

## Deblocking filter selection in video or image coding

## TECHNICAL FIELD

**[001]** This disclosure relates to video and/or image coding and decoding.

## BACKGROUND

**[002]** A video sequence consists of a series of images where each image consists of one or more components. Each component can be described as a two-dimensional rectangular array of sample values. It is common that an image in a video sequence consists of three components; one luma component Y where the sample values are luma values and two chroma components Cb and Cr, where the sample values are chroma values. Other examples include Y' Cb Cr, Yuv and ICTCP. In ICTCP, I is the "intensity luma" component. For the remainder of this document we will refer to any luma component Y', Y or I as Y or simply luma. It is common that the dimensions of the chroma components are smaller than the luma components by a factor of two in each dimension. For example, the size of the luma component of an HD image would be 1920x1080 and the chroma components would each have the dimension of 960x540. Components are sometimes referred to as color components.

**[003]** A "block" is a two-dimensional array of samples. In video coding, each component is split into one or more blocks and the coded video bitstream is a series of blocks. It is common in video coding that an image is split into units that cover a specific area of the image. Each unit consist of all blocks from all components that make up that specific area and each block belongs fully to one unit. The macroblock in H.264 and the Coding unit (CU) in HEVC are examples of units.

**[004]** In HEVC, each image is partitioned into coding tree units (CTU). A CTU consist of an NxN block of luma samples and two MxM corresponding chroma blocks. A CTU in HEVC is like macroblocks in H.264 and earlier standards but in contrast to macroblocks the CTU size is configurable. Most often, however, the CTU size in HEVC is set to 64x64 luma samples. Each CTU can be recursively quadtree split. The root of the quadtree is then associated with the CTU. The quadtree is split until a leaf is reached, which is referred to as the coding unit (CU). A CU in HEVC always consist of a luma block with equal height and width. How each

CTU is split is conveyed in the bitstream. The CU is further the root node of two other trees, the prediction tree that has prediction units (PUs) as nodes and the transform tree that has transform units (TUs) as nodes. Some decoding processes in HEVC are done on the CU level, some are done on the PU level and some on TU level. Boundaries between PUs and boundaries between TUs are filtered by a deblocking filter to reduce discontinuities between TUs and PUs. In HEVC there exist two kinds of prediction types for a PU, intra prediction which only uses prediction from previously decoded samples of the current image for prediction, and inter prediction which uses prediction from at least one previously decoded image.

**[005]** In HEVC, deblocking is first applied on vertical boundaries and then on horizontal boundaries. The boundaries are either TU boundaries or PU boundaries. To enable parallel friendly deblocking, the deblocking is performed on an 8x8 sample grid.

**[006]** A deblocking filter strength parameter (bs) is set for each boundary. If the value of bs is larger than 0, then deblocking may be applied. The larger the boundary strength is, the stronger filtering is applied. First it is checked if any of the blocks at a PU boundary between the blocks is an intra predicted block then (bs is set to= 2), or if both blocks use inter prediction but and they use different reference frames or have significantly different motion vectors then (bs is set to =1). It is also checked if a TU boundary between the blocks has non-zero transform coefficients in at least one of the blocks (code block flag CBF equal to 1), then (bs is set to =1). This first check sets a boundary strength (bs) which is larger than 0 to indicate that deblocking should be applied. The larger the boundary strength is the stronger filtering is applied. To reduce/avoid removing natural structures when deblocking, a check that there are not any natural structures on respective sides of the boundary is then applied for luma. In HEVC, gradient calculations are used on respective sides of the boundary using the following inequality:  $abs(p_0 - 2 * p_1 + p_2) + abs(q_0 - 2 * q_1 + q_2) < \beta$ , where  $\beta$  (also denoted “ $\beta$ ”) is a parameter based on the quantization parameter for the block and  $p_0, p_1, p_2$  are samples on one side of the block boundary and  $q_0, q_1, q_2$  are samples on the other side of the block boundary. The condition is checked at two positions along the boundary, and if both conditions are fulfilled, then the luma samples are deblocked for that 4 sample part of the boundary. Chroma boundaries may always be filtered if one any of the neighbouring blocks are intra coded.

**[007]** In the current draft of the specification for VVC (VVC draft 6 JVET-O2001-v14)

a coding tree unit (CTU) is similar to the CTU in HEVC with the difference that the CTU in H.266 has a size of 128x128 luma samples. In VVC, the CTU can be split more flexibly such that a resulting CUs may consist of a rectangular luma block. In VVC, there is no prediction tree or transform tree as in HEVC. However, a CU in VVC can be divided into a multiple of TUs or into a multiple of prediction subblocks.

**[008]** In the current draft of the specification for VVC (VVC draft 6 JVET-O2001-v14), the deblocking is applied on an 4x4 grid for CUs first on vertical boundaries (CU/implicit TU/prediction sub-block boundaries) and then on horizontal boundaries (CU/implicit TU/prediction sub-blocks). Prediction sub-block boundaries inside a CU is filtered on an 8x8 grid. The deblocking is based on HEVC deblocking but also have longer deblocking filters if the size orthogonal to the block boundary is equal to or larger than 32 on at least one side for luma and the other side is larger than 4, modifying at most 7 samples (reading at most 8 samples), if the size orthogonal to the block boundary is less than 32 for one side for luma it modifies at most 3 samples and reading at most 4 samples on that side, and if it is equal to or larger than 8 on both side of a boundary in chroma samples for chroma modifying at most 3 chroma samples and reading at most 4 chroma samples otherwise it modifies at most one sample and reading at most two samples on respective side of the boundary.

**[009]** The VVC specification (JVET-O2001-v14) has long filters and decisions specified in section 8.8.3 Deblocking filter process.

**[0010]** The deblocking decisions are computed for line 0 and line 4 for segments of for lines.

**[0011]** FIG. 3 show a boundary between first block 302 (denoted the “P block”) and a second block 304 (denoted the “Q block”) for 4 lines, line 0 to line 3, and for eight sample, samples 0 to 7, for each line and block.

**[0012]** The following is an excerpt from The VVC specification (JVET-O2001-v14). This excerpt is directed to the long filter decision.

**[0013]** - - Begin Excerpt - -

8.8.3.6.1 Decision process for luma block edges

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The following ordered steps apply:

1. The variables dp0, dp3, dq0 and dq3 are derived as follows:

$$dp0 = \text{Abs}(p_{2,0} - 2 * p_{1,0} + p_{0,0}) \quad (8-1077)$$

$$dp3 = \text{Abs}(p_{2,3} - 2 * p_{1,3} + p_{0,3}) \quad (8-1078)$$

$$dq0 = \text{Abs}(q_{2,0} - 2 * q_{1,0} + q_{0,0}) \quad (8-1079)$$

$$dq3 = \text{Abs}(q_{2,3} - 2 * q_{1,3} + q_{0,3}) \quad (8-1080)$$

2. When maxFilterLengthP and maxFilterLengthQ both are equal to or greater than 3 the variables sp0, sq0, spq0, sp3, sq3 and spq3 are derived as follows:

$$sp0 = \text{Abs}(p_{3,0} - p_{0,0}) \quad (8-1081)$$

$$sq0 = \text{Abs}(q_{0,0} - q_{3,0}) \quad (8-1082)$$

$$spq0 = \text{Abs}(p_{0,0} - q_{0,0}) \quad (8-1083)$$

$$sp3 = \text{Abs}(p_{3,3} - p_{0,3}) \quad (8-1084)$$

$$sq3 = \text{Abs}(q_{0,3} - q_{3,3}) \quad (8-1085)$$

$$spq3 = \text{Abs}(p_{0,3} - q_{0,3}) \quad (8-1086)$$

3. The variables sidePisLargeBlk and sideQisLargeBlk are set equal to 0.
4. When maxFilterLengthP is greater than 3, sidePisLargeBlk is set equal to 1:
5. When maxFilterLengthQ is greater than 3, sideQisLargeBlk is set equal to 1:
6. When edgeType is equal to EDGE\_HOR and (yCb + yBl) % CtbSizeY is equal to 0, sidePisLargeBlk is set equal to 0.
7. The variables dSam0 and dSam3 are initialized to 0.
8. When sidePisLargeBlk or sideQisLargeBlk is greater than 0, the following applies:
  - a. The variables dp0L, dp3L are derived and maxFilterLengthP is modified as follows:

- If sidePisLargeBlk is equal to 1, the following applies:

$$dp0L = (dp0 + \text{Abs}(p_{5,0} - 2 * p_{4,0} + p_{3,0}) + 1) >> 1 \quad (8-1087)$$

$$dp3L = (dp3 + \text{Abs}(p_{5,3} - 2 * p_{4,3} + p_{3,3}) + 1) >> 1 \quad (8-1088)$$

- Otherwise, the following applies:

$$dp0L = dp0 \quad (8-1089)$$

$$dp3L = dp3 \quad (8-1090)$$

$$\text{maxFilterLengthP} = 3 \quad (8-1091)$$

b. The variables dq0L and dq3L are derived as follows:

– If sideQisLargeBlk is equal to 1, the following applies:

$$\text{dq0L} = ( \text{dq0} + \text{Abs}( \text{q}_{5,0} - 2 * \text{q}_{4,0} + \text{q}_{3,0} ) + 1 ) >> 1 \quad (8-1092)$$

$$\text{dq3L} = ( \text{dq3} + \text{Abs}( \text{q}_{5,3} - 2 * \text{q}_{4,3} + \text{q}_{3,3} ) + 1 ) >> 1 \quad (8-1093)$$

– Otherwise, the following applies:

$$\text{dq0L} = \text{dq0} \quad (8-1094)$$

$$\text{dq3L} = \text{dq3} \quad (8-1095)$$

c. The variables dpq0L, dpq3L, and dL are derived as follows:

$$\text{dpq0L} = \text{dp0L} + \text{dq0L} \quad (8-1096)$$

$$\text{dpq3L} = \text{dp3L} + \text{dq3L} \quad (8-1097)$$

$$\text{dL} = \text{dpq0L} + \text{dpq3L} \quad (8-1098)$$

d. When dL is less than  $\beta$ , the following ordered steps apply:

i. The variable dpq is set equal to  $2 * \text{dpq0L}$ .

ii. The variable sp is set equal to sp0, the variable sq is set equal to sq0 and the variable spq is set equal to spq0.

iii. The variables p0 p3 q0 and q3 are first initialized to 0 and then modified according to sidePisLargeBlk and sideQisLargeBlk as follows:

– When sidePisLargeBlk is equal to 1, the following applies:

$$\text{p3} = \text{p}_{3,0} \quad (8-1099)$$

$$\text{p0} = \text{p}_{\text{maxFilterLengthP},0} \quad (8-1100)$$

– When sideQisLargeBlk is equal to 1, the following applies:

$$\text{q3} = \text{q}_{3,0} \quad (8-1101)$$

$$\text{q0} = \text{q}_{\text{maxFilterLengthQ},0} \quad (8-1102)$$

iv. For the sample location ( xCb + xBl, yCb + yBl ), the decision process for a luma sample as specified in clause 8.8.3.6.5 is invoked with the sample values p0, p3, q0, q3, the variables dpq, sp, sq, spq, sidePisLargeBlk, sideQisLargeBlk,  $\beta$  and tc as inputs, and the output is assigned to the decision dSam0.

v. The variable dpq is set equal to  $2 * \text{dpq3L}$ .

