

QUANTIZATION PARAMETER FOR CHROMA DEBLOCKING FILTERING

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] Under the applicable patent law and/or rules pursuant to the Paris Convention, this application is made to timely claim the priority to and benefits of International Patent Application No. PCT/CN2019/105831, filed on September 14, 2019. For all purposes under the law, the entire disclosure of the aforementioned application is incorporated by reference as part of the disclosure of this application.

TECHNICAL FIELD

[0002] This patent document relates to video coding techniques, devices and systems.

BACKGROUND

[0001] Currently, efforts are underway to improve the performance of current video codec technologies to provide better compression ratios or provide video coding and decoding schemes that allow for lower complexity or parallelized implementations. Industry experts have recently proposed several new video coding tools and tests are currently underway for determining their effectivity.

SUMMARY

[0003] Devices, systems and methods related to digital video coding, and specifically, to management of motion vectors are described. The described methods may be applied to existing video coding standards (e.g., High Efficiency Video Coding (HEVC) or Versatile Video Coding) and future video coding standards or video codecs.

[0004] In one representative aspect, the disclosed technology may be used to provide a method for video processing. This method includes performing a conversion between a block of a chroma component of a video and a bitstream representation of the video. During the conversion, a deblocking filtering process is selectively applied to samples along edges of the block, and chroma quantization parameter (QP) offsets are added to outputs from a chroma QP table to determine parameters for the deblocking filter process.

[0005] In another representative aspect, the disclosed technology may be used to provide a method for video processing. This method includes determining, for a conversion between a block of a chroma component of a video and a bitstream representation of the video, whether or how to apply a filtering process to an edge of the block based on a first quantization information for a first video region comprising samples on one side of the edge and/or a second quantization information for a second video region comprising samples on the other side of the edge according to a rule. The rule is based on a coding mode applicable to the block for coding the samples on the one side or the samples on the other side of the edge. The rule specifies that multiple QP offsets at different video unit levels are used to determine the first quantization information or the second quantization information. The method also includes performing the conversion based on the determining.

[0006] In another representative aspect, the disclosed technology may be used to provide a method for video processing. This method includes determining, for a conversion between a current block of a video and a bitstream representation of the video, whether to enable usage of a chroma quantization parameter (QP) offset for the current block according to a syntax element at a level of a video unit. The video unit includes the current block and a second block of the video.

[0007] In another representative aspect, the disclosed technology may be used to provide a method for video processing. This method includes performing a conversion between a video comprising a first chroma component and a second chroma component and a bitstream representation of the video. Residuals of a first chroma block of the first chroma component and a second chroma block of the second chroma component are jointly coded in the bitstream representation using a coding mode according to a rule. The rule specifies that a manner of deriving a quantization parameter (QP) for the conversion is independent of the coding mode.

[0008] In another representative aspect, the disclosed technology may be used to provide a method for video processing. This method includes performing a conversion between a first block of a video and a bitstream representation of the video. The video has a color format of multiple color components and the first block is associated with a first color component of the video. During the conversion, a deblocking filtering process is applied to at least some samples along an edge of the first block. The method also includes performing subsequent conversions between blocks associated with remaining color components of the video and the bitstream representation of the video. During

the subsequent conversions, the deblocking filter process is applied to at least some samples along an edge of each of the blocks in a same manner as the conversion of the first block.

[0009] In another representative aspect, the disclosed technology may be used to provide a method for video processing. This method includes determining, for a conversion between a video and a bitstream representation of the video, a boundary strength of a boundary between two blocks of a video. The boundary strength is determined regardless of whether any one of the two blocks is coded in a joint coding of chroma residuals (JCCR) mode. The method also includes performing the conversion based on the determining.

[0010] In another representative aspect, the disclosed technology may be used to provide a method for video processing. This method includes determining, for a conversion between a video and a bitstream representation of the video, a boundary strength of a boundary between a first block and a second block. The determining is performed without comparing information of the first block with corresponding information of the second block. The information comprises a reference picture and/or a number motion vectors of a corresponding block, and the boundary strength is used to determine whether a deblocking filtering process is applicable to the boundary. The method also includes performing the conversion based on the determining.

[0011] In another representative aspect, the disclosed technology may be used to provide a method for video processing. This method includes determining, for a conversion between a video block of a video and a bitstream representation of the video, a quantization parameter (QP) used for applying a deblocking filtering on the video block according to a rule. The rule specifies that a first QP is used for the determining in case that the video block is coded using a transform skip (TS) mode in which a residue of the video block is coded in the bitstream representation by skipping application of a transform. A second QP that is different from the first QP is used for the determining in case that the video block is coded using a non-transform skip mode in which the residue of the video block is coded in the bitstream representation after applying the transform. The method also includes performing the conversion based on the determining.

[0012] In another representative aspect, the disclosed technology may be used to provide a method for video processing. This method includes determining, for a conversion between a video block of a video and a bitstream representation of the video, a gradient for determining applicability of a deblocking filtering process to at least some samples of an edge of the video block according to

a rule. The rule specifies that a manner in which the gradient is determined is independent of a size of the video block. The method also includes performing the conversion based on the determining.

[0013] In another representative aspect, the disclosed technology may be used to provide a method for video processing. This method includes performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that when a chroma quantization parameter (QP) table is used to derive parameters of the deblocking filter, processing by the chroma QP table is performed on individual chroma QP values.

[0014] In another representative aspect, the disclosed technology may be used to provide another method for video processing. This method includes performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that chroma QP offsets are used in the deblocking filter, wherein the chroma QP offsets are at picture/slice/tile/brick/subpicture level.

[0015] In another representative aspect, the disclosed technology may be used to provide another method for video processing. This method includes performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that chroma QP offsets are used in the deblocking filter, wherein information pertaining to a same luma coding unit is used in the deblocking filter and for deriving a chroma QP offset.

[0016] In another representative aspect, the disclosed technology may be used to provide another method for video processing. This method includes performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that chroma QP offsets are used in the deblocking filter, wherein an indication of enabling usage of the chroma QP offsets is signaled in the bitstream representation.

