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| *Title:* | **On positive/negative sign for Category 1, 4 Edge Offset in SAO** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

# In HM6.0, the sign of edge offsets (EOs) are restricted depending on category types in order to reduce the salt noise, which generates two major problems, ie, loss of sharpness and coding gain for specified sequences. Positive or negative sign of edge offset category 1 and 4 is allowed in this proposal. The experimental results show that the average coding gain is 0.4% LB-main/LB-HE10 for class E. High coding gain for specific sequence (“Johnny”) is observed by 1.1% LB-main, 1.0% LB-HE10.

# Introduction

Increment of contrast between neighboring pixels causes visual artifact such as salt noise. The current HM, the positive sign for category 1 and 2 and negative sign for category 3 and 4 are only allowed. The main idea of this proposal is that both signs on category 1 and 4 have to be considered to improve coding gain and remove salt noise.

# Proposed Method

## Permit positive/negative sign offset for Category 1, 4 in SAO EO

The EO could be one of four categories with different features as depicted in Fig.1. Generally speaking, category 2 and 3 are easily observed in the smoothing regions. On the contrary, category 1 and 4 have less possibility to be exist in those areas. The restriction of the difference between neighboring pixels is the one of solution for salt noise as shown in the current HM. However, it causes the degradation of coding gain because it does not compensate properly for the sharp or complex regions. Therefore, both sign for category 1 and 4, positive sign for category 2 and negative sign for category3 are allowed in this proposal as shown in Fig.2.



Negative offset

Positive offset

**Fig. 1. Edge offset categorization according to edge shape in HM 6.0**

****

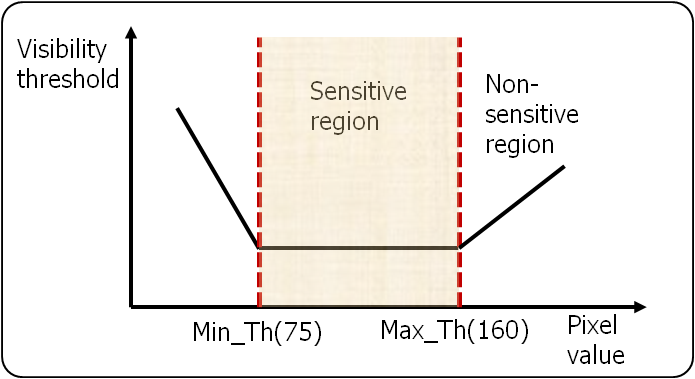
Positive/Negative offset

Positive/Negative offset

**Fig. 2. Proposed method**

## Encoding process for proposed method

Both sign allowance for category 1 and 4 caused visual artifacts due to higher difference of neighboring pixels. We solve this problem not restriction of signs but using the background luminance dependent function [3]. It gives several benefits; coding gain for specific sequences (Johnny has the sharp edges on jacket strip), no salt noise and reduction of encoding/decoding time.

**

**Fig. 3. Background-luminance dependent function**

The background-luminance dependent function has two dividable regions which are sensitive or not depicted in Fig.3. The pseudo code of the proposal is follows;

*if ((category 1 && offset < 0) || (category 4 && offset > 0))*

*if (Min\_Th (75) < avgPix < Max\_Th (160) && Qp>=37) offset = 0;*

*else if (category 2 && offset < 0) offset = 0;*

*else if (category 3 && offset > 0) offset = 0;*

*else offset = offset;*

**Fig. 4. Offset restriction method using background-luminance dependent function.**

Fig. 4. illustrates offset restriction method with background-luminance dependent function in the encoding process. *avgPix* represents average level of pixels included in each category. *Min\_Th*, *Max\_Th* , and *Qp* represent minimum threshold, maximum threshold, and Quantization parameter, respectively.

# Experimental Results

## Subjective quality

Fig. 5 shows the subjective test of the proposed method compared to HM 6.0 anchor. The result shows that no differences is observed at all sequences.