- vi. The variable  $sp$  is set equal to  $sp_3$ , the variable  $sq$  is set equal to  $sq_3$  and the variable  $spq$  is set equal to  $spq_3$ .
- vii. The variables  $p_0$ ,  $p_3$ ,  $q_0$  and  $q_3$  are first initialized to 0 and are then modified according to  $sidePisLargeBlk$  and  $sideQisLargeBlk$  as follows:

- When  $sidePisLargeBlk$  is equal to 1, the following applies:

$$p_3 = p_{3,3} \quad (8-1103)$$

$$p_0 = p_{\maxFilterLengthP,3} \quad (8-1104)$$

- When  $sideQisLargeBlk$  is equal to 1, the following applies:

$$q_3 = q_{3,3} \quad (8-1105)$$

$$q_0 = q_{\maxFilterLengthQ,3} \quad (8-1106)$$

- viii. When  $edgeType$  is equal to  $EDGE\_VER$  for the sample location  $(xCb + xBl, yCb + yBl + 3)$  or when  $edgeType$  is equal to  $EDGE\_HOR$  for the sample location  $(xCb + xBl + 3, yCb + yBl)$ , the decision process for a luma sample as specified in clause 8.8.3.6.5 is invoked with the sample values  $p_0$ ,  $p_3$ ,  $q_0$ ,  $q_3$ , the variables  $dpq$ ,  $sp$ ,  $sq$ ,  $spq$ ,  $sidePisLargeBlk$ ,  $sideQisLargeBlk$ ,  $\beta$  and  $tc$  as inputs, and the output is assigned to the decision  $dSam3$ .

- 9. The variables  $dE$ ,  $dEp$  and  $dEq$  are derived as follows:

- If  $dSam0$  and  $dSam3$  are both equal to 1, the variable  $dE$  is set equal to 3,  $dEp$  is set equal to 1, and  $dEq$  is set equal to 1.
- Otherwise, the following ordered steps apply:

- a. The variables  $dpq0$ ,  $dpq3$ ,  $dp$ ,  $dq$  and  $d$  are derived as follows:

$$dpq0 = dp0 + dq0 \quad (8-1107)$$

$$dpq3 = dp3 + dq3 \quad (8-1108)$$

$$dp = dp0 + dp3 \quad (8-1109)$$

$$dq = dq0 + dq3 \quad (8-1110)$$

$$d = dpq0 + dpq3 \quad (8-1111)$$

- b. The variables  $dE$ ,  $dEp$ ,  $dEq$ ,  $sidePisLargeBlk$  and  $sideQisLargeBlk$  are set equal to 0.
- c. When  $d$  is less than  $\beta$  and both  $\maxFilterLengthP$  and  $\maxFilterLengthQ$  are greater than 2, the following ordered steps apply:
  - i. The variable  $dpq$  is set equal to  $2 * dpq0$ .
  - ii. The variable  $sp$  is set equal to  $sp0$ , the variable  $sq$  is set equal to  $sq0$  and the variable  $spq$  is set equal to  $spq0$ .

- iii. For the sample location (  $x_{Cb} + x_{Bl}$ ,  $y_{Cb} + y_{Bl}$  ), the decision process for a luma sample as specified in clause 8.8.3.6.5 is invoked with the variables  $p_0$ ,  $p_3$ ,  $q_0$ ,  $q_3$  all set equal to 0, the variables  $dpq$ ,  $sp$ ,  $sq$ ,  $spq$ ,  $sidePisLargeBlk$ ,  $sideQisLargeBlk$ ,  $\beta$  and  $tc$  as inputs, and the output is assigned to the decision  $d_{Sam0}$ .
  - iv. The variable  $dpq$  is set equal to  $2 * dpq_3$ .
  - v. The variable  $sp$  is set equal to  $sp_3$ , the variable  $sq$  is set equal to  $sq_3$  and the variable  $spq$  is set equal to  $spq_3$ .
  - vi. When  $edgeType$  is equal to  $EDGE\_VER$  for the sample location (  $x_{Cb} + x_{Bl}$ ,  $y_{Cb} + y_{Bl} + 3$  ) or when  $edgeType$  is equal to  $EDGE\_HOR$  for the sample location (  $x_{Cb} + x_{Bl} + 3$ ,  $y_{Cb} + y_{Bl}$  ), the decision process for a sample as specified in clause 8.8.3.6.5 is invoked with the variables  $p_0$ ,  $p_3$ ,  $q_0$ ,  $q_3$  all set equal to 0, the variables  $dpq$ ,  $sp$ ,  $sq$ ,  $spq$ ,  $sidePisLargeBlk$ ,  $sideQisLargeBlk$ ,  $\beta$  and  $tc$  as inputs, and the output is assigned to the decision  $d_{Sam3}$ .
- d. When  $d$  is less than  $\beta$ , the following ordered steps apply:
- i. The variable  $dE$  is set equal to 1.
  - ii. When  $d_{Sam0}$  is equal to 1 and  $d_{Sam3}$  is equal to 1, the variable  $dE$  is set equal to 2.
  - iii. When  $maxFilterLengthP$  is greater than 1, and  $maxFilterLengthQ$  is greater than 1, and  $dp$  is less than  $(\beta + (\beta \gg 1)) \gg 3$ , the variable  $dEp$  is set equal to 1.
  - iv. When  $maxFilterLengthP$  is greater than 1, and  $maxFilterLengthQ$  is greater than 1, and  $dq$  is less than  $(\beta + (\beta \gg 1)) \gg 3$ , the variable  $dEq$  is set equal to 1.

Table 8-18 – Derivation of threshold variables  $\beta'$  and  $t_c'$  from input Q

|                            |    |    |     |     |     |     |     |     |     |     |     |     |     |     |     |    |    |
|----------------------------|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|
| <b>Q</b>                   | 0  | 1  | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15 | 16 |
| <b><math>\beta'</math></b> | 0  | 0  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 6  |
| <b><math>t_c'</math></b>   | 0  | 0  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 0  |
| <b>Q</b>                   | 17 | 18 | 19  | 20  | 21  | 22  | 23  | 24  | 25  | 26  | 27  | 28  | 29  | 30  | 31  | 32 | 33 |
| <b><math>\beta'</math></b> | 7  | 8  | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 20  | 22  | 24  | 26 | 28 |
| <b><math>t_c'</math></b>   | 0  | 3  | 4   | 4   | 4   | 4   | 5   | 5   | 5   | 5   | 7   | 7   | 8   | 9   | 10  | 10 | 11 |
| <b>Q</b>                   | 34 | 35 | 36  | 37  | 38  | 39  | 40  | 41  | 42  | 43  | 44  | 45  | 46  | 47  | 48  | 49 | 50 |
| <b><math>\beta'</math></b> | 30 | 32 | 34  | 36  | 38  | 40  | 42  | 44  | 46  | 48  | 50  | 52  | 54  | 56  | 58  | 60 | 62 |
| <b><math>t_c'</math></b>   | 13 | 14 | 15  | 17  | 19  | 21  | 24  | 25  | 29  | 33  | 36  | 41  | 45  | 51  | 57  | 64 | 71 |
| <b>Q</b>                   | 51 | 52 | 53  | 54  | 55  | 56  | 57  | 58  | 59  | 60  | 61  | 62  | 63  | 64  | 65  |    |    |
| <b><math>\beta'</math></b> | 64 | 66 | 68  | 70  | 72  | 74  | 76  | 78  | 80  | 82  | 84  | 86  | 88  | -   | -   |    |    |
| <b><math>t_c'</math></b>   | 80 | 89 | 100 | 112 | 125 | 141 | 157 | 177 | 198 | 222 | 250 | 280 | 314 | 352 | 395 |    |    |

## 8.8.3.6.2 Filtering process for luma block edges

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Depending on the value of edgeType, the following applies:

- If edgeType is equal to EDGE\_VER, the following ordered steps apply:

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3. When dE is equal to 3, for each sample location ( xCb + xBl, yCb + yBl + k ), k = 0..3, the following ordered steps apply:

- a. The filtering process for a luma sample using long filters as specified in clause 8.8.3.6.7 is invoked with the sample values  $p_{i,k}$ ,  $q_{j,k}$  with  $i = 0..maxFilterLengthP$  and  $j = 0..maxFilterLengthQ$ , the locations ( xPi, yPi ) set equal to ( xCb + xBl - i - 1, yCb + yBl + k ) with  $i = 0..maxFilterLengthP - 1$  and ( xQj, yQj ) set equal to ( xCb + xBl + j, yCb + yBl + k ) with  $j = 0..maxFilterLengthQ - 1$ , the variables maxFilterLengthP, maxFilterLengthQ and tc as inputs and the filtered samples values  $p_i'$  and  $q_j'$  as outputs.
- b. The filtered sample values  $p_i'$  with  $i = 0..maxFilterLengthP - 1$  replace the corresponding samples inside the sample array recPicture as follows:

$$\text{recPicture}[ \text{xCb} + \text{xBl} - i - 1 ][ \text{yCb} + \text{yBl} + k ] = p_i' \quad (8-1116)$$

- c. The filtered sample values  $q_j'$  with  $j = 0..\text{maxFilterLengthQ} - 1$  replace the corresponding samples inside the sample array `recPicture` as follows:

$$\text{recPicture}[ \text{xCb} + \text{xBl} + j ][ \text{yCb} + \text{yBl} + k ] = q_j' \quad (8-1117)$$

...

- Otherwise (`edgeType` is equal to `EDGE_HOR`), the following ordered steps apply:

...

3. When `dE` is equal to 3, for each sample location  $(\text{xCb} + \text{xBl} + k, \text{yCb} + \text{yBl})$ ,  $k = 0..3$ , the following ordered steps apply:

- a. The filtering process for a luma sample using long filters as specified in clause 8.8.3.6.7 is invoked with the sample values  $p_{i,k}$ ,  $q_{j,k}$  with  $i = 0..\text{maxFilterLengthP}$  and  $j = 0..\text{maxFilterLengthQ}$ , the locations  $(\text{xP}_i, \text{yP}_i)$  set equal to  $(\text{xCb} + \text{xBl} + k, \text{yCb} + \text{yBl} - i - 1)$  with  $i = 0..\text{maxFilterLengthP} - 1$  and  $(\text{xQ}_j, \text{yQ}_j)$  set equal to  $(\text{xCb} + \text{xBl} + k, \text{yCb} + \text{yBl} + j)$  with  $j = 0..\text{maxFilterLengthQ} - 1$ , the variables `maxFilterLengthP`, `maxFilterLengthQ`, and the variable `tc` as inputs, and the filtered sample values  $p_i'$  and  $q_j'$  as outputs.

- b. The filtered sample values  $p_i'$  with  $i = 0..\text{maxFilterLengthP} - 1$  replace the corresponding samples inside the sample array `recPicture` as follows:

$$\text{recPicture}[ \text{xCb} + \text{xBl} + k ][ \text{yCb} + \text{yBl} - i - 1 ] = p_i' \quad (8-1122)$$

- c. The filtered sample values  $q_j'$  with  $j = 0..\text{maxFilterLengthQ} - 1$  replace the corresponding samples inside the sample array `recPicture` as follows:

$$\text{recPicture}[ \text{xCb} + \text{xBl} + k ][ \text{yCb} + \text{yBl} + j ] = q_j' \quad (8-1123)$$

...

#### 8.8.3.6.5 Decision process for a luma sample

Inputs to this process are:

- the sample values  $p_0, p_3, q_0$  and  $q_3$ ,
  - the variables `dpq`, `sp`, `sq`, `spq`, `sidePisLargeBlk`, `sideQisLargeBlk`,  $\beta$  and `tc`.
- Output of this process is the variable `dSam` containing a decision.

