).

MediaTek 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).