[0017] In another representative aspect, the disclosed technology may be used to provide another method for video processing. This method includes performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that chroma QP offsets are used in the deblocking filter, wherein the chroma QP offsets used in the deblocking filter are identical of whether JCCR

coding method is applied on a boundary of the video unit or a method different from the JCCR coding method is applied on the boundary of the video unit.

[0018] In another representative aspect, the disclosed technology may be used to provide another method for video processing. This method includes performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that chroma QP offsets are used in the deblocking filter, wherein a boundary strength (BS) of the deblocking filter is calculated without comparing reference pictures and/or a number of motion vectors (MVs) associated with the video unit at a P side boundary with reference pictures of the video unit at a Q side boundary.

[0019] Further, in a representative aspect, an apparatus in a video system comprising a processor and a non-transitory memory with instructions thereon is disclosed. The instructions upon execution by the processor, cause the processor to implement any one or more of the disclosed methods.

[0020] Additionally, in a representative aspect, a video decoding apparatus comprising a processor configured to implement any one or more of the disclosed methods.

[0021] In another representative aspect, a video encoding apparatus comprising a processor configured to implement any one or more of the disclosed methods.

[0022] Also, a computer program product stored on a non-transitory computer readable media, the computer program product including program code for carrying out any one or more of the disclosed methods is disclosed.

[0023] The above and other aspects and features of the disclosed technology are described in greater detail in the drawings, the description and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. 1 shows an example of an overall processing flow of a blocking deblocking filter process.

[0025] FIG. 2 shows an example of a flow diagram of a Bs calculation.

[0026] FIG. 3 shows an example of a referred information for Bs calculation at CTU boundary.

[0027] FIG. 4 shows an example of pixels involved in filter on/off decision and strong/weak filter selection.

- [0028] FIG. 5 shows an example of an overall processing flow of deblocking filter process in VVC.
- [0029] FIG. 6 shows an example of a luma deblocking filter process in VVC.
- [0030] FIG. 7 shows an example of a chroma deblocking filter process in VVC.
- [0031] FIG. 8 shows an example of a filter length determination for sub PU boundaries.
- [0032] FIG. 9A shows an example of center positions of a chroma block.
- [0033] FIG. 9B shows another example of center positions of a chroma block.
- [0034] FIG. 10 shows examples of blocks at P side and Q side.
- [0035] FIG. 11 shows examples of usage of a luma block's decoded information.
- [0036] FIG. 12 is a block diagram of an example of a hardware platform for implementing a visual media decoding or a visual media encoding technique described in the present document.
- [0037] FIG. 13 shows a flowchart of an example method for video coding.
- [0038] FIG. 14 is a block diagram of an example video processing system in which disclosed techniques may be implemented.
- [0039] FIG. 15 is a flowchart representation of a method of video processing in accordance with the present technology.
- [0040] FIG. 16 is a flowchart representation of another method of video processing in accordance with the present technology.
- [0041] FIG. 17 is a flowchart representation of another method of video processing in accordance with the present technology.
- [0042] FIG. 18 is a flowchart representation of another method of video processing in accordance with the present technology.
- [0043] FIG. 19 is a flowchart representation of another method of video processing in accordance with the present technology.
- [0044] FIG. 20 is a flowchart representation of another method of video processing in accordance with the present technology.
- [0045] FIG. 21 is a flowchart representation of another method of video processing in accordance with the present technology.
- [0046] FIG. 22 is a flowchart representation of another method of video processing in accordance with the present technology.

[0047] FIG. 23 is a flowchart representation of yet another method of video processing in accordance with the present technology.

[0048] FIG. 24 is a block diagram that illustrates an example video coding system.

[0049] FIG. 25 is a block diagram that illustrates an encoder in accordance with some embodiments of the present disclosure.

[0050] FIG. 26 is a block diagram that illustrates a decoder in accordance with some embodiments of the present disclosure.

DETAILED DESCRIPTION

1. Video coding in HEVC/H.265

[0051] Video coding standards have evolved primarily through the development of the well-known ITU-T and ISO/IEC standards. The ITU-T produced H.261 and H.263, ISO/IEC produced MPEG-1 and MPEG-4 Visual, and the two organizations jointly produced the H.262/MPEG-2 Video and H.264/MPEG-4 Advanced Video Coding (AVC) and H.265/HEVC standards. Since H.262, the video coding standards are based on the hybrid video coding structure wherein temporal prediction plus transform coding are utilized. To explore the future video coding technologies beyond HEVC, Joint Video Exploration Team (JVET) was founded by VCEG and MPEG jointly in 2015. Since then, many new methods have been adopted by JVET and put into the reference software named Joint Exploration Model (JEM). In April 2018, the Joint Video Expert Team (JVET) between VCEG (Q6/16) and ISO/IEC JTC1 SC29/WG11 (MPEG) was created to work on the VVC standard targeting at 50% bitrate reduction compared to HEVC.

2.1. Deblocking scheme in HEVC

[0052] A deblocking filter process is performed for each CU in the same order as the decoding process. First, vertical edges are filtered (horizontal filtering), then horizontal edges are filtered (vertical filtering). Filtering is applied to 8x8 block boundaries which are determined to be filtered, for both luma and chroma components. 4x4 block boundaries are not processed in order to reduce the complexity.

[0053] FIG. 1 illustrates the overall processing flow of deblocking filter process. A boundary can have three filtering status: no filtering, weak filtering and strong filtering. Each filtering decision is based on boundary strength, Bs, and threshold values, β and t_c .

[0054] Three kinds of boundaries may be involved in the filtering process: CU boundary, TU boundary and PU boundary. CU boundaries, which are outer edges of CU, are always involved in the filtering since CU boundaries are always also TU boundary or PU boundary. When PU shape is $2N \times N$ ($N > 4$) and RQT depth is equal to 1, TU boundary at 8×8 block grid and PU boundary between each PU inside CU are involved in the filtering. One exception is that when the PU boundary is inside the TU, the boundary is not filtered.