The variables `sp` and `sq` are modified as follows:

- When `sidePisLargeBlk` is equal to 1, the following applies:

$$\text{sp} = ( \text{sp} + \text{Abs}( p_3 - p_0 ) + 1 ) \gg 1 \quad (8-1158)$$

- When `sideQisLargeBlk` is equal to 1, the following applies:

$$sq = (sq + \text{Abs}(q_3 - q_0) + 1) \gg 1 \quad (8-1159)$$

The variable sThr is derived as follows:

- If sidePisLargeBlk is equal to 1 or sideQisLargeBlk is equal to 1, the following applies:

$$sThr = 3 * \beta \gg 5 \quad (8-1160)$$

- Otherwise, the following applies:

$$sThr = \beta \gg 3 \quad (8-1161)$$

The variable dSam is specified as follows:

- If all of the following conditions are true, dSam is set equal to 1:
  - dpq is less than  $(\beta \gg 2)$ ,
  - $sp + sq$  is less than sThr,
  - $spq$  is less than  $(5 * tc + 1) \gg 1$ .
- Otherwise, dSam is set equal to 0.

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#### 8.8.3.6.6 Filtering process for a luma sample using short filters

Inputs to this process are:

- the sample values  $p_i$  and  $q_i$  with  $i = 0..3$ ,
- the locations of  $p_i$  and  $q_i$ ,  $(xP_i, yP_i)$  and  $(xQ_i, yQ_i)$  with  $i = 0..2$ ,
- a variable dE,
- the variables dEp and dEq containing decisions to filter samples  $p_1$  and  $q_1$ , respectively,
- a variable tc.

Outputs of this process are:

- the number of filtered samples nDp and nDq,
- the filtered sample values  $p_i'$  and  $q_j'$  with  $i = 0..nDp - 1, j = 0..nDq - 1$ .

Depending on the value of dE, the following applies:

- If the variable dE is equal to 2, nDp and nDq are both set equal to 3 and the following strong filtering applies:

$$p_0' = \text{Clip3}(p_0 - 3 * tc, p_0 + 3 * tc, (p_2 + 2 * p_1 + 2 * p_0 + 2 * q_0 + q_1 + 4) \gg 3) \quad (8-1162)$$

$$p_1' = \text{Clip3}(p_1 - 2 * tc, p_1 + 2 * tc, (p_2 + p_1 + p_0 + q_0 + 2) \gg 2) \quad (8-1163)$$

$$p_2' = \text{Clip3}(p_2 - 1 * t_c, p_2 + 1 * t_c, (2 * p_3 + 3 * p_2 + p_1 + p_0 + q_0 + 4) \gg 3) \quad (8-1164)$$

$$q_0' = \text{Clip3}(q_0 - 3 * t_c, q_0 + 3 * t_c, (p_1 + 2 * p_0 + 2 * q_0 + 2 * q_1 + q_2 + 4) \gg 3) \quad (8-1165)$$

$$q_1' = \text{Clip3}(q_1 - 2 * t_c, q_1 + 2 * t_c, (p_0 + q_0 + q_1 + q_2 + 2) \gg 2) \quad (8-1166)$$

$$q_2' = \text{Clip3}(q_2 - 1 * t_c, q_2 + 1 * t_c, (p_0 + q_0 + q_1 + 3 * q_2 + 2 * q_3 + 4) \gg 3) \quad (8-1167)$$

– Otherwise, nDp and nDq are set both equal to 0 and the following weak filtering applies:

– The following applies:

$$\Delta = (9 * (q_0 - p_0) - 3 * (q_1 - p_1) + 8) \gg 4 \quad (8-1168)$$

– When Abs( $\Delta$ ) is less than  $t_c * 10$ , the following ordered steps apply:

– The filtered sample values  $p_0'$  and  $q_0'$  are specified as follows:

$$\Delta = \text{Clip3}(-t_c, t_c, \Delta) \quad (8-1169)$$

$$p_0' = \text{Clip1}_Y(p_0 + \Delta) \quad (8-1170)$$

$$q_0' = \text{Clip1}_Y(q_0 - \Delta) \quad (8-1171)$$

– When dEp is equal to 1, the filtered sample value  $p_1'$  is specified as follows:

$$\Delta p = \text{Clip3}(-(t_c \gg 1), t_c \gg 1, (((p_2 + p_0 + 1) \gg 1) - p_1 + \Delta) \gg 1) \quad (8-1172)$$

$$p_1' = \text{Clip1}_Y(p_1 + \Delta p) \quad (8-1173)$$

– When dEq is equal to 1, the filtered sample value  $q_1'$  is specified as follows:

$$\Delta q = \text{Clip3}(-(t_c \gg 1), t_c \gg 1, (((q_2 + q_0 + 1) \gg 1) - q_1 - \Delta) \gg 1) \quad (8-1174)$$

$$q_1' = \text{Clip1}_Y(q_1 + \Delta q) \quad (8-1175)$$

– nDp is set equal to dEp + 1 and nDq is set equal to dEq + 1.

When nDp is greater than 0 and one or more of the following conditions are true, nDp is set equal to 0:

- cu\_transquant\_bypass\_flag of the coding unit that includes the coding block containing the sample  $p_0$  is equal to 1.
- pred\_mode\_plt\_flag of the coding unit that includes the coding block containing the sample  $p_0$  is equal to 1.

When nDq is greater than 0 and one or more of the following conditions are true, nDq is set equal to 0:

- cu\_transquant\_bypass\_flag of the coding unit that includes the coding block containing the sample  $q_0$  is equal to 1.
- pred\_mode\_plt\_flag of the coding unit that includes the coding block containing the sample  $q_0$  is equal to 1.

### 8.8.3.6.7 Filtering process for a luma sample using long filters

Inputs to this process are:

- the variables maxFilterLengthP and maxFilterLengthQ,
- the sample values  $p_i$  and  $q_j$  with  $i = 0..maxFilterLengthP$  and  $j = 0..maxFilterLengthQ$ ,
- the locations of  $p_i$  and  $q_j$ ,  $(xP_i, yP_i)$  and  $(xQ_j, yQ_j)$  with  $i = 0..maxFilterLengthP - 1$  and  $j = 0..maxFilterLengthQ - 1$ ,
- a variable tc.

Outputs of this process are:

- the filtered sample values  $p_i'$  and  $q_j'$  with  $i = 0..maxFilterLengthP - 1$ ,  $j = 0..maxFilterLengthQ - 1$ .

The variable refMiddle is derived as follows:

- If maxFilterLengthP is equal to maxFilterLengthQ and maxFilterLengthP is equal to 5, the following applies:

$$refMiddle = (p_4 + p_3 + 2 * (p_2 + p_1 + p_0 + q_0 + q_1 + q_2) + q_3 + q_4 + 8) \gg 4 \quad (8-1176)$$

- Otherwise, if maxFilterLengthP is equal to maxFilterLengthQ and maxFilterLengthP is not equal to 5, the following applies:

$$refMiddle = (p_6 + p_5 + p_4 + p_3 + p_2 + p_1 + 2 * (p_0 + q_0) + q_1 + q_2 + q_3 + q_4 + q_5 + q_6 + 8) \gg 4 \quad (8-1177)$$

- Otherwise, if one of the following conditions are true,

- maxFilterLengthQ is equal to 7 and maxFilterLengthP is equal to 5,
  - maxFilterLengthQ is equal to 5 and maxFilterLengthP is equal to 7,
- the following applies:

$$refMiddle = (p_4 + p_3 + 2 * (p_2 + p_1 + p_0 + q_0 + q_1 + q_2) + q_3 + q_4 + 8) \gg 4 \quad (8-1178)$$

- Otherwise, if one of the following conditions are true,

- maxFilterLengthQ is equal to 5 and maxFilterLengthP is equal to 3,
  - maxFilterLengthQ is equal to 3 and maxFilterLengthP is equal to 5,
- the following applies:

$$refMiddle = (p_3 + p_2 + p_1 + p_0 + q_0 + q_1 + q_2 + q_3 + 4) \gg 3 \quad (8-1179)$$

- Otherwise, if maxFilterLengthQ is equal to 7 and maxFilterLengthP is equal to 3, the following applies:

$$refMiddle = (2 * (p_2 + p_1 + p_0 + q_0) + p_0 + p_1 + q_1 + q_2 + q_3 + q_4 + q_5 + q_6 + 8) \gg 4 \quad (8-1180)$$

- Otherwise, the following applies:

$$\text{refMiddle} = (p_6 + p_5 + p_4 + p_3 + p_2 + p_1 + 2*(q_2 + q_1 + q_0 + p_0) + q_0 + q_1 + 8) \gg 4 \quad (8-1181)$$

The variables refP and refQ are derived as follows:

$$\text{refP} = (p_{\text{maxFilterLengthP}} + p_{\text{maxFilterLengthP}-1} + 1) \gg 1 \quad (8-1182)$$

$$\text{refQ} = (q_{\text{maxFilterLengthQ}} + q_{\text{maxFilterLengthQ}-1} + 1) \gg 1 \quad (8-1183)$$

The variables  $f_i$  and  $\text{tcPD}_i$  are defined as follows:

- If maxFilterLengthP is equal to 7, the following applies:

$$f_{0..6} = \{ 59, 50, 41, 32, 23, 14, 5 \} \quad (8-1184)$$

$$\text{tcPD}_{0..6} = \{ 6, 5, 4, 3, 2, 1, 1 \} \quad (8-1185)$$

- Otherwise, if maxFilterLengthP is equal to 5, the following applies:

$$f_{0..4} = \{ 58, 45, 32, 19, 6 \} \quad (8-1186)$$

$$\text{tcPD}_{0..4} = \{ 6, 5, 4, 3, 2 \} \quad (8-1187)$$

- Otherwise, the following applies:

$$f_{0..2} = \{ 53, 32, 11 \} \quad (8-1188)$$

$$\text{tcPD}_{0..2} = \{ 6, 4, 2 \} \quad (8-1189)$$

The variables  $g_j$  and  $\text{tcQD}_j$  are defined as follows:

- If maxFilterLengthQ is equal to 7, the following applies:

$$g_{0..6} = \{ 59, 50, 41, 32, 23, 14, 5 \} \quad (8-1190)$$

$$\text{tcQD}_{0..6} = \{ 6, 5, 4, 3, 2, 1, 1 \} \quad (8-1191)$$

- Otherwise, if maxFilterLengthQ is equal to 5, the following applies:

$$g_{0..4} = \{ 58, 45, 32, 19, 6 \} \quad (8-1192)$$

$$\text{tcQD}_{0..4} = \{ 6, 5, 4, 3, 2 \} \quad (8-1193)$$

- Otherwise, the following applies:

$$g_{0..2} = \{ 53, 32, 11 \} \quad (8-1194)$$

$$\text{tcQD}_{0..2} = \{ 6, 4, 2 \} \quad (8-1195)$$

The filtered sample values  $p_i'$  and  $q_j'$  with  $i = 0..\text{maxFilterLengthP} - 1$  and  $j = 0..\text{maxFilterLengthQ} - 1$  are derived as follows:

$$p_i' = \text{Clip3}(p_i - (t_c * t_{cPD_i}) \gg 1, p_i + (t_c * t_{cPD_i}) \gg 1, (\text{refMiddle} * f_i + \text{refP} * (64 - f_i) + 32) \gg 6) \quad (8-1196)$$

$$q_j' = \text{Clip3}(q_j - (t_c * t_{cQD_j}) \gg 1, q_j + (t_c * t_{cQD_j}) \gg 1, (\text{refMiddle} * g_j + \text{refQ} * (64 - g_j) + 32) \gg 6) \quad (8-1197)$$

When one or more of the following conditions are true, the filtered sample value,  $p_i'$  is substituted by the corresponding input sample value  $p_i$  with  $i = 0..maxFilterLengthP - 1$ :

- `cu_transquant_bypass_flag` of the coding unit that includes the coding block containing the sample  $p_i$  is equal to 1.
- `pred_mode_plt_flag` of the coding unit that includes the coding block containing the sample  $p_i$  is equal to 1.