HM6.0 proposed

1. BasketballDrive AI\_HE10 QP37 Frame 286

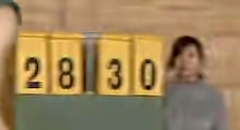
HM6.0 proposed

1. BQMall LB\_HE10 QP37 Frame 29

HM6.0 proposed

1. BQMall LB\_HE10 QP37 Frame 102

HM6.0 proposed

1. BasketballDrive LB\_HE10 QP37 Frame 146

HM6.0 proposed

1. BasketballDrive LB\_HE10 QP37 Frame 423

HM6.0 proposed

1. BasketballDrillText LB\_HE10 QP37 Frame 351

HM6.0 proposed

1. BQTerrace AI\_HE10 QP37 Frame 194

HM6.0 proposed

1. ChinaSpeed AI\_HE10 QP37 Frame 499

**Fig. 5. Subjective quality of the proposed method compared to HM 6.0 anchor.**

## Objective quality

The average coding gain shows 0.4% LB-main/LB-HE10 for class E. High coding gain for specific sequence (“Johnny”) is observed by 1.1% LB-main, 1.0% LB-HE10. As mentioned above, accurate compensation by allowing both signs for category 1 and 4 is the promising approach of controlling salt noise not to scarify coding gain.

**Table 1. BD-rate results of the proposed method compared to HM 6.0 anchor.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main** | | | **All Intra HE10** | | |
|  | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class C | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class D | 0.0% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| Class E | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class F | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
|  | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | 102% | | |
| Dec Time[%] | 100% | | | 101% | | |
|  |  |  |  |  |  |  |
|  | **Random Access Main** | | | **Random Access HE10** | | |
|  | Y | U | V | Y | U | V |
| Class A | 0.0% | -0.2% | -0.6% | 0.0% | 0.0% | 0.1% |
| Class B | 0.0% | -0.5% | -0.3% | 0.0% | -0.1% | 0.0% |
| Class C | 0.0% | -0.1% | -0.1% | 0.0% | 0.1% | 0.0% |
| Class D | 0.0% | -0.1% | 0.1% | 0.1% | 0.0% | 0.1% |
| Class E |  |  |  |  |  |  |
| Class F | 0.0% | 0.0% | -0.1% | 0.1% | 0.0% | 0.0% |
| **Overall** | 0.0% | -0.2% | -0.2% | 0.0% | 0.0% | 0.0% |
|  | 0.0% | -0.2% | -0.2% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 95% | | | 100% | | |
| Dec Time[%] | 96% | | | 101% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B Main** | | | **Low delay B HE10** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | -0.1% | -0.4% | 0.1% | 0.0% | -0.2% | 0.1% |
| Class C | 0.0% | 0.2% | -0.1% | 0.0% | 0.1% | 0.1% |
| Class D | 0.1% | 0.1% | 0.4% | 0.0% | 0.0% | -0.3% |
| Class E | -0.4% | -0.2% | 0.5% | -0.4% | -0.2% | 0.1% |
| Class F | 0.0% | 0.1% | 0.0% | 0.0% | 0.2% | -0.2% |
| **Overall** | -0.1% | -0.1% | 0.2% | 0.0% | 0.0% | 0.0% |
|  | -0.1% | -0.1% | 0.1% | 0.0% | 0.0% | -0.1% |
| Enc Time[%] | 99% | | | 101% | | |
| Dec Time[%] | 99% | | | 102% | | |
|  |  |  |  |  |  |  |
|  | **Low delay P Main** | | | **Low delay P HE10** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | 0.1% | -0.2% | 0.0% | 0.0% | 0.2% | 0.4% |
| Class C | 0.1% | -0.2% | -0.2% | 0.0% | 0.0% | 0.0% |
| Class D | 0.1% | 0.5% | -0.4% | 0.0% | 0.9% | -0.1% |
| Class E | -0.1% | -0.1% | 0.6% | 0.0% | 1.0% | 0.3% |
| Class F | 0.0% | 0.0% | 0.3% | 0.1% | 0.3% | 0.3% |
| **Overall** | 0.0% | 0.0% | 0.0% | 0.0% | 0.4% | 0.2% |
|  | 0.0% | 0.0% | 0.0% | 0.0% | 0.4% | 0.2% |
| Enc Time[%] | 98% | | | 97% | | |
| Dec Time[%] | 98% | | | 96% | | |

# Conclusion

We strongly recommend the proposed method to be adopted because that the average coding gain shows 0.4% LB-main/LB-HE10 for class E. High coding gain for specific sequence (“Johnny”) is observed by 1.1% LB-main, 1.0% LB-HE10.