2.1.1. Boundary strength calculation

[0055] Generally speaking, boundary strength (Bs) reflects how strong filtering is needed for the boundary. If Bs is large, strong filtering should be considered.

[0056] Let P and Q be defined as blocks which are involved in the filtering, where P represents the block located in left (vertical edge case) or above (horizontal edge case) side of the boundary and Q represents the block located in right (vertical edge case) or below (horizontal edge case) side of the boundary. FIG. 2 illustrates how the Bs value is calculated based on the intra coding mode, existence of non-zero transform coefficients and motion information, reference picture, number of motion vectors and motion vector difference.

[0057] Bs is calculated on a 4×4 block basis, but it is re-mapped to an 8×8 grid. The maximum of the two values of Bs which correspond to 8 pixels consisting of a line in the 4×4 grid is selected as the Bs for boundaries in the 8×8 grid.

[0058] In order to reduce line buffer memory requirement, only for CTU boundary, information in every second block (4×4 grid) in left or above side is re-used as depicted in FIG. 3.

2.1.2. β and t_C decision

[0059] Threshold values β and t_C which involving in filter on/off decision, strong and weak filter selection and weak filtering process are derived based on luma quantization parameter of P and Q blocks, QP_P and QP_Q , respectively. Q used to derive β and t_C is calculated as follows.

$$Q = ((QP_P + QP_Q + 1) \gg 1).$$

[0060] A variable β is derived as shown in Table 1, based on Q. If Bs is greater than 1, the variable t_C is specified as Table 1 with $\text{Clip3}(0, 55, Q + 2)$ as input. Otherwise (BS is equal or less than 1), the variable t_C is specified as Table 1 with Q as input.

Table 1 Derivation of threshold variables β and t_C from input Q

Q	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
β	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	7	8
tc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Q	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
β	9	10	11	12	13	14	15	16	17	18	20	22	24	26	28	30	32	34	36
tc	1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4
Q	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	
β	38	40	42	44	46	48	50	52	54	56	58	60	62	64	64	64	64	64	
tc	5	5	6	6	7	8	9	9	10	10	11	11	12	12	13	13	14	14	

2.1.3. Filter on/off decision for 4 lines

[0061] Filter on/off decision is done for four lines as a unit. FIG. 4 illustrates the pixels involving in filter on/off decision. The 6 pixels in the two red boxes for the first four lines are used to determine filter on/off for 4 lines. The 6 pixels in two red boxes for the second 4 lines are used to determine filter on/off for the second four lines.

[0062] If $dp0 + dq0 + dp3 + dq3 < \beta$, filtering for the first four lines is turned on and strong/weak filter selection process is applied. Each variable is derived as follows.

$$dp0 = |p_{2,0} - 2*p_{1,0} + p_{0,0}|, dp3 = |p_{2,3} - 2*p_{1,3} + p_{0,3}|, dp4 = |p_{2,4} - 2*p_{1,4} + p_{0,4}|, dp7 = |p_{2,7} - 2*p_{1,7} + p_{0,7}|$$

$$dq0 = |q_{2,0} - 2*q_{1,0} + q_{0,0}|, dq3 = |q_{2,3} - 2*q_{1,3} + q_{0,3}|, dq4 = |q_{2,4} - 2*q_{1,4} + q_{0,4}|, dq7 = |q_{2,7} - 2*q_{1,7} + q_{0,7}|$$

[0063] If the condition is not met, no filtering is done for the first 4 lines. Additionally, if the condition is met, dE, dEp1 and dEp2 are derived for weak filtering process. The variable dE is set equal to 1. If $dp0 + dp3 < (\beta + (\beta \gg 1)) \gg 3$, the variable dEp1 is set equal to 1. If $dq0 + dq3 < (\beta + (\beta \gg 1)) \gg 3$, the variable dEq1 is set equal to 1.

[0064] For the second four lines, decision is made in a same fashion with above.

2.1.4. Strong/weak filter selection for 4 lines

[0065] After the first four lines are determined to filtering on in filter on/off decision, if following two conditions are met, strong filter is used for filtering of the first four lines. Otherwise, weak filter is used for filtering. Involving pixels are same with those used for filter on/off decision as depicted in Figure 4.

$$1) 2*(dp0+dq0) < (\beta \gg 2), |p3_0 - p0_0| + |q0_0 - q3_0| < (\beta \gg 3) \text{ and } |p0_0 - q0_0| < (5 * t_c + 1) \gg 1$$

$$2) 2*(dp3+dq3) < (\beta \gg 2), |p3_3 - p0_3| + |q0_3 - q3_3| < (\beta \gg 3) \text{ and } |p0_3 - q0_3| < (5 * t_c + 1) \gg 1$$

[0066] As a same fashion, if following two conditions are met, strong filter is used for filtering of the second 4 lines. Otherwise, weak filter is used for filtering.

$$1) 2*(dp4+dq4) < (\beta \gg 2), |p3_4 - p0_4| + |q0_4 - q3_4| < (\beta \gg 3) \text{ and } |p0_4 - q0_4| < (5 * t_c + 1) \gg 1$$

$$2) 2*(dp7+dq7) < (\beta \gg 2), |p3_7 - p0_7| + |q0_7 - q3_7| < (\beta \gg 3) \text{ and } |p0_7 - q0_7| < (5 * t_c + 1) \gg 1$$

2.1.4.1. Strong filtering

[0067] For strong filtering, filtered pixel values are obtained by following equations. It is worth to note that three pixels are modified using four pixels as an input for each P and Q block, respectively.

$$p_0' = (p_2 + 2*p_1 + 2*p_0 + 2*q_0 + q_1 + 4) \gg 3$$

$$q_0' = (p_1 + 2*p_0 + 2*q_0 + 2*q_1 + q_2 + 4) \gg 3$$

$$p_1' = (p_2 + p_1 + p_0 + q_0 + 2) \gg 2$$

$$q_1' = (p_0 + q_0 + q_1 + q_2 + 2) \gg 2$$

$$p_2' = (2*p_3 + 3*p_2 + p_1 + p_0 + q_0 + 4) \gg 3$$

$$q_2' = (p_0 + q_0 + q_1 + 3*q_2 + 2*q_3 + 4) \gg 3$$

2.1.4.2. Weak filtering

[0068] Let's define Δ as follows.