When one or more of the following conditions are true, the filtered sample value,  $q_j'$  is substituted by the corresponding input sample value  $q_j$  with  $j = 0..maxFilterLengthQ - 1$ :

- `cu_transquant_bypass_flag` of the coding unit that includes the coding block containing the sample  $q_j$  is equal to 1.
- `pred_mode_plt_flag` of the coding unit that includes the coding block containing the sample  $q_j$  is equal to 1.

...

[0014] -- End Excerpt - -

## SUMMARY

[0015] Certain challenges exist. For example, the long filter decision for 7 sample filtering on one or two sides does not take into consideration either sample  $p_6$  for block P or  $q_6$  for block Q, and this can enable the long filtering notwithstanding the fact that such long filtering will reduce image quality (e.g., destroy a natural texture) by modifying  $p_6$  and/or  $q_6$ .

[0016] Here follow's examples of sample values across a boundary between block P ( $p_0$  to  $p_7$ ) and block Q ( $q_0$  to  $q_7$ ), where  $p_0$  and  $q_0$  are adjacent to the boundary, that the current long filter decisions totally ignore and thus may apply deblocking that removes natural texture:

[0017] Samples:  $p_7 \ p_6 \ p_5 \ p_4 \ p_3 \ p_2 \ p_1 \ p_0 \mid q_0 \ q_1 \ q_2 \ q_3 \ q_4 \ q_5 \ q_6 \ q_7$

[0018] A peak in sample  $p_6$  or  $q_6$  where  $p_6$  and  $q_6$  is larger or smaller than neighboring samples as shown in example 1 cannot be detected.

[0019] Example 1    10 0 10 10 10 10 10 10 | 10 10 10 10 10 10 0 10

[0020] A peak in sample  $p_5$  or  $q_5$  where  $p_4$ ,  $p_5$ ,  $p_6$ ,  $q_4$ ,  $q_5$  and  $q_6$  are larger or smaller

than neighboring samples as shown in example 2 cannot be detected.

**[0021]** Example 2 10 20 30 20 10 10 10 10 | 10 10 10 10 20 30 20 10

**[0022]** To overcome this problem, this disclosure proposes embodiments where the long filter decision in VVC is modified by adding at least one gradient check that at least includes sample p6 or q6. This makes it possible to avoid using the long filters when there is some natural structure at sample p6 or q6. In one specific embodiment at least two gradient checks including both q6 and p6 are added. In another embodiment, the dpq threshold is modified from  $\beta > 2$  to  $\beta > 4$ . This threshold change embodiment may be used in conjunction with or instead of the embodiment in which a gradient check that includes p6 and/or q6 is added to the long filter decision. An advantage of the proposed embodiments is that they increase the quality of the image displayed to the user (e.g., it avoids removing narrow lines or blurring narrow lines).

**[0023]** Accordingly, in one aspect there is provided a method (400) for filtering sample values associated with an image. The method includes obtaining (s402) a first set of sample values comprising a first block of sample values and a second block of sample values, wherein the first block of sample values comprises a set of sample values  $B1_{i,k}$  for  $i=0-7$  and  $k=0-3$ , and the second block of sample values comprises a set of sample values  $B2_{i,k}$  for  $i=0-7$  and  $k=0-3$ . The method also includes deciding (s404) whether or not to use a long filter to filter at least a subset of the first set of sample values. Deciding whether or not to use a long filter to filter at least a subset of the first set of sample values comprises: calculating (s502) a first gradient value,  $\maxGradB1_{6,0}$ , using sample value  $B1_{6,0}$ ; calculating (s504) a first pq value,  $pq1_0$ , using  $\maxGradB1_{6,0}$ ; and comparing (s508)  $pq1_0$  to a threshold. In another aspect there is provided an apparatus configured to perform this method.

**[0024]** In another aspect there is provided a method (400) for filtering sample values associated with an image. The method includes obtaining (s402) a first set of sample values comprising a first block of sample values and a second block of sample values, wherein the first block of sample values comprises a set of sample values  $B1_{i,k}$  for  $i=0-7$  and  $k=0-3$ , and the second block of sample values comprises a set of sample values  $B2_{i,k}$  for  $i=0-7$  and  $k=0-3$ . The method also includes selecting (s404) a filter. Selecting the filter comprises calculating (s504) a first pq value,  $pq2_0$ , using at least a first value equal to  $Abs(B1_{2,0} - 2 * B1_{1,0} + B1_{0,0})$

and a second value equal to  $\text{Abs}(B2_{2,0} - 2 * B2_{1,0} + B2_{0,0})$ ; and comparing (s508)  $pq2\_0$  to a threshold, wherein the threshold is equal to  $\beta \gg 4$ , and  $\beta$  is selected from a set of predetermined beta values based on a quantization parameter value,  $Q$ . In another aspect there is provided an apparatus configured to perform this method.

**[0025]** In another aspect there is provided a method for filtering sample values associated with an image. The method includes obtaining (s402) a first set of sample values comprising a first block of sample values and a second block of sample values, wherein the first block of sample values comprises a set of sample values  $B1_{i,k}$  for  $i=0-7$  and  $k=0-3$ , and the second block of sample values comprises a set of sample values  $B2_{i,k}$  for  $i=0-7$  and  $k=0-3$ . The method also includes selecting (s404) a filter. Selecting the filter comprises: i) calculating a first pq value,  $pq1\_0$ , wherein calculating  $pq1\_0$  comprises calculating a value  $sp$ , calculating a value  $sq$ , and calculating  $sp + sq$ , wherein  $pq1\_0 = (sp + sq)$ ; ii) comparing  $pq1\_0$  to a first threshold; iii) calculating (s504) a second pq value,  $pq2\_0$ , using at least a first value equal to  $\text{Abs}(B1_{2,0} - 2 * B1_{1,0} + B1_{0,0})$  and a second value equal to  $\text{Abs}(B2_{2,0} - 2 * B2_{1,0} + B2_{0,0})$ ; and iv) comparing (s508)  $pq2\_0$  to a second threshold, wherein the second threshold is equal to  $\beta \gg 4$ , and  $\beta$  is selected from a set of predetermined beta values based on a quantization parameter value,  $Q$ . In another aspect there is provided an apparatus configured to perform this method.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0026]** FIG. 1 is a schematic block diagram of a video encoder according to an embodiment.

**[0027]** FIG. 2 is a schematic block diagram of a video decoder according to an embodiment.

**[0028]** FIG. 3 illustrates a boundary between a first block (denoted a P block) and a second block (denoted a Q block).

**[0029]** FIG. 4 is a flowchart illustrating a process according to an embodiment.

**[0030]** FIG. 5 is a flowchart illustrating a process according to an embodiment.

**[0031]** FIG. 6 is a block diagram of an apparatus according to an embodiment.

**[0032]** FIG. 7 a functional block diagram of an apparatus according to an embodiment.

## DETAILED DESCRIPTION

**[0033]** The embodiments described herein can be used in a video encoder or video decoder to deblock vertical and/or horizontal block boundaries. It also applies to an image encoder or image decoder to deblock vertical and/or horizontal block boundaries.

**[0034]** FIG. 1 is a schematic block diagram of a video encoder 140 to encode a block of pixels in a video image (also referred to as a frame) of a video sequence according to some embodiments.

**[0035]** A current block of pixels is predicted by performing a motion estimation using motion estimator 150 from an already provided block of pixels in the same frame or in a previous frame. The result of the motion estimation is a motion or displacement vector associated with the reference block, in the case of inter prediction. The motion vector may be used by motion compensator 150 to output an inter prediction of the block of pixels.

**[0036]** Intra predictor 149 computes an intra prediction of the current block of pixels. The outputs from the motion estimator/compensator 150 and the intra predictor 149 are input in selector 151 that either selects intra prediction or inter prediction for the current block of pixels. The output from the selector 151 is input to an error calculator in the form of adder 141 that also receives the pixel values of the current block of pixels. Adder 141 calculates and outputs a residual error as the difference in pixel values between the block of pixels and its prediction.

**[0037]** The error is transformed in transformer 142, such as by a discrete cosine transform, and quantized by quantizer 143 followed by coding in encoder 144, such as by entropy encoder. In inter coding, also the estimated motion vector is brought to encoder 144 to generate the coded representation of the current block of pixels.

**[0038]** The transformed and quantized residual error for the current block of pixels is also provided to an inverse quantizer 145 and inverse transformer 146 to retrieve the original residual error. This error is added by adder 147 to the block prediction output from the motion compensator 150 or intra predictor 149 to create a reference block of pixels that can be used in the prediction and coding of a next block of pixels. This new reference block is first processed by a deblocking filter 100 according to examples/embodiments discussed below to perform deblocking filtering to reduce/combat blocking artifacts. The processed new reference block is

then temporarily stored in frame buffer 148, where it is available to intra predictor 149 and motion estimator/compensator 150.

**[0039]** FIG. 2 is a corresponding schematic block diagram of a video decoder 260 including deblocking filter 100 according to some embodiments. Decoder 260 includes decoder 261, such as entropy decoder, to decode an encoded representation of a block of pixels to get a set of quantized and transformed residual errors. These residual errors are dequantized by inverse quantizer 262 and inverse transformed by inverse transformer 263 to provide a set of residual errors.

**[0040]** These residual errors are added by adder 264 to the pixel values of a reference block of pixels. The reference block is determined by a motion estimator/compensator 267 or intra predictor 266, depending on whether inter or intra prediction is performed. Selector 268 is thereby interconnected to adder 264 and motion estimator/compensator 267 and intra predictor 266. The resulting decoded block of pixels output from adder 264 is input to deblocking filter 100 according to some embodiments of inventive concepts to provide deblocking filtering of blocking artifacts. The filtered block of pixels is output from decoder 260 and may be furthermore temporarily provided to frame buffer 265 to be used as a reference block of pixels for a subsequent block of pixels to be decoded. Frame buffer 265 is thereby connected to motion estimator/compensator 267 to make the stored blocks of pixels available to motion estimator/compensator 267.

**[0041]** The output from adder 264 may also be input to intra predictor 266 to be used as an unfiltered reference block of pixels.

**[0042]** In embodiments of FIG. 1 and FIG. 2, deblocking filter 100 may perform deblocking filtering as so called in-loop filtering. In alternative embodiments at decoder 260, deblocking filter 100 may be arranged to perform so called post-processing filtering. In such a case, deblocking filter 100 operates on the output frames outside of the loop formed by adder 264, frame buffer 265, intra predictor 266, motion estimator/compensator 267, and selector 268. In such embodiments, no deblocking filtering is typically done at the encoder. Operations of deblocking filter 100 will be discussed in greater detail below.

**[0043]** When the maximum number of samples that can be modified on at least one side of the block boundary is determined to be 7 samples and the boundary strength is determined to

be larger than 0 for one line of samples, a long filter decision is based on determining a gradient value (denoted “magGradp6”) (e.g., the magnitude of a gradient) using sample value p6 in block P if maxFilterLengthP is equal to 7 and based on determining a gradient value (denoted “magGradq6”) using sample value q6 in block Q if maxFilterLengthQ is equal to 7.

**[0044]** In one embodiment, calculating magGradp6 comprises calculating magGradp6 using p6 and using at least one of p3, p4, p5, and p7, and calculating magGradq6 comprises calculating magGradq6 using q6 and using at least one of q3, q4, q5, and q7.