# Reference

1. [B. Bross](mailto:benjamin.bross@hhi.fraunhofer.de), [W.-J. Han](mailto:wjhan.han@samsung.com), [J.-R. Ohm](mailto:ohm@ient.rwth-aachen.de), [G. J. Sullivan](mailto:garysull@microsoft.com), [T. Wiegand](mailto:thomas.wiegand@hhi.fraunhofer.de), “High efficiency video coding (HEVC) text specification draft 6,” ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, Document JCTVC-H1003, Feb. 2012.
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# Patent rights declaration(s)

**Samsung Electronics Co. Ltd. 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).**

# WD Text Changes (adds marked in yellow)

**7.3.2.8 Sample adaptive offset VLC syntax**

|  |  |
| --- | --- |
| sao\_offset\_vlc( rx, ry, cIdx ) { | Descriptor |
| **sao\_type\_idx**[ cIdx ][ rx ][ ry ] | ue(v) |
| if( sao\_type\_idx[ cIdx ][ rx ][ ry ] = =5 ) { |  |
| **sao\_band\_position**[ cIdx ][ rx ][ ry ] | u(5) |
| for( i = 0; i < 4; i++ ) |  |
| **sao\_offset**[ cIdx ][ rx][ ry ][ i ] | se(v) |
| } else if( sao\_type\_idx[ cIdx ][ rx ][ ry ] != 0 ) |  |
| for( i = 0; i < 4; i++ ) |  |
| if( i == 0 || i == 3 ) |  |
| **sao\_offset**[ cIdx ][ rx][ ry ][ i ] | se(v) |
| else |  |
| **sao\_offset**[ cIdx ][ rx][ ry ][ i ] | ue(v) |
| } |  |

**7.4.2.8 Sample adaptive offset VLC sementics**

**sao\_offset**[ cIdx ][ rx ][ ry ][ i ] indicates the offset value of i-th category of current coding treeblock at position rx and ry for the colour component cIdx.

The variable bitDepth is derived as follows.

* If cIdx is equal to 0, bitDepth is set equal to BitDepthY..
* Otherwise (cIdx is equal to1 or 2), bitDepth is set equal to BitDepthC.

The values of sao\_offset[ cIdx ][ rx ][ ry ][ i ] shall be in the range of −( 1<< ( Min( bitDepth, 10 ) − 5 ) ) to ( 1<< ( Min( bitDepth, 10 ) − 5 ) ) −1.

When sao\_offset[ cIdx ][ rx ][ ry ][ i ] is not present, it is inferred as follows.

* If sao\_merge\_up\_flag is equal to 1, sao\_offset[ cIdx ][ rx ][ ry ][ i ] is set equal to sao\_offset[ cIdx ][ rx ][ ry − 1 ][ i ].
* Otherwise, sao\_offset[ cIdx ][ rx ][ ry ][ i ] is set equal to sao\_offset[ cIdx ][ rx − 1 ][ ry ][ i ].

The variable offsetSign is derived as follows.

* If sao\_type\_idx[ cIdx ][ rx ][ ry ] is less than 5 and i is 2, offsetSign is set to −1.
* Otherwise, offsetSign is set to 1.

The array SaoOffsetVal is derived as follows.

SaoOffsetVal[ cIdx ][ rx ][ ry ][ 0 ] = 0 (7‑36)

SaoOffsetVal[ cIdx ][ rx ][ ry ][ i + 1 ] =   
 offsetSign\*sao\_offset[ cIdx ][ rx ][ ry ][ i ] << ( bitDepth – Min( bitDepth, 10 ) ) (7‑37)

**9.2.2.x Sample adaptive offset binarization process**

Input to this process is sao\_type\_idx, SaoOffsetVal and category index i.

Output to this process is the Binarization of the syntax element.

* if sao\_type\_index[cIdx][rx][ry] is not equal to 5 and category index is 0 and 3, the binarization type is unary.
* Otherwise, the binarization type is signed unary.