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

When $\text{abs}(\Delta)$ is less than $t_c * 10$,

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

$$p_0' = \text{Clip1Y}(p_0 + \Delta)$$

$$q_0' = \text{Clip1Y}(q_0 - \Delta)$$

If $dEp1$ is equal to 1,

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

$$p_1' = \text{Clip1Y}(p_1 + \Delta p)$$

If $dEq1$ is equal to 1,

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

$$q_1' = \text{Clip1}_Y(q_1 + \Delta q)$$

[0069] It is worth to note that maximum two pixels are modified using three pixels as an input for each P and Q block, respectively.

2.1.4.3. Chroma filtering

[0070] Bs of chroma filtering is inherited from luma. If Bs > 1 or if coded chroma coefficient existing case, chroma filtering is performed. No other filtering decision is there. And only one filter is applied for chroma. No filter selection process for chroma is used. The filtered sample values p_0' and q_0' are derived as follows.

$$\Delta = \text{Clip3}(-t_c, t_c, (((q_0 - p_0) \ll 2) + p_1 - q_1 + 4) \gg 3)$$

$$p_0' = \text{Clip1}_C(p_0 + \Delta)$$

$$q_0' = \text{Clip1}_C(q_0 - \Delta)$$

2.2 Deblocking scheme in VVC

[0071] In the VTM6, deblocking filtering process is mostly the same to those in HEVC. However, the following modifications are added.

[0072] A) The filter strength of the deblocking filter dependent of the averaged luma level of the reconstructed samples.

[0073] B) Deblocking tC table extension and adaptation to 10-bit video.

[0074] C) 4x4 grid deblocking for luma.

[0075] D) Stronger deblocking filter for luma.

[0076] E) Stronger deblocking filter for chroma.

[0077] F) Deblocking filter for subblock boundary.

[0078] G) Deblocking decision adapted to smaller difference in motion.

[0079] FIG. 5 depicts a flowchart of deblocking filters process in VVC for a coding unit.

2.2.1. Filter strength dependent on reconstructed average luma

[0080] In HEVC, the filter strength of the deblocking filter is controlled by the variables β and t_c which are derived from the averaged quantization parameters qP_L . In the VTM6, deblocking filter controls the strength of the deblocking filter by adding offset to qP_L according to the luma level of the reconstructed samples if the SPS flag of this method is true. The reconstructed luma level LL is derived as follow:

$$LL = ((p_{0,0} + p_{0,3} + q_{0,0} + q_{0,3}) \gg 2) / (1 \ll \text{bitDepth}) \quad (3-1)$$

where, the sample values $p_{i,k}$ and $q_{i,k}$ with $i = 0..3$ and $k = 0$ and 3 can be derived. Then LL is used to decide the offset $qpOffset$ based on the threshold signaled in SPS. After that, the qP_L , which is derived as follows, is employed to derive the β and t_C .

$$qP_L = ((Qp_Q + Qp_P + 1) \gg 1) + qpOffset \quad (3-2)$$

where Qp_Q and Qp_P denote the quantization parameters of the coding units containing the sample $q_{0,0}$ and $p_{0,0}$, respectively. In the current VVC, this method is only applied on the luma deblocking process.

2.2.2. 4x4 deblocking grid for luma

[0081] HEVC uses an 8x8 deblocking grid for both luma and chroma. In VTM6, deblocking on a 4x4 grid for luma boundaries was introduced to handle blocking artifacts from rectangular transform shapes. Parallel friendly luma deblocking on a 4x4 grid is achieved by restricting the number of samples to be deblocked to 1 sample on each side of a vertical luma boundary where one side has a width of 4 or less or to 1 sample on each side of a horizontal luma boundary where one side has a height of 4 or less.

2.2.3. Boundary Strength derivation for luma

[0082] The detailed boundary strength derivation could be found in Table 2. The conditions in Table 2 are checked sequentially.

Table 2 Boundary strength derivation

Conditions	Y	U	V
P and Q are BDPCM	0	N/A	N/A
P or Q is intra	2	2	2
It is a transform block edge, and P or Q is CIIP	2	2	2
It is a transform block edge, and P or Q has non-zero transform coefficients	1	1	1
It is a transform block edge, and P or Q is JCCR	N/A	1	1
P and Q are in different coding modes	1	1	1

One or more of the following conditions are true: 1. P and Q are both IBC, and the BV distance $\geq$ half-pel in x- or y-dir 2. P and Q have different ref pictures*, or have different number of MVs 3. Both P and Q have only one mv, and the MV distance $\geq$ half-pel in x- or y-dir 4. P has two MVs pointing to two different ref pictures, and P and Q have same ref pictures in the list 0, the MV pair in the list 0 or list 1 has a distance $\geq$ half-pel in x- or y-dir 5. P has two MVs pointing to two different ref pictures, and P and Q have different ref pictures in the list 0, the MV of P in the list 0 and the MV of Q in the list 1 have the distance $\geq$ half-pel in x- or y-dir, or the MV of P in the list 1 and the MV of Q in the list 0 have the distance $\geq$ half-pel in x- or y-dir 6. Both P and Q have two MVs pointing to the same ref pictures, and both of the following two conditions are satisfied: ○ The MV of P in the list 0 and the MV of Q in the list 0 has a distance $\geq$ half-pel in x- or y-dir or the MV of P in the list 1 and the MV of Q in the list 1 has a distance $\geq$ half-pel in x- or y-dir ○ The MV of P in the list 0 and the MV of Q in the list 1 has a distance $\geq$ half-pel in x- or y-dir or the MV of P in the list 1 and the MV of Q in the list 0 has a distance $\geq$ half-pel in x- or y-dir *Note: The determination of whether the reference pictures used for the two coding subblocks are the same or different is based only on which pictures are referenced, without regard to whether a prediction is formed using an index	1	N/A	N/A
---	---	-----	-----

into reference picture list 0 or an index into reference picture list 1, and also without regard to whether the index position within a reference picture list is different.			
Otherwise	0	0	0

2.2.4. Stronger deblocking filter for luma

[0083] The proposal uses a bilinear filter when samples at either one side of a boundary belong to a large block. A sample belonging to a large block is defined as when the width ≥ 32 for a vertical edge, and when height ≥ 32 for a horizontal edge.