**[0045]** Alternative 1

**[0046]** The magGradp6 value is added to other gradient computations including at least sample p0, p3 and p7. For example, a value sp is calculated as:

$$sp = (\text{Abs}(p0 - p3) + \text{Abs}(p3 - p7) + \text{magGradp6} + 1) \gg 1$$

**[0047]** The magGradq6 value is added to other gradient computations including at least sample q0, q3 and q7. For example, a value sq is calculated as:

$$sq = (\text{Abs}(q0 - q3) + \text{Abs}(q3 - q7) + \text{magGradq6} + 1) \gg 1.$$

**[0048]** A value spq may then be computed where  $spq = sp + sq$ .

$$\text{dp} = (\text{Abs}(p0 - 2*p1 + p2) + \text{Abs}(p3 - 2*p4 + p5) + 1) \gg 1.$$

$$\text{dq} = (\text{Abs}(q0 - 2*q1 + q2) + \text{Abs}(q3 - 2*q4 + q5) + 1) \gg 1.$$

**[0051]** Alternative 2

**[0052]** The magGradp6 value replaces the magnitude computed for the case of maxFilterLengthP equal to 5 as follows:

**[0053]** If maxFilterLengthP == 7, then

$$\text{dp} = (\text{Abs}(p0 - 2*p1 + p2) + \text{magGradp6} + 1) \gg 1, \text{ otherwise}$$

$$\text{dp} = (\text{Abs}(p0 - 2*p1 + p2) + \text{Abs}(p3 - 2*p4 + p5) + 1) \gg 1.$$

**[0054]** The magGradq6 value replaces the magnitude computed for the case of maxFilterLengthQ equal to 5 as follows:

**[0055]** If maxFilterLengthQ == 7, then

$$\text{dq} = (\text{Abs}(q0 - 2*q1 + q2) + \text{magGradq6} + 1) \gg 1, \text{ otherwise}$$

$dq = (\text{Abs}(q_0 - 2*q_1 + q_2) + \text{Abs}(q_3 - 2*q_4 + q_5) + 1) \gg 1$ .

**[0056]** A value, dpq, is then computed as  $dpq = dq + dp$ .

**[0057]** For either alternative 1 or alternative 2 above, in one embodiment it is decided to use a long filter if all of the following three conditions are TRUE:

(1)  $spq < \text{threshold1}$ ,

(2)  $2*dpq < \text{threshold2}$ , and

$(\text{Abs}(p_0 - q_0) < \text{threshold3})$ .

**[0058]** If one or more of the above conditions is not true, then the long filter is not applied and  $\text{maxFilterLengthP}$  and  $\text{maxFilterLengthQ}$  are equal to 3 or less.

**[0059]** In one embodiment,  $\text{threshold1} = sThr$  (e.g.,  $(3*\beta) \gg 5$ ).

**[0060]** In one embodiment,  $\text{threshold2} = \beta \gg 2$ , where  $\beta$  depends on a quantization parameter value,  $Q$ , as shown above in table 8-18.

**[0061]** In one embodiment,  $\text{threshold3} = (5*tC+1) \gg 1$ , where  $tC$  depends on a quantization parameter value,  $Q$ , as shown above in table 8-18.

**[0062]** For either alternative 1 or alternative 2 above, in one embodiment  $\text{magGradp6}$  is determined as:  $\text{Abs}(p_6 - p_7)$ , and  $\text{magGradq6}$  is determined as:  $\text{Abs}(q_7 - q_6)$ .

**[0063]** In another embodiment,  $\text{magGradp6}$  is equal to  $\text{Abs}(p_4 - p_5 - p_6 + p_7)$  and  $\text{magGradq6}$  is equal to  $\text{Abs}(q_7 - q_5 - q_6 + q_4)$ . One benefit of this embodiment compared to embodiment with gradient determined from difference between two samples is that this approach to determine the magnitude of the gradient do not increase sensitive to a ramp, a slope with increasing or decreasing values from  $p_0$  to  $p_7$  or from  $q_0$  to  $q_7$ .

**[0064]** In another embodiment,  $\text{magGradp6}$  is equal to  $\text{Abs}(p_4 - 2*p_5 + p_6)$  and  $\text{magGradq6}$  is equal to  $\text{Abs}(q_6 - 2*q_5 + q_4)$ . One benefit of this embodiment compared to embodiment with gradient determined from difference between two samples is that this approach to determine the magnitude of the gradient do not increase sensitive to a ramp, a slope with increasing or decreasing values from  $p_0$  to  $p_7$  or from  $q_0$  to  $q_7$ .

**[0065]** For alternative 1, the specification Section 8.8.3.6.1 equations 8-1081, 8-1082, 8-1084, and 8-1085 may be modified as follows:

$sp0 = \text{maxFilterLengthP} == 7 ? \text{Abs}(p3,0 - p0,0) + \text{magGradp6\_0} : \text{Abs}(p3,0 - p0,0) \text{ (8-1081)},$   
 $sq0 = \text{maxFilterLengthQ} == 7 ? \text{Abs}(q0,0 - q3,0) + \text{magGradq6\_0} : \text{Abs}(q0,0 - q3,0) \text{ (8-1082)},$   
 $sp3 = \text{maxFilterLengthP} == 7 ? \text{Abs}(p3,3 - p0,3) + \text{magGradp6\_3} : \text{Abs}(p3,3 - p0,3) \text{ (8-1084)},$   
 $sq3 = \text{maxFilterLengthQ} == 7 ? \text{Abs}(q0,3 - q3,3) + \text{magGradq6\_3} : \text{Abs}(q0,3 - q3,3) \text{ (8-1085)},$   
 where

$\text{magGradp6\_0} = \text{Abs}(p7,0 - p6,0) \text{ or}$   
 $\text{Abs}(p7,0 - p6,0 - p5,0 + p4,0) \text{ or}$   
 $\text{Abs}(p6,0 - 2 * p5,0 + p4,0);$   
 $\text{magGradp6\_3} = \text{Abs}(p7,3 - p6,3) \text{ or}$   
 $\text{Abs}(p7,3 - p6,3 - p5,3 + p4,3) \text{ or}$   
 $\text{Abs}(p6,3 - 2 * p5,3 + p4,3);$   
 $\text{magGradq6\_0} = \text{Abs}(q6,0 - q7,0) \text{ or}$   
 $\text{Abs}(q4,0 - q6,0 - q5,0 + q7,0) \text{ or}$   
 $\text{Abs}(q4,0 - 2 * q5,0 + q6,0); \text{ and}$   
 $\text{magGradq6\_3} = \text{Abs}(q6,3 - q7,3) \text{ or}$   
 $\text{Abs}(q4,3 - q6,3 - q5,3 + q7,3) \text{ or}$   
 $\text{Abs}(q4,3 - 2 * q5,3 + q6,3).$

**[0066]** For alternative 2, the specification Section 8.8.3.6.1 equations 8-1087, 8-1088, 8-1092, and 8-1093 may be modified as follows:

$dp0L = (dp0 + (\text{maxFilterLengthP} == 7 ? \text{magGradp6\_0} : \text{Abs}(p5,0 - 2 * p4,0 + p3,0)) + 1) >> 1 \text{ (8-1087)},$   
 $dp3L = (dp3 + (\text{maxFilterLengthP} == 7 ? \text{magGradp6\_3} : \text{Abs}(p5,3 - 2 * p4,3 + p3,3)) + 1) >> 1 \text{ (8-1088)},$   
 $dq0L = (dq0 + (\text{maxFilterLengthQ} == 7 ? \text{magGradq6\_0} : \text{Abs}(q5,0 - 2 * q4,0 + q3,0)) + 1) >> 1 \text{ (8-1092)},$   
 $dq3L = (dq3 + (\text{maxFilterLengthQ} == 7 ? \text{magGradq6\_3} : \text{Abs}(q5,3 - 2 * q4,3 + q3,3)) + 1) >> 1 \text{ (8-1093)},$   
 where

$\text{magGradp6\_0} = \text{Abs}(p7,0 - p6,0 - p5,0 + p4,0) \text{ or}$   
 $\text{Abs}(p6,0 - 2 * p5,0 + p4,0);$   
 $\text{magGradp6\_3} = \text{Abs}(p7,3 - p6,3 - p5,3 + p4,3) \text{ or}$   
 $\text{Abs}(p6,3 - 2 * p5,3 + p4,3);$   
 $\text{magGradq6\_0} = \text{Abs}(q4,0 - q6,0 - q5,0 + q7,0) \text{ or}$   
 $\text{Abs}(q4,0 - 2 * q5,0 + q6,0); \text{ and}$   
 $\text{magGradq6\_3} = \text{Abs}(q4,3 - q6,3 - q5,3 + q7,3) \text{ or}$

$$\text{Abs}(q_{4,3} - 2 * q_{5,3} + q_{6,3}).$$

**[0067]** In another embodiment, the dpq threshold (a.k.a., “threshold2” is modified such that threshold2 is equal to  $\beta \gg 4$ , instead of being equal to  $\beta \gg 2$ . In this embodiment Section 8.8.3.6.5 is modified as follows:

The variable sThr1 and sThr2 are derived as follows:

- If sidePisLargeBlk is equal to 1 or sideQisLargeBlk is equal to 1, the following applies:

$$sThr1 = 3 * \beta \gg 5 \quad (8-1160)$$

$$sThr2 = \beta \gg 4 \quad (8-1160b)$$

- Otherwise, the following applies:

$$sThr1 = \beta \gg 3 \quad (8-1161)$$

$$sThr2 = \beta \gg 2 \quad (8-1161b)$$

The variable dSam is specified as follows:

- If all of the following conditions are true, dSam is set equal to 1:
  - dpq is less than sThr2,
  - $sp + sq$  is less than sThr1,
  - $spq$  is less than  $(5 * tc + 1) \gg 1$ .

Otherwise, dSam is set equal to 0.

**[0068]** In another embodiment, the dqp threshold modification also applies to the strong/weak filter decision. In this embodiment Section 8.8.3.6.5 is modified as follows:

The variable sThr1 and sThr2 are derived as follows:

- If sidePisLargeBlk is equal to 1 or sideQisLargeBlk is equal to 1, the following applies:

$$sThr1 = 3 * \beta \gg 5 \quad (8-1160)$$

$$sThr2 = \beta \gg 4 \quad (8-1160b)$$

- Otherwise, the following applies:

$$sThr1 = \beta \gg 3 \quad (8-1161)$$

$$sThr2 = \beta \gg 4 \quad (8-1161b)$$

The variable dSam is specified as follows:

- If all of the following conditions are true, dSam is set equal to 1:
  - dpq is less than sThr2,
  - sp + sq is less than sThr1,
  - spq is less than ( 5 \* tc + 1 ) >> 1.

Otherwise, dSam is set equal to 0.

**[0069]** FIG. 4 is a flowchart illustrating a process 400 according to some embodiments. Process 400 may begin in step s402.

**[0070]** Step s402 comprises obtaining a first set of sample values. In one embodiment the first set of sample values comprises a first block of sample values (e.g., block 302) (hereafter referred to as the P block) and a second block of sample values (e.g., block 304) (hereafter referred to as the Q block). In one embodiment, as shown in FIG. 3, the P block comprises a set of sample values  $p_{i,k}$  for  $i=0$  to 7 and  $k=0$  to 3, and the q block comprises a set of sample values  $q_{i,k}$  for  $i=0$  to 7 and  $k=0$  to 3.

**[0071]** Step s404 comprises selecting a filter to use to filter at least a subset of the first set of sample values (e.g., sample values  $p_{i,k}$  for  $i=0$  to 7 and  $k=0$  to 3 and/or sample values  $q_{i,k}$  for  $i=0$  to 7 and  $k=0$  to 3). For example, step s404 may comprise deciding whether or not to use a long filter to filter at least a subset of the first set of sample values or deciding whether or not to use a strong filtering should apply (see e.g., VVC specification at 8.8.3.6.6).

**[0072]** Step s406 comprises applying the selected filter.

**[0073]** FIG. 5 is a flowchart illustrating a process 500 according to one embodiment for performing step s404. Process 500 may begin in step s501. Step s501 comprises initializing three variables: k, dSam\_0, and dSam\_3, where all of these variables are initialized to 0.

