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| *Title:* | **CE12 Subset1: SKT/SKKU Deblocking Filter** | | |
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| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes a deblocking filter modified from the one in the HM2.0 with special attention to intra coded blocks. It is reported that the proposed filter has BDBR gain of 1.2% (HE\_IO) and 1.1% (LC\_IO) with approximately the same encoding and decoding time compared to HM2.0. The subjective quality of the proposed method is also reported to be similar to that of the HM2.0 anchor.

# Introduction

In the HM 2.0 deblocking filter, boundary strength (bS) is selected depending on the coding conditions of adjacent blocks (P and Q). However, the bS decision process does not pay full attention to various coding conditions of intra coded blocks. Moreover, the selected bS is not fully utilized to control the strength of deblocking filter (e.g., tc value is only changed according to prediction mode of P and Q). Therefore, this contribution proposes a few modifications for the HM 2.0 deblocking filter to select a boundary strength and also to utilize its values in deblocking filtering.

# Algorithm description

The proposed method has a few modifications from the current HM2.0 deblocking filter – bS decision for intra coded blocks, filtering decision for the second position pixels, and modified weak filter. Except above modifications, other deblocking filtering processes are the same as the HM2.0 .

## bS decision

In this proposal, the bS decision process is slightly modified from the previous proposed contribution [1]. Its new bS decision process is as follows: when P and Q blocks are inter-coded blocks, bS value is selected as the same manner as the HM 2.0. Otherwise, the proposed method controls bS for intra-coded blocks as shown in Table 1.

Table 1. bS decision for intra coded blocks

|  |  |
| --- | --- |
| Conditions | bS |
| Q is intra coded,  *and* Q is predicted in the same direction as the deblocking filtering,  *and* Q has no coded residual coefficient. | 0 |
| P and Q are intra coded,  *and* P and Q have the same intra prediction direction,  *and* boundary direction & prediction direction are the same. | 1 |
| P and Q are intra coded,  *and* P and Q have the same intra prediction direction,  *and* boundary direction & prediction direction are different. | 2 |
| P and Q are intra coded,  *and* P and Q have DC intra prediction modes. | 3 |
| Otherwise | 4 |

As the first step, following conditions are checked to see whether bS can be set 0 or not. When Q is intra coded block and predicted in the same direction as the deblocking filtering, blocking artifact caused *by prediction* does not occur on the block boundary. However, there is a still possibility of having blocking artifacts *by quantization*. Therefore, in the case as shown in Fig 1, additional condition is checked: if Q has no coded residual coefficient, bS value is set to 0.This makes sense since, in this case, blocking artifact caused by quantization does not exist either. The decision has computational benefit as well since bS value of 0 can avoid unnecessary deblocking filter process.



Fig 1. Example of bS=0 case

Following, the second set of cases in Table 1 is checked. If P and Q have the same intra prediction mode, and its prediction direction is identical to boundary direction as in Fig.2(a), bS is set to 1 to avoid an unintended smoothing over the block boundary between P and Q. On the other hand, if intra prediction is performed across the given block boundary, bS is set to 2. Since deblocking filtering is applied to vertical and horizontal block boundaries, vertical and horizontal intra prediction modes are considered to check for above two cases.

 

(a) Same direction (b) Different direction

Fig 2. Example of block boundary direction and prediction direction

Lastly, if both of P and Q have DC mode, it means that P and Q are included in flat regions. Thus, in this case, relatively strong filtering can be helpful, so bS is set to 3. Otherwise, that is, when P and Q has different prediction type or different prediction direction, the effects of prediction and quantization in P and Q are quite different each other and the boundary between P and Q is likely to show the strongest blocking artifact. For this case, the strongest deblocking filter (bS=4) is applied. According to QP and the selected bS, the strength of deblocking filter (tc) is changed.

## Filtering decision

In the proposed method, the pixels (p0 and q0) which are at the first position from the boundary are always filtered when the filtering decision conditions are satisfied. This is in the same way as the HM2.0 design as follows:

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 | < β

However, for the pixels at the second positions from the boundary (that is, p1 and q1), two additional conditions are checked to decide whether to apply the deblocking filtering or not. Each of two conditions is satisfied, p1 and q1 are filtered, respectively.

dp = | p2,2 – 2\*p1,2 + p0,2 | + | p2,5 – 2\*p1,5 + p0,5 | < βp

dq = | q2,2 – 2\*q1,2 + q0,2 | + | q2,5 – 2\*q1,5 + q0,5 | < βq

## Luma weak filter

HM2.0 adopts two different types of deblocking filters – a strong and a weak filter. In this proposal, the weak filter is modified as follows:

△ = Clip3 (-tc, tc, ((q0 – p0) << 2) + (q1 – p1) + 4) >> 3))

p0' = Clip0-255 (p0 + △)

q0' = Clip0-255 (q0 – △)

p1' = Clip0-255 (p1 + △/2) when dp < βp

q1' = Clip0-255 (q1 – △/2) when dq < βq

The first position pixels from the boundary (p0 and q0) are modified by the same filter of H.264/AVC deblocking filtering. To reduced complexity, however, the pixels at the second position from the boundary (p1 and q1) are modified by using △/2 value.

# Experimental results

The proposed method is modified from HM2.0 software and simulated under CE12 Subset1 conditions [4]. Table 2 shows the summarized coding performance of the proposed method compared to HM2.0 anchor. More detailed results are included in *JCTVC-E417\_SKKU\_DF\_result.xls*.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | HE\_IO | | | LC\_IO | | |
| Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | -1.6 | -0.4 | -0.5 | -1.5 | -0.5 | -0.5 |
| Class B | -1.2 | -0.6 | -0.5 | -1.1 | -0.5 | -0.4 |
| Class C | -0.9 | -0.7 | -0.6 | -0.9 | -0.6 | -0.5 |
| Class D | -0.8 | -0.6 | -0.7 | -0.8 | -0.5 | -0.5 |
| Class E | -1.3 | 0.0 | -0.1 | -1.0 | 0.2 | 0.1 |
| All | -1.2 | -0.5 | -0.5 | -1.1 | -0.4 | -0.4 |
| Enc Time[%] | 101% | | | 100% | | |
| Dec Time[%] | 100% | | | 101% | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | HE\_RA | | | LC\_RA | | |
| Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | -1.1 | 2.6 | 2.8 | -0.6 | 5.3 | 5.7 |
| Class B | -1.0 | 1.3 | 1.1 | -0.6 | 1.3 | 1.3 |
| Class C | -0.7 | 0.9 | 0.7 | -0.5 | 1.2 | 0.8 |
| Class D | -0.6 | 1.1 | 1.1 | -0.4 | 1.4 | 1.5 |
| Class E |  |  |  |  |  |  |
| All | -0.9 | 1.5 | 1.4 | -0.5 | 2.2 | 2.2 |
| Enc Time[%] | 106% | | | 101% | | |
| Dec Time[%] | 100% | | | 101% | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | HE\_LD | | | LC\_LD | | |
|  | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A |  |  |  |  |  |  |
| Class B | -1.2 | 1.2 | 0.9 | -0.5 | 1.6 | 2.3 |
| Class C | -0.8 | 1.6 | 1.9 | -0.2 | 2.7 | 2.1 |
| Class D | -0.8 | 2.6 | 3.2 | -0.2 | 3.9 | 4.6 |
| Class E | -2.7 | -3.4 | -2.7 | -1.9 | -6.4 | -3.7 |
| All | -1.3 | 0.8 | 1.0 | -0.6 | 0.9 | 1.7 |
| Enc Time[%] | 103% | | | 100% | | |
| Dec Time[%] | 98% | | | 101% | | |

# Concluding remarks

This contribution proposed a deblocking filter modified from the one in the HM2.0 with special attention to intra coded blocks. According to the test condition agreed by CE12, it is reported that the proposed filter has BDBR gain of 1.2% (HE\_IO) and 1.1% (LC\_IO) with approximately the same encoding and decoding time compared to HM2.0. The subjective quality of the proposed method is also reported to be similar to that of the HM2.0 anchor.

# References

[1] J. Yang, K. Won, H. Yang, B. Jeon and J. Lim, “CE8 Subset1: Results of intra deblocking filter testing by SKKU/SKT (JCTVC-C130),” JCTVC-D334, Daegu, Jan. 2011.

[2] J. Yang, K. Won, B. Jeon, J. Lim and J. Song, “In-loop deblocking filtering for intra blocks,” JCTVC-C130, Oct, 2010.

[3] J. Yang, K. Won, H. Yang, B. Jeon, J. Lim, J. Song “In-loop deblocking filtering for intra blocks,” JCTVC-B075, July, 2010.

[4] A. Norkin, B. Jeon, M. Narroschke et al., “Description of CE12: Deblocking Filtering,” JCTVC-D612, Daegu, Jan. 2011.

# Patent rights declaration(s)

**SK Telecom and Sungkyunkwan University 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).**