[0084] The bilinear filter is listed below.

[0085] Block boundary samples p_i for $i=0$ to S_p-1 and q_j for $j=0$ to S_q-1 (p_i and q_j follow the definitions in HEVC deblocking described above) are then replaced by linear interpolation as follows:

- $p_i' = (f_i * Middle_{s,t} + (64 - f_i) * P_s + 32) \gg 6$, clipped to $p_i \pm tcPD_i$
- $q_j' = (g_j * Middle_{s,t} + (64 - g_j) * Q_s + 32) \gg 6$, clipped to $q_j \pm tcPD_j$

where $tcPD_i$ and $tcPD_j$ term is a position dependent clipping described in Section 2.2.5 and $g_j, f_i, Middle_{s,t}, P_s$ and Q_s are given below:

S_p, S_q 7, 7 (p side: 7, q side: 7)	$f_i = 59 - i * 9$, can also be described as $\mathbf{f} = \{59, 50, 41, 32, 23, 14, 5\}$ $g_j = 59 - j * 9$, can also be described as $\mathbf{g} = \{59, 50, 41, 32, 23, 14, 5\}$ $Middle_{7,7} = (2 * (p_o + q_o) + p_1 + q_1 + p_2 + q_2 + p_3 + q_3 + p_4 + q_4 + p_5 + q_5 + p_6 + q_6 + 8) \gg 4$ $P_7 = (p_6 + p_7 + 1) \gg 1$, $Q_7 = (q_6 + q_7 + 1) \gg 1$
7, 3 (p side: 7 q side: 3)	$f_i = 59 - i * 9$, can also be described as $\mathbf{f} = \{59, 50, 41, 32, 23, 14, 5\}$ $g_j = 53 - j * 21$, can also be described as $\mathbf{g} = \{53, 32, 11\}$

	$Middle_{7,3} = (2 * (p_o + q_o) + q_o + 2 * (q_1 + q_2) + p_1 + q_1 + p_2 + p_3 + p_4 + p_5 + p_6 + 8) \gg 4$ $P_7 = (p_6 + p_7 + 1) \gg 1, \quad Q_3 = (q_2 + q_3 + 1) \gg 1$
3, 7 (p side: 3 q side: 7)	$g_j = 59 - j * 9, \text{ can also be described as } \mathbf{g} = \{59, 50, 41, 32, 23, 14, 5\}$ $f_i = 53 - i * 21, \text{ can also be described as } \mathbf{f} = \{53, 32, 11\}$ $Middle_{3,7} = (2 * (q_o + p_o) + p_o + 2 * (p_1 + p_2) + q_1 + p_1 + q_2 + q_3 + q_4 + q_5 + q_6 + 8) \gg 4$ $Q_7 = (q_6 + q_7 + 1) \gg 1, \quad P_3 = (p_2 + p_3 + 1) \gg 1$
7, 5 (p side: 7 q side: 5)	$g_j = 58 - j * 13, \text{ can also be described as } \mathbf{g} = \{58, 45, 32, 19, 6\}$ $f_i = 59 - i * 9, \text{ can also be described as } \mathbf{f} = \{59, 50, 41, 32, 23, 14, 5\}$ $Middle_{7,5} = (2 * (p_o + q_o + p_1 + q_1) + q_2 + p_2 + q_3 + p_3 + q_4 + p_4 + q_5 + p_5 + 8) \gg 4$ $Q_5 = (q_4 + q_5 + 1) \gg 1, \quad P_7 = (p_6 + p_7 + 1) \gg 1$
5, 7 (p side: 5 q side: 7)	$g_j = 59 - j * 9, \text{ can also be described as } \mathbf{g} = \{59, 50, 41, 32, 23, 14, 5\}$ $f_i = 58 - i * 13, \text{ can also be described as } \mathbf{f} = \{58, 45, 32, 19, 6\}$ $Middle_{5,7} = (2 * (q_o + p_o + p_1 + q_1) + q_2 + p_2 + q_3 + p_3 + q_4 + p_4 + q_5 + p_5 + 8) \gg 4$ $Q_7 = (q_6 + q_7 + 1) \gg 1, \quad P_5 = (p_4 + p_5 + 1) \gg 1$
5, 5 (p side: 5 q side: 5)	$g_j = 58 - j * 13, \text{ can also be described as } \mathbf{g} = \{58, 45, 32, 19, 6\}$ $f_i = 58 - i * 13, \text{ can also be described as } \mathbf{f} = \{58, 45, 32, 19, 6\}$ $Middle_{5,5} = (2 * (q_o + p_o + p_1 + q_1 + q_2 + p_2) + q_3 + p_3 + q_4 + p_4 + 8) \gg 4$ $Q_5 = (q_4 + q_5 + 1) \gg 1, \quad P_5 = (p_4 + p_5 + 1) \gg 1$
5, 3 (p side: 5 q side: 3)	$g_j = 53 - j * 21, \text{ can also be described as } \mathbf{g} = \{53, 32, 11\}$ $f_i = 58 - i * 13, \text{ can also be described as } \mathbf{f} = \{58, 45, 32, 19, 6\}$ $Middle_{5,3} = (q_o + p_o + p_1 + q_1 + q_2 + p_2 + q_3 + p_3 + 4) \gg 3$ $Q_3 = (q_2 + q_3 + 1) \gg 1, \quad P_5 = (p_4 + p_5 + 1) \gg 1$
3, 5 (p side: 3 q side: 5)	$g_j = 58 - j * 13, \text{ can also be described as } \mathbf{g} = \{58, 45, 32, 19, 6\}$ $f_i = 53 - i * 21, \text{ can also be described as } \mathbf{f} = \{53, 32, 11\}$ $Middle_{3,5} = (q_o + p_o + p_1 + q_1 + q_2 + p_2 + q_3 + p_3 + 4) \gg 3$ $Q_5 = (q_4 + q_5 + 1) \gg 1, \quad P_3 = (p_2 + p_3 + 1) \gg 1$

2.2.5. Deblocking control for luma

[0086] The deblocking decision process is described in this sub-section.