**[0074]** After step s501, process 500 may include performing steps s502 and s504 or instead performing step s506. Steps s502 and s504 are performed with the assumption that  $\text{maxFilterLengthP} = 7$ .

**[0075]** Step s502 comprises calculating a first gradient value,  $\text{maxGradp6\_k}$ , using

sample value  $p_{6,k}$ . For example, calculating  $\max\text{Grad}p_{6\_k}$  includes: calculating  $\text{Abs}(p_{7,k} - p_{6,k})$  or calculating  $\text{Abs}(p_{7,k} - p_{6,k} - p_{5,k} + p_{4,k})$  or calculating  $\text{Abs}(p_{6,k} - 2 * p_{5,k} + p_{4,k})$ .

**[0076]** Step s504 comprises calculating three  $pq$  values ( $pq_1$ ,  $pq_2$ , and  $pq_3$ ), wherein at least  $pq_1$  is calculated using  $\max\text{Grad}p_{6\_k}$ .

**[0077]** For example, in one embodiment calculating  $pq_1$  comprises calculating a value  $sp + sq$ , wherein calculating  $sp$  comprises calculating  $sp = (\text{Abs}(p_{0,k} - p_{3,k}) + \text{Abs}(p_{3,k} - p_{7,k}) + \max\text{Grad}p_{6\_k} + 1) \gg 1$ . Calculating  $sq$  may comprise calculating:  $(\text{Abs}(q_{0,k} - q_{3,k}) + \text{Abs}(q_{3,k} - q_{7,k}) + \max\text{Grad}q_{6\_k} + 1) \gg 1$ , where  $\max\text{Grad}q_{6\_k}$  equals:  $\text{Abs}(q_{7,k} - q_{6,k})$  or  $\text{Abs}(q_{7,k} - q_{6,k} - q_{5,k} + q_{4,k})$  or  $\text{Abs}(q_{6,k} - 2 * q_{5,k} + q_{4,k})$ .

**[0078]** In another embodiment, calculating  $pq_1$  comprises calculating  $2*(dp + dq)$ , wherein calculating  $dp$  comprises calculating  $dp = (\text{Abs}(p_{0,k} - 2 * p_{1,k} + p_{2,k}) + \max\text{Grad}p_{6\_k} + 1) \gg 1$ . Calculating  $dq$  may comprise calculating:  $(\text{Abs}(q_{0,k} - 2 * q_{1,k} + q_{2,k}) + \max\text{Grad}q_{6\_k} + 1) \gg 1$ .

**[0079]** Step s506 comprises calculating the three  $pq$  values ( $pq_1$ ,  $pq_2$ , and  $pq_3$ ) without using  $\max\text{Grad}p_{6\_k}$  (i.e., without using sample value  $p_{6,k}$ ). In one embodiment,  $pq_1 = sp + sq$ ;  $pq_2 = dpq$ ; and  $pq_3 = \text{Abs}(p_{0,k} - q_{0,k})$ .

**[0080]** Step s508 comprises: i) comparing  $pq_1$  to a first threshold ( $t_1$ ), ii) comparing  $pq_2$  to a second threshold ( $t_2$ ), and iii) comparing  $pq_3$  to a third threshold ( $t_3$ ).

**[0081]** If  $pq_1$  is less than  $t_1$ , and  $pq_2$  is less than  $t_2$ , and  $pq_3$  is less than  $t_3$ , then process 500 proceeds to step s510, otherwise it proceeds to step s509 (i.e., a first filter is selected (e.g., short filtering is applied)).

**[0082]** Step s510 comprises checking whether  $k$  equals 3. If  $k$  is not equal to 3, then process 500 proceeds to step s512, otherwise it proceeds to step s516. In step s512,  $k$  is set equal to 3 and  $d\text{Sam}_0$  is set to 1. After step s512, process returns to either step s502 or s506. Step s516 comprises checking whether  $d\text{Sam}_0$  is equal to 1. If it is not, process 500 goes to step s509, otherwise process 500 goes to step s518 (i.e., a second filter is selected (e.g., long filtering is applied)).

**[0083]** In an embodiment where step s506 is performed instead of steps s502 and s504,  $pq_1$  is equal to  $2*(dp + dq)$ , where

$dp = (\text{Abs}(p_0 - 2*p_1 + p_2) + \text{Abs}(p_5 - 2*p_4 + p_3) + 1) \gg 1$ , and

$dq = (\text{Abs}(q_0 - 2*q_1 + q_2) + \text{Abs}(q_5 - 2*q_4 + q_3) + 1) \gg 1$ . In such an embodiment, the first

threshold ( $t_1$ ) may be equal to  $\beta \gg 4$ .

**[0084]** FIG. 6 is a block diagram of an apparatus 600, according to some embodiments, for implementing the video encoder 140 or the video decoder 260. As shown in FIG. 6, apparatus 600 may comprise: processing circuitry (PC) 602, which may include one or more processors (P) 655 (e.g., a general purpose microprocessor and/or one or more other processors, such as an application specific integrated circuit (ASIC), field-programmable gate arrays (FPGAs), and the like), which processors may be co-located in a single housing or in a single data center or may be geographically distributed (i.e., apparatus 600 may be a distributed computing apparatus); a network interface 648 comprising a transmitter (Tx) 645 and a receiver (Rx) 647 for enabling apparatus 600 to transmit data to and receive data from other nodes connected to a network 110 (e.g., an Internet Protocol (IP) network) to which network interface 648 is connected (directly or indirectly) (e.g., network interface 648 may be wirelessly connected to the network 110, in which case network interface 648 is connected to an antenna arrangement); and a local storage unit (a.k.a., “data storage system”) 608, which may include one or more non-volatile storage devices and/or one or more volatile storage devices. In embodiments where PC 602 includes a programmable processor, a computer program product (CPP) 641 may be provided. CPP 641 includes a computer readable medium (CRM) 642 storing a computer program (CP) 643 comprising computer readable instructions (CRI) 644. CRM 642 may be a non-transitory computer readable medium, such as, magnetic media (e.g., a hard disk), optical media, memory devices (e.g., random access memory, flash memory), and the like. In some embodiments, the CRI 644 of computer program 643 is configured such that when executed by PC 602, the CRI causes apparatus 600 to perform steps described herein (e.g., steps described herein with reference to the flow charts). In other embodiments, apparatus 600 may be configured to perform steps described herein without the need for code. That is, for example, PC 602 may consist merely of one or more ASICs. Hence, the features of the embodiments described herein may be implemented in hardware and/or software.

**[0085]** FIG. 7 is a functional block diagram of apparatus 600 according to some other embodiments. The apparatus 600 includes an obtaining module 702 and a filter selection module 704. The obtaining module 702 is adapted to obtain a first set of sample values comprising a first block of sample values (hereafter referred to as the P block) and a second block of sample values (hereafter referred to as the Q block), wherein the P block comprises a set of sample values  $p_{i,k}$

for  $i=0-7$  and  $k=0-3$ , and the Q block comprises a set of sample values  $q_{i,k}$  for  $i=0-7$  and  $k=0-3$ .

**[0086]** In one embodiment, the filter selection module is adapted to decide whether or not to use a long filter to filter at least a subset of the first set of sample values, wherein the filter selection module is configured to decide whether or not to use a long filter to filter at least a subset of the first set of sample values by performing a process that includes: calculating a first gradient value,  $\text{maxGradp6\_0}$ , using sample value  $p_{6,0}$ ; calculating a first pq value,  $pq1\_0$ , using  $\text{maxGradp6\_0}$ ; and comparing  $pq1\_0$  to a threshold.

**[0087]** In another embodiment, the filter selection module is adapted to select a filter, wherein the filter selection module 704 is configured to select a by performing a process that includes: calculating a first pq value,  $pq1$ , using at least a first value equal to  $\text{Abs}(p_{2,0} - 2 * p_{1,0} + p_{0,0})$  and a second value equal to  $\text{Abs}(q_{2,0} - 2 * q_{1,0} + q_{0,0})$ ; and comparing  $pq1$  to a threshold, wherein the threshold is equal to  $\beta >> 4$ , and  $\beta$  is selected from a set of predetermined beta values based on a quantization parameter value,  $Q$ .

**[0088]** Concise description of Some Embodiments

**[0089]** A1. A method (400) for filtering sample values associated with an image, the method comprising: obtaining (s402) a first set of sample values comprising a first block of sample values (hereafter referred to as the P block) and a second block of sample values (hereafter referred to as the Q block), wherein the P block comprises a set of sample values  $p_{i,k}$  for  $i=0-7$  and  $k=0-3$ , and the Q block comprises a set of sample values  $q_{i,k}$  for  $i=0-7$  and  $k=0-3$ ; and deciding (s404) whether or not to use a long filter to filter at least a subset of the first set of sample values, wherein deciding whether or not to use a long filter to filter at least a subset of the first set of sample values comprises: calculating (s502) a first gradient value,  $\text{maxGradp6\_0}$ , using sample value  $p_{6,0}$ ; calculating (s504) a first pq value,  $pq1\_0$ , using  $\text{maxGradp6\_0}$ ; and comparing (s508)  $pq1\_0$  to a threshold.

**[0090]** A2. The method of embodiment A1, wherein deciding whether or not to use a long filter to filter at least a subset of the first set of sample values further comprises: calculating a second gradient value,  $\text{maxGradp6\_3}$ , using sample value  $p_{6,3}$ , calculating a second pq value,  $pq1\_3$ , using  $\text{maxGradp6\_3}$ , and comparing (s508)  $pq1\_3$  to a threshold.

**[0091]** A3. The method of embodiment A1 or A2, wherein calculating  $pq1\_0$  comprises calculating a value  $sp + sq$ , wherein calculating  $sp$  comprises calculating  $sp = (\text{Abs}(p_{0,0} - p_{3,0}) + \text{Abs}(p_{3,0} - p_{7,0}) + \text{magGradp6\_0} + 1) >> 1$ .

**[0092]** A4. The method of embodiment A3, wherein  $\text{magGradp6\_0}$  equals  $\text{Abs}(p7,0 - p6,0)$ ,  $\text{magGradp6\_0}$  equals  $\text{Abs}(p7,0 - p6,0 - p5,0 + p4,0)$ , or  $\text{magGradp6\_0}$  equals  $\text{Abs}(p6,0 - 2 * p5,0 + p4,0)$ .

**[0093]** A5. The method of embodiment A1 or A2, wherein calculating  $\text{pq1\_0}$  comprises calculating  $2 * (\text{dp} + \text{dq})$ , wherein  $\text{dp}$  is equal to  $(\text{Abs}(p0,0 - 2 * p1,0 + p2,0) + \text{magGradp6\_0} + 1) >> 1$ .

**[0094]** A6. The method of embodiment A5, wherein  $\text{magGradp6\_0}$  equals  $\text{Abs}(p7,0 - p6,0 - p5,0 + p4,0)$ , or  $\text{magGradp6\_0}$  equals  $\text{Abs}(p6,0 - 2 * p5,0 + p4,0)$ .

**[0095]** A7. The method of any one of embodiments A1-A6, wherein the step of calculating  $\text{pq1\_0}$  using  $\text{maxGradp6\_0}$  is performed as a result of determining that a max filter length for the P block,  $\text{maxFilterLengthP}$ , is equal to 7.

**[0096]** B1. A method (400) for filtering sample values associated with an image, the method comprising: obtaining (s402) a first set of sample values comprising a first block of sample values (hereafter referred to as the P block) and a second block of sample values (hereafter referred to as the Q block), wherein the P block comprises a set of sample values  $p_{i,k}$  for  $i=0-7$  and  $k=0-3$ , and the Q block comprises a set of sample values  $q_{i,k}$  for  $i=0-7$  and  $k=0-3$ ; and selecting (s404) a filter, wherein selecting the filter comprises: calculating (s504) a first pq value,  $\text{pq1}$ , using at least a first value equal to  $\text{Abs}(p2,0 - 2 * p1,0 + p0,0)$  and a second value equal to  $\text{Abs}(q2,0 - 2 * q1,0 + q0,0)$ ; and comparing (s508)  $\text{pq1}$  to a threshold, wherein the threshold is equal to  $\beta >> 4$ , and  $\beta$  is selected from a set of predetermined beta values based on a quantization parameter value,  $Q$ .

**[0097]** C1. A method for filtering sample values associated with an image, the method comprising: 1) obtaining (s402) a first set of sample values comprising a first block of sample values and a second block of sample values, wherein the first block of sample values comprises a set of sample values  $B1_{i,k}$  for  $i=0-7$  and  $k=0-3$ , and the second block of sample values comprises a set of sample values  $B2_{i,k}$  for  $i=0-7$  and  $k=0-3$ ; and 2) selecting (s404) a filter, wherein selecting the filter comprises: i) calculating a first pq value,  $\text{pq1\_0}$ , wherein calculating  $\text{pq1\_0}$  comprises calculating a value  $\text{sp}$ , calculating a value  $\text{sq}$ , and calculating  $\text{sp} + \text{sq}$ , wherein  $\text{pq1\_0} = (\text{sp} + \text{sq})$ ; ii) comparing  $\text{pq1\_0}$  to a first threshold; iii) calculating (s505) a second pq value,  $\text{pq2\_0}$ , using at least a first value equal to  $\text{Abs}(B1_{2,0} - 2 * B1_{1,0} + B1_{0,0})$  and a second value equal to  $\text{Abs}(B2_{2,0} - 2 * B2_{1,0} + B2_{0,0})$ ; and iv) comparing (s508)  $\text{pq2\_0}$  to a

second threshold, wherein the second threshold is equal to  $\beta \gg 4$ , and  $\beta$  is selected from a set of predetermined beta values based on a quantization parameter value, Q.

**[0098]** C2. The method as in claim C1 wherein selecting the filter further comprises: calculating a third pq value,  $pq3\_0$ , wherein  $pq3\_0 = \text{Abs}(B1\_0,0 - B2\_0,0)$ ; and comparing  $pq3\_0$  with a third threshold, wherein the third threshold is equal to  $(5*tC+1) \gg 1$ , wherein tC is selected from a set of predetermined values based on a quantization parameter value, Q.

**[0099]** C3. The method as in claim C1 or claim C2, wherein selecting the filter further comprises: calculating a fourth pq value,  $pq2\_3$ ; comparing  $pq2\_3$  to the second threshold; calculating a fifth pq value,  $pq1\_3$ ; and comparing  $pq1\_3$  to the first threshold, wherein the step of calculating  $pq2\_3$  comprises calculating  $pq2\_3$  using at least a first value equal to  $\text{Abs}(B1\_2,3 - 2 * B1\_1,3 + B1\_0,3)$  and a second value equal to  $\text{Abs}(B2\_2,3 - 2 * B2\_1,3 + B2\_0,3)$ , and when  $\text{maxFilterLengthP}$  is greater than 3 also using a third value  $\text{Abs}(B1\_5,3 - 2*B1\_4,3 + B1\_3,3)$  and when  $\text{maxFilterLengthQ}$  is greater than 3 also using a fourth value  $\text{Abs}(B2\_5,3 - 2*B2\_4,3 + B2\_3,3)$ , the step of calculating  $pq1\_3$  comprises: calculating a value  $sp3$ , calculating a value  $sq3$ , and calculating  $sp3 + sq3$ , where  $pq1\_3 = (sp3 + sq3)$ .

**[00100]** C4. The method as in claim C3, wherein selecting the filter further comprises: calculating a sixth pq value,  $pq3\_3$ , wherein  $pq3\_3 = \text{Abs}(B1\_0,3 - B2\_0,3)$ ; and comparing  $pq3\_3$  with the third threshold.

**[00101]** C5. The method of any one of claims C1-C4, wherein the filter is used to modify 7 samples on each of lines 0 to line 3 in block B1 when conditions for line 0 and line 3 are less than a respective threshold (e.g. for line 0  $pq1\_0 < \text{thr1}$  and  $pq2\_0 < \text{thr2}$  and  $pq3\_0 < \text{thr3}$  and line 3  $pq1\_3 < \text{thr1}$  and  $pq2\_3 < \text{thr2}$  and  $pq3\_3 < \text{thr3}$ ).

**[00102]** C6. The method as in claim C5, wherein  $\text{thr1}$  is equal to  $3 * \beta \gg 5$ ,  $\text{thr2}$  is equal to  $\beta \gg 4$  and  $\text{thr3}$  is equal to  $(5*tC+1) \gg 1$ .

**[00103]** C7. The method of any one of claims C1-C6, wherein the first block has a maximum filter length,  $\text{maxFilterLengthP}$ , if  $\text{maxFilterLengthP}$  is equal to 7, then calculating  $sp$  comprises calculating  $sp = (\text{Abs}(B1\_0,0 - B1\_3,0) + \text{Abs}(B1\_3,0 - B1\_7,0) + \text{maxGradB1\_6,0} + 1) \gg 1$ , where  $\text{maxGradB1\_6,0}$  is a gradient value, if  $\text{maxFilterLengthP}$  is 5, then calculating  $sp$  comprises calculating  $sp = (\text{Abs}(B1\_0,0 - B1\_3,0) + \text{Abs}(B1\_3,0 - B1\_5,0) + 1) \gg 1$ , and if  $\text{maxFilterLengthP}$  is equal to 3, then calculating  $sp$  comprises calculating  $sp = \text{Abs}(B1\_0,0 - B1\_3,0)$ .

**[00104]** C8. The method of claim C7, wherein  $\max\text{GradB1}_{6,0}$  equals  $\text{Abs}(\text{B1}_{7,0} - \text{B1}_{6,0} - \text{B1}_{5,0} + \text{B1}_{4,0})$ .

**[00105]** C9. The method of any one of claims C1-C9, wherein the second block has a maximum filter length,  $\max\text{FilterLengthQ}$ , if  $\max\text{FilterLengthQ}$  is equal to 7, then calculating sq comprises calculating  $\text{sq} = (\text{Abs}(\text{B2}_{0,0} - \text{B2}_{3,0}) + \text{Abs}(\text{B2}_{3,0} - \text{B2}_{7,0}) + \max\text{GradB2}_{6,0} + 1) \gg 1$ , where  $\max\text{GradB2}_{6,0}$  is a gradient value, if  $\max\text{FilterLengthQ}$  is equal to 5, then calculating sq comprises calculating  $\text{sq} = (\text{Abs}(\text{B2}_{0,0} - \text{B2}_{3,0}) + \text{Abs}(\text{B2}_{3,0} - \text{B2}_{5,0}) + 1) \gg 1$ , and if  $\max\text{FilterLengthQ}$  is equal to 3, then calculating sq comprises calculating  $\text{sq} = \text{Abs}(\text{B1}_{0,0} - \text{B1}_{3,0})$ .

**[00106]** C10. The method of claim C9, wherein  $\max\text{GradB2}_{6,0}$  equals  $\text{Abs}(\text{B2}_{7,0} - \text{B2}_{6,0} - \text{B2}_{5,0} + \text{B2}_{4,0})$ .

**[00107]** C11. The method of any one of claims C1-C10, wherein and when  $\max\text{FilterLengthP}$  is greater than 3 also using a third value  $\text{Abs}(\text{B1}_{5,0} - 2 * \text{B1}_{4,0} + \text{B1}_{3,0})$  and wherein the second block has a maximum filter length,  $\max\text{FilterLengthQ}$ , and when  $\max\text{FilterLengthQ}$  is greater than 3 also using a fourth value  $\text{Abs}(\text{B2}_{5,0} - 2 * \text{B2}_{4,0} + \text{B2}_{3,0})$ .

**[00108]** C12. The method of claim C3 or C4, wherein if  $\max\text{FilterLengthP}$  is equal to 7, then calculating  $\text{sp3}$  comprises calculating  $\text{sp3} = (\text{Abs}(\text{B1}_{0,3} - \text{B1}_{3,3}) + \text{Abs}(\text{B1}_{3,3} - \text{B1}_{7,3}) + \max\text{GradB1}_{6,3} + 1) \gg 1$ , where  $\max\text{GradB1}_{6,3}$  is a gradient value, if  $\max\text{FilterLengthP}$  is equal to 5, then calculating  $\text{sp3}$  comprises calculating  $\text{sp3} = (\text{Abs}(\text{B1}_{0,3} - \text{B1}_{3,3}) + \text{Abs}(\text{B1}_{3,3} - \text{B1}_{5,3}) + 1) \gg 1$ , if  $\max\text{FilterLengthP}$  is equal to 3, then calculating  $\text{sp3}$  comprises calculating  $\text{sp3} = \text{Abs}(\text{B1}_{0,3} - \text{B1}_{3,3})$ , if  $\max\text{FilterLengthQ}$  is equal to 7, then calculating  $\text{sq3}$  comprises calculating  $\text{sq3} = (\text{Abs}(\text{B2}_{0,3} - \text{B2}_{3,3}) + \text{Abs}(\text{B2}_{3,3} - \text{B2}_{7,3}) + \max\text{GradB2}_{6,3} + 1) \gg 1$ , where  $\max\text{GradB2}_{6,3}$  is a gradient value, if  $\max\text{FilterLengthQ}$  is equal to 5, then calculating  $\text{sq3}$  comprises calculating  $\text{sq3} = (\text{Abs}(\text{B2}_{0,3} - \text{B2}_{3,3}) + \text{Abs}(\text{B2}_{3,3} - \text{B2}_{5,3}) + 1) \gg 1$ , and if  $\max\text{FilterLengthQ}$  is equal to 3, then calculating  $\text{sq3}$  comprises calculating  $\text{sq3} = \text{Abs}(\text{B2}_{0,3} - \text{B2}_{3,3})$ .

**[00109]** D1. A method (400) for filtering sample values associated with an image, the method comprising: obtaining (s402) a first set of sample values comprising a first block of sample values and a second block of sample values, wherein the first block of sample values comprises a set of sample values  $\text{B1}_{i,k}$  for  $i=0-7$  and  $k=0-3$ , and the second block of sample values comprises a set of sample values  $\text{B2}_{i,k}$  for  $i=0-7$  and  $k=0-3$ ; and deciding (s404) whether

or not to use a long filter to filter at least a subset of the first set of sample values, wherein deciding whether or not to use a long filter to filter at least a subset of the first set of sample values comprises: calculating (s502) a first gradient value,  $\text{maxGradB1\_6,0}$ , using sample value  $\text{B1\_6,0}$ ; calculating (s504) a first pq value,  $\text{pq1\_0}$ , using  $\text{maxGradB1\_6,0}$ ; and comparing (s508)  $\text{pq1\_0}$  to a threshold.

**[00110]** D2. The method of claim D1, wherein deciding whether or not to use a long filter to filter at least a subset of the first set of sample values further comprises: calculating a second gradient value,  $\text{maxGradB1\_6,3}$ , using sample value  $\text{B1\_6,3}$ , calculating a second pq value,  $\text{pq1\_3}$ , using  $\text{maxGradB1\_6,3}$ , and comparing (s508)  $\text{pq1\_3}$  to the threshold.