[0087] Wider-stronger luma filter is filters are used only if all of the **Condition1**, **Condition2** and **Condition 3** are TRUE.

[0088] The condition 1 is the “large block condition”. This condition detects whether the samples at P-side and Q-side belong to large blocks, which are represented by the variable bSidePisLargeBlk and bSideQisLargeBlk respectively. The bSidePisLargeBlk and bSideQisLargeBlk are defined as follows.

bSidePisLargeBlk = ((edge type is vertical and p₀ belongs to CU with width ≥ 32) || (edge type is horizontal and p₀ belongs to CU with height ≥ 32))? TRUE: FALSE

bSideQisLargeBlk = ((edge type is vertical and q₀ belongs to CU with width ≥ 32) || (edge type is horizontal and q₀ belongs to CU with height ≥ 32))? TRUE: FALSE

[0089] Based on bSidePisLargeBlk and bSideQisLargeBlk, the condition 1 is defined as follows.

Condition1 = (bSidePisLargeBlk || bSideQisLargeBlk) ? TRUE: FALSE

[0090] Next, if **Condition 1** is true, the condition 2 will be further checked. First, the following variables are derived:

dp0, dp3, dq0, dq3 are first derived as in HEVC

if (p side is greater than or equal to 32)

dp0 = (dp0 + Abs(p_{5,0} - 2 * p_{4,0} + p_{3,0}) + 1) >> 1

dp3 = (dp3 + Abs(p_{5,3} - 2 * p_{4,3} + p_{3,3}) + 1) >> 1

if (q side is greater than or equal to 32)

dq0 = (dq0 + Abs(q_{5,0} - 2 * q_{4,0} + q_{3,0}) + 1) >> 1

dq3 = (dq3 + Abs(q_{5,3} - 2 * q_{4,3} + q_{3,3}) + 1) >> 1

dpq0, dpq3, dp, dq, d are then derived as in HEVC.

[0091] Then the condition 2 is defined as follows.

Condition2 = (d < β) ? TRUE: FALSE

Where d=dp0+dq0+dp3+dq3, as shown in section 2.1.4.

[0092] If Condition1 and Condition2 are valid it is checked if any of the blocks uses sub-blocks:

If(bSidePisLargeBlk)

```

If(mode block P == SUBBLOCKMODE)
    Sp = 5
else
    Sp = 7
else
    Sp = 3
If(bSideQisLargeBlk)
    If(mode block Q == SUBBLOCKMODE)
        Sq = 5
    else
        Sq = 7
else
    Sq = 3

```

[0093] Finally, if both the Condition 1 and Condition 2 are valid, the proposed deblocking method will check the condition 3 (the large block Strong filter condition), which is defined as follows.

In the Condition3 StrongFilterCondition, the following variables are derived:

dpq is derived as in HEVC.

$sp3 = \text{Abs}(p3 - p0)$, derived as in HEVC

if (p side is greater than or equal to 32)

if($Sp == 5$)

$sp3 = (sp3 + \text{Abs}(p5 - p3) + 1) \gg 1$

else

$sp3 = (sp3 + \text{Abs}(p7 - p3) + 1) \gg 1$

$sq3 = \text{Abs}(q0 - q3)$, derived as in HEVC

if (q side is greater than or equal to 32)

If($Sq == 5$)

$sq3 = (sq3 + \text{Abs}(q5 - q3) + 1) \gg 1$

else

$sq3 = (sq3 + \text{Abs}(q7 - q3) + 1) \gg 1$

[0094] As in HEVC derive, StrongFilterCondition = (dpq is less than ($\beta \gg 2$), sp3 + sq3 is less than ($3 * \beta \gg 5$), and Abs(p0 - q0) is less than ($5 * tC + 1$) $\gg 1$) ? TRUE : FALSE

[0095] FIG. 6 depicts the flowchart of luma deblocking filter process.

2.2.6. Strong deblocking filter for chroma

[0096] The following strong deblocking filter for chroma is defined:

$$p_2' = (3 * p_3 + 2 * p_2 + p_1 + p_0 + q_0 + 4) \gg 3$$

$$p_1' = (2 * p_3 + p_2 + 2 * p_1 + p_0 + q_0 + q_1 + 4) \gg 3$$

$$p_0' = (p_3 + p_2 + p_1 + 2 * p_0 + q_0 + q_1 + q_2 + 4) \gg 3$$

[0097] The proposed chroma filter performs deblocking on a 4x4 chroma sample grid.

2.2.7. Deblocking control for chroma

[0098] The above chroma filter performs deblocking on a 8x8 chroma sample grid. The chroma strong filters are used on both sides of the block boundary. Here, the chroma filter is selected when both sides of the chroma edge are greater than or equal to 8 (in unit of chroma sample), and the following decision with three conditions are satisfied. The first one is for decision of boundary strength as well as large block. The second and third one are basically the same as for HEVC luma decision, which are on/off decision and strong filter decision, respectively.

[0099] FIG. 7 depicts the flowchart of chroma deblocking filter process.