**[00111]** D3. The method of claim D1 or D2, wherein calculating  $\text{pq1\_0}$  comprises calculating a value  $\text{sp}$ , calculating a value  $\text{sq}$ , and calculating  $\text{sp} + \text{sq}$ , wherein  $\text{pq1\_0} = (\text{sp} + \text{sq})$ , and wherein calculating  $\text{sp}$  comprises calculating  $\text{sp} = (\text{Abs}(\text{B1\_0,0} - \text{B1\_3,0}) + \text{Abs}(\text{B1\_3,0} - \text{B1\_7,0}) + \text{maxGradB1\_6,0} + 1) >> 1$ .

**[00112]** D4. The method of claim D3, wherein  $\text{maxGradB1\_6,0}$  equals  $\text{Abs}(\text{B1\_7,0} - \text{B1\_6,0} - \text{B1\_5,0} + \text{B1\_4,0})$ .

**[00113]** D5. The method of claim D3 or D4, wherein the second block has a maximum filter length,  $\text{maxFilterLengthQ}$ , if  $\text{maxFilterLengthQ}$  is equal to 7, then  $\text{sq} = (\text{Abs}(\text{B2\_0,0} - \text{B2\_3,0}) + \text{Abs}(\text{B2\_3,0} - \text{B2\_7,0}) + \text{maxGradB2\_6,0} + 1) >> 1$ , where  $\text{maxGradB2\_6,0}$  is a third gradient value, if  $\text{maxFilterLengthQ}$  is equal to 5, then  $\text{sq} = (\text{Abs}(\text{B2\_0,0} - \text{B2\_3,0}) + \text{Abs}(\text{B2\_3,0} - \text{B2\_5,0}) + 1) >> 1$ , and if  $\text{maxFilterLengthQ}$  is not equal to 7 and is not equal to 5, then  $\text{sq} = \text{Abs}(\text{B2\_0,0} - \text{B2\_3,0})$ .

**[00114]** D6. The method of claim D5, wherein  $\text{maxGradB2\_6,0}$  equals  $\text{Abs}(\text{B2\_7,0} - \text{B2\_6,0} - \text{B2\_5,0} + \text{B2\_4,0})$ .

**[00115]** D7. The method of any one of claims D2-D6, wherein calculating  $\text{pq1\_3}$  comprises calculating a value  $\text{sp3}$ , calculating a value  $\text{sq3}$ , and calculating  $\text{sp3} + \text{sq3}$ , wherein  $\text{pq1\_3} = (\text{sp3} + \text{sq3})$ , and wherein calculating  $\text{sp3}$  comprises calculating  $\text{sp3} = (\text{Abs}(\text{B1\_0,3} - \text{B1\_3,3}) + \text{Abs}(\text{B1\_3,3} - \text{B1\_7,3}) + \text{maxGradB1\_6,3} + 1) >> 1$ .

**[00116]** D8. The method of claim D7, wherein  $\text{maxGradB1\_6,3}$  equals  $\text{Abs}(\text{B1\_7,3} - \text{B1\_6,3} - \text{B1\_5,3} + \text{B1\_4,3})$ .

**[00117]** D9. The method of any one of claims D1-D8, wherein the step of calculating  $\text{pq1\_0}$  using  $\text{maxGradB1\_6,0}$  is performed as a result of determining that a maximum filter

length for the first block, maxFilterLengthP, is equal to 7.

**[00118]** D10. The method of any one of claims D2-D9, wherein the step of calculating pq1\_3 using maxGradB1\_6,3 is performed as a result of determining that a max filter length for the first block, maxFilterLengthP, is equal to 7.

**[00119]** D11. The method of claim D7, wherein the second block has a maximum filter length, maxFilterLengthQ, if maxFilterLengthQ is equal to 7, then  $sq3 = (\text{Abs}(B2\_0,3 - B2\_3,3) + \text{Abs}(B2\_3,3 - B2\_7,3) + \text{maxGradB2\_6,3} + 1) \gg 1$ , where maxGradB2\_6,3 is a fourth gradient value, if maxFilterLengthQ is equal to 5, then  $sq3 = (\text{Abs}(B2\_0,3 - B2\_3,3) + \text{Abs}(B2\_3,3 - B2\_5,3) + 1) \gg 1$ , and if maxFilterLengthQ is not equal to 5 and not equal to 7, then  $sq3 = \text{Abs}(B2\_0,3 - B2\_3,3)$ .

**[00120]** D12. The method of claim D11, wherein maxGradB2\_6,3 equals  $\text{Abs}(B2\_7,3 - B2\_6,3 - B2\_5,3 + B2\_4,3)$ .

**[00121]** D13. The method of any one of claims D1-D12, wherein when deblocking a vertical boundary, the i value identifies a column of a block and the k value identifies a row of the block, and when deblocking a horizontal boundary, the k value identifies a column of the block and the i value identifies a row of the block.

**[00122]** D14. The method of any one of claims D1-D13, wherein B1\_0,0 refers to the sample in the first block which is closest to a sample B2\_0,0 in the second block, wherein B1\_1,0 is closest to B1\_0,0, B1\_2,0 is closest to B1\_1,0, B1\_3,0 is closest to B1\_2,0, B1\_4,0 is closest to B1\_3,0, B1\_5,0 is closest to B1\_4,0, B1\_6,0 is closest to B1\_5,0, B1\_7,0 is closest to B1\_6,0, B2\_1,0 is closest to B2\_0,0, B2\_2,0 is closest to B2\_1,0, B2\_3,0 is closest to B2\_2,0, B2\_4,0 is closest to B2\_3,0, B2\_5,0 is closest to B2\_4,0, B2\_6,0 is closest to B2\_5,0, B2\_7,0 is closest to B2\_6,0, wherein B1\_0,3 refers to the sample in the first block which is closest to a sample B2\_0,3 in the second block, wherein B1\_1,3 is closest to B1\_0,3, B1\_2,3 is closest to B1\_1,3, B1\_3,3 is closest to B1\_2,3, B1\_4,3 is closest to B1\_3,3, B1\_5,3 is closest to B1\_4,3, B1\_6,3 is closest to B1\_5,3, B1\_7,3 is closest to B1\_6,3, B2\_1,3 is closest to B2\_0,3, B2\_2,3 is closest to B2\_1,3, B2\_3,3 is closest to B2\_2,3, B2\_4,3 is closest to B2\_3,3, B2\_5,3 is closest to B2\_4,3, B2\_6,3 is closest to B2\_5,3, B2\_7,3 is closest to B2\_6,3.

**[00123]** D15. The method of any one of claims D1-D14, wherein the samples to filter by the long filter when maxFilterLengthP is equal to 7 are B1\_0,0 to B1\_6,0, B1\_0,1 to B1\_6,1, B1\_0,2 to B1\_6,2 and B1\_0,3 to B1\_6,3.

**[00124]** D16. The method of any one of claims D1 – D15, wherein the samples to filter by the long filter when maxFilterLengthQ is equal to 7 are B2<sub>\_0,0</sub> to B2<sub>\_6,0</sub>, B2<sub>\_0,1</sub> to B2<sub>\_6,1</sub>, B2<sub>\_0,2</sub> to B2<sub>\_6,2</sub> and B2<sub>\_0,3</sub> to B2<sub>\_6,3</sub>.

**[00125]** E1. A method (400) for filtering sample values associated with an image, the method comprising: obtaining (s402) a first set of sample values comprising a first block of sample values and a second block of sample values, wherein the first block of sample values comprises a set of sample values B1<sub>\_i,k</sub> for i=0-7 and k=0-3, and the second block of sample values comprises a set of sample values B2<sub>\_i,k</sub> for i=0-7 and k=0-3; and selecting (s404) a filter, wherein selecting the filter comprises: calculating (s505) a first pq value, pq2<sub>\_0</sub>, using at least a first value equal to  $\text{Abs}(B1_{_2,0} - 2 * B1_{_1,0} + B1_{_0,0})$  and a second value equal to  $\text{Abs}(B2_{_2,0} - 2 * B2_{_1,0} + B2_{_0,0})$ ; and comparing (s508) pq2<sub>\_0</sub> to a threshold, wherein the threshold is equal to  $\beta \gg 4$ , and  $\beta$  is selected from a set of predetermined beta values based on a quantization parameter value, Q.

**[00126]** E2. The method of E1 wherein selecting the filter further comprises calculating a second pq value, pq2<sub>\_3</sub>, using at least a first value equal to  $\text{Abs}(B1_{_2,3} - 2 * B1_{_1,3} + B1_{_0,3})$  and a second value equal to  $\text{Abs}(B2_{_2,3} - 2 * B2_{_1,3} + B2_{_0,3})$ ; and comparing pq2<sub>\_3</sub> to the threshold.

**[00127]** F1. An encoder (140) or a decoder (260) adapted to perform the method of any one of the above embodiments.

**[00128]** F2. An apparatus (500), wherein the apparatus implements the encoder (140) or the decoder (260) of embodiment F1.

**[00129]** G1. A computer program (643) comprising instructions (644) which when executed by processing circuitry (602) causes the processing circuitry (602) to perform the method of any one of the above embodiments.

**[00130]** G2. A carrier containing the computer program of embodiment G1, wherein the carrier is one of an electronic signal, an optical signal, a radio signal, and a computer readable storage medium (642).

**[00131]** H1. An apparatus (600) for filtering sample values associated with an image, the apparatus comprising: an obtaining module (702 (see FIG. 7)) adapted to obtain a first set of sample values comprising a first block of sample values (hereafter referred to as the P block) and a second block of sample values (hereafter referred to as the Q block), wherein the P block

comprises a set of sample values  $p_{i,k}$  for  $i=0-7$  and  $k=0-3$ , and the Q block comprises a set of sample values  $q_{i,k}$  for  $i=0-7$  and  $k=0-3$ ; and a filter selection module (704 (see FIG. 7)) adapted to decide whether or not to use a long filter to filter at least a subset of the first set of sample values, wherein the filter selection module (704) is configured to decide whether or not to use a long filter to filter at least a subset of the first set of sample values by performing a process that includes: calculating (s502) a first gradient value,  $\max\text{Grad}p6\_0$ , using sample value  $p6,0$ ; calculating (s504) a first pq value,  $pq1\_0$ , using  $\max\text{Grad}p6\_0$ ; and comparing (s508)  $pq1\_0$  to a threshold.

**[00132]** I1. An apparatus (600) for filtering sample values associated with an image, the apparatus comprising: an obtaining module (702 (see FIG. 7)) adapted to obtain a first set of sample values comprising a first block of sample values (hereafter referred to as the P block) and a second block of sample values (hereafter referred to as the Q block), wherein the P block comprises a set of sample values  $p_{i,k}$  for  $i=0-7$  and  $k=0-3$ , and the Q block comprises a set of sample values  $q_{i,k}$  for  $i=0-7$  and  $k=0-3$ ; and a filter selection module (704 (see FIG. 7)) adapted to select a filter, wherein the filter selection module (704) is configured to select a by performing a process that includes: calculating (s504) a first pq value,  $pq1$ , using at least a first value equal to  $\text{Abs}(p2,0 - 2 * p1,0 + p0,0)$  and a second value equal to  $\text{Abs}(q2,0 - 2 * q1,0 + q0,0)$ ; and comparing (s508)  $pq1$  to a threshold, wherein the threshold is equal to  $\beta \gg 4$ , and  $\beta$  is selected from a set of predetermined beta values based on a quantization parameter value,  $Q$ .

**[00133]** While various embodiments are described herein, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of this disclosure should not be limited by any of the above-described exemplary embodiments. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.

**[00134]** Additionally, while the processes described above and illustrated in the drawings are shown as a sequence of steps, this was done solely for the sake of illustration. Accordingly, it is contemplated that some steps may be added, some steps may be omitted, the order of the steps may be re-arranged, and some steps may be performed in parallel.