2.2.8. Position dependent clipping

[0100] The proposal also introduces a position dependent clipping tcPD which is applied to the output samples of the luma filtering process involving strong and long filters that are modifying 7, 5 and 3 samples at the boundary. Assuming quantization error distribution, it is proposed to increase clipping value for samples which are expected to have higher quantization noise, thus expected to have higher deviation of the reconstructed sample value from the true sample value.

[0101] For each P or Q boundary filtered with proposed asymmetrical filter, depending on the result of decision making process described in Section 2.2, position dependent threshold table is selected from Tc7 and Tc3 tables that are provided to decoder as a side information:

$$Tc7 = \{ 6, 5, 4, 3, 2, 1, 1 \};$$

$$Tc3 = \{ 6, 4, 2 \};$$

$$tcPD = (SP == 3) ? Tc3 : Tc7;$$

$$tcQD = (SQ == 3) ? Tc3 : Tc7;$$

[0102] For the P or Q boundaries being filtered with a short symmetrical filter, position dependent threshold of lower magnitude is applied:

$$Tc3 = \{3, 2, 1\};$$

[0103] Following defining the threshold, filtered p'_i and q'_i sample values are clipped according to tcP and tcQ clipping values:

$$p''_i = clip3(p'_i + tcP_i, p'_i - tcP_i, p'_i);$$

$$q''_j = clip3(q'_j + tcQ_j, q'_j - tcQ_j, q'_j);$$

where p'_i and q'_i are filtered sample values, p''_i and q''_j are output sample value after the clipping and tcP_i tcP_i are clipping thresholds that are derived from the VVC tc parameter and $tcPD$ and $tcQD$. Term clip3 is a clipping function as it is specified in VVC.

2.2.9. Sub-block deblocking adjustment

[0104] To enable parallel friendly deblocking using both long filters and sub-block deblocking the long filters is restricted to modify at most 5 samples on a side that uses sub-block deblocking (AFFINE or ATMVP) as shown in the luma control for long filters. Additionally, the sub-block deblocking is adjusted such that that sub-block boundaries on an 8x8 grid that are close to a CU or an implicit TU boundary is restricted to modify at most two samples on each side.

[0105] Following applies to sub-block boundaries that not are aligned with the CU boundary.

```
If(mode block Q == SUBBLOCKMODE && edge!=0){
  if (!(implicitTU && (edge == (64 / 4))))
    if (edge == 2 || edge == (orthogonalLength - 2) || edge == (56 / 4) || edge == (72 / 4))
      Sp = Sq = 2;
    else
      Sp = Sq = 3;
  else
    Sp = Sq = bSideQisLargeBlk? 5:3
}
```

[0106] Where edge equal to 0 corresponds to CU boundary, edge equal to 2 or equal to orthogonalLength-2 corresponds to sub-block boundary 8 samples from a CU boundary etc. Where implicit TU is true if implicit split of TU is used. FIG. 8 show the flowcharts of determination process for TU boundaries and sub-PU boundaries.

[0107] Filtering of horizontal boundary is limiting $Sp=3$ for luma, $Sp=1$ and $Sq=1$ for chroma, when the horizontal boundary is aligned with the CTU boundary.

2.2.10. Deblocking decision adapted to smaller difference in motion

[0108] HEVC enables deblocking of a prediction unit boundary when the difference in at least one motion vector component between blocks on respective side of the boundary is equal to or larger than a threshold of 1 sample. In VTM6, a threshold of a half luma sample is introduced to also enable removal of blocking artifacts originating from boundaries between inter prediction units that have a small difference in motion vectors.

2.3. Combined inter and intra prediction (CIIP)

[0109] In VTM6, when a CU is coded in merge mode, if the CU contains at least 64 luma samples (that is, CU width times CU height is equal to or larger than 64), and if both CU width and CU height are less than 128 luma samples, an additional flag is signalled to indicate if the combined inter/intra prediction (CIIP) mode is applied to the current CU. As its name indicates, the CIIP prediction combines an inter prediction signal with an intra prediction signal. The inter prediction signal in the CIIP mode P_{inter} is derived using the same inter prediction process applied to regular merge mode; and the intra prediction signal P_{intra} is derived following the regular intra prediction process with the planar mode. Then, the intra and inter prediction signals are combined using weighted averaging, where the weight value is calculated depending on the coding modes of the top and left neighbouring blocks as follows:

- If the top neighbor is available and intra coded, then set $isIntraTop$ to 1, otherwise set $isIntraTop$ to 0;
- If the left neighbor is available and intra coded, then set $isIntraLeft$ to 1, otherwise set $isIntraLeft$ to 0;
- If $(isIntraLeft + isIntraTop)$ is equal to 2, then wt is set to 3;
- Otherwise, if $(isIntraLeft + isIntraTop)$ is equal to 1, then wt is set to 2;
- Otherwise, set wt to 1.

[0110] The CIIP prediction is formed as follows:

$$P_{CIIP} = ((4 - wt) * P_{inter} + wt * P_{intra} + 2) \gg 2$$

2.4. Chroma QP table design in VTM-6.0

[0111] In some embodiments, a chroma QP table is used. In some embodiments, a signalling mechanism is used for chroma QP tables, which enables that it is flexible to provide encoders the

opportunity to optimize the table for SDR and HDR content. It supports for signalling the tables separately for Cb and Cr components. The proposed mechanism signals the chroma QP table as a piece-wise linear function.

2.5. Transform Skip(TS)

[0112] As in HEVC, the residual of a block can be coded with transform skip mode. To avoid the redundancy of syntax coding, the transform skip flag is not signalled when the CU level MTS_CU_flag is not equal to zero. The block size limitation for transform skip is the same to that for MTS in JEM4, which indicate that transform skip is applicable for a CU when both block width and height are equal to or less than 32. Note that implicit MTS transform is set to DCT2 when LFNST or MIP is activated for the current CU. Also the implicit MTS can be still enabled when MTS is enabled for inter coded blocks.

[0113] In addition, for transform skip block, minimum allowed Quantization Parameter (QP) is defined as $6 * (\text{internalBitDepth} - \text{inputBitDepth}) + 4$.

2.6. Joint coding of chroma residuals (JCCR)

[0114] In some embodiments, the chroma residuals are coded jointly. The usage (activation) of a joint chroma coding mode is indicated by a TU-level flag *tu_joint_cbr_residual_flag* and the selected mode is implicitly indicated by the chroma CBFs. The flag *tu_joint_cbr_residual_flag* is present if either or both chroma CBFs for a TU are equal to 1. In the PPS and slice header, chroma QP offset values are signalled for the joint chroma residual coding mode to differentiate from the usual chroma QP offset values signalled for regular chroma residual coding mode. These chroma QP offset values are used to derive the chroma QP values for those blocks coded using the joint chroma residual coding mode. When a corresponding joint chroma coding mode (modes 2 in Table 3) is active in a TU, this chroma QP offset is added to the applied luma-derived chroma QP during quantization and decoding of that TU. For the other modes (modes 1 and 3 in Table 3), the chroma QPs are derived in the same way as for conventional Cb or Cr blocks. The reconstruction process of the chroma residuals (resCb and resCr) from the transmitted transform blocks is depicted in Table 3. When this mode is activated, one single joint chroma residual block (resJointC[x][y] in Table 3) is signalled, and residual block for Cb (resCb)

and residual block for Cr (resCr) are derived considering information such as tu_cbf_cb, tu_cbf_cr, and CSign, which is a sign value specified in the slice header.

[0115] At the encoder side, the joint chroma components are derived as explained in the following. Depending on the mode (listed in the tables above), resJointC{1,2} are generated by the encoder as follows:

- If mode is equal to 2 (single residual with reconstruction Cb = C, Cr = CSign * C), the joint residual is determined according to

$$\text{resJointC}[x][y] = (\text{resCb}[x][y] + \text{CSign} * \text{resCr}[x][y]) / 2.$$

- Otherwise, if mode is equal to 1 (single residual with reconstruction Cb = C, Cr = (CSign * C) / 2), the joint residual is determined according to

$$\text{resJointC}[x][y] = (4 * \text{resCb}[x][y] + 2 * \text{CSign} * \text{resCr}[x][y]) / 5.$$

- Otherwise (mode is equal to 3, i. e., single residual, reconstruction Cr = C, Cb = (CSign * C) / 2), the joint residual is determined according to

$$\text{resJointC}[x][y] = (4 * \text{resCr}[x][y] + 2 * \text{CSign} * \text{resCb}[x][y]) / 5.$$

Table 3 Reconstruction of chroma residuals. The value CSign is a sign value (+1 or -1), which is specified in the slice header, resJointC[][] is the transmitted residual.

tu_cbf_cb	tu_cbf_cr	reconstruction of Cb and Cr residuals	mode
1	0	$\text{resCb}[x][y] = \text{resJointC}[x][y]$ $\text{resCr}[x][y] = (\text{CSign} * \text{resJointC}[x][y]) \gg 1$	1
1	1	$\text{resCb}[x][y] = \text{resJointC}[x][y]$ $\text{resCr}[x][y] = \text{CSign} * \text{resJointC}[x][y]$	2
0	1	$\text{resCb}[x][y] = (\text{CSign} * \text{resJointC}[x][y]) \gg 1$ $\text{resCr}[x][y] = \text{resJointC}[x][y]$	3

[0116] Different QPs are utilized are the above three modes. For mode 2, the QP offset signaled in PPS for JCCR coded block is applied, while for other two modes, it is not applied, instead, the QP offset signaled in PPS for non-JCCR coded block is applied.

[0117] The corresponding specification is as follows:

8.7.1 Derivation process for quantization parameters

The variable Qp_Y is derived as follows:

$$\text{Qp}_Y = ((\text{qP}_{Y_PRED} + \text{CuQpDeltaVal} + 64 + 2 * \text{QpBdOffset}_Y) \% (64 + \text{QpBdOffset}_Y)) - \text{QpBdOffset}_Y (8-933)$$

The luma quantization parameter Qp'_Y is derived as follows:

$$Qp'_Y = Qp_Y + QpBdOffset_Y \quad (8-934)$$

When ChromaArrayType is not equal to 0 and treeType is equal to SINGLE_TREE or DUAL_TREE_CHROMA, the following applies:

- When treeType is equal to DUAL_TREE_CHROMA, the variable Qp_Y is set equal to the luma quantization parameter Qp_Y of the luma coding unit that covers the luma location ($x_{Cb} + cbWidth / 2, y_{Cb} + cbHeight / 2$).
- The variables qP_{Cb} , qP_{Cr} and qP_{CbCr} are derived as follows:

$$qPi_{Chroma} = Clip3(-QpBdOffset_C, 63, Qp_Y) \quad (8-935)$$

$$qPi_{Cb} = ChromaQpTable[0][qPi_{Chroma}] \quad (8-936)$$

$$qPi_{Cr} = ChromaQpTable[1][qPi_{Chroma}] \quad (8-937)$$

$$qPi_{CbCr} = ChromaQpTable[2][qPi_{Chroma}] \quad (8-938)$$

- The chroma quantization parameters for the Cb and Cr components, Qp'_{Cb} and Qp'_{Cr} , and joint Cb-Cr coding Qp'_{CbCr} are derived as follows:

$$Qp'_{Cb} = Clip3(-QpBdOffset_C, 63, qP_{Cb} + pps_cb_qp_offset + slice_cb_qp_offset + CuQpOffset_{Cb}) + QpBdOffset_C \quad (8-939)$$

$$Qp'_{Cr} = Clip3(-QpBdOffset_C, 63, qP_{Cr} + pps_cr_qp_offset + slice_cr_qp_offset + CuQpOffset_{Cr}) + QpBdOffset_C \quad (8-940)$$

$$Qp'_{CbCr} = Clip3(-QpBdOffset_C, 63, qP_{CbCr} + pps_cbcr_qp_offset + slice_cbcr_qp_offset + CuQpOffset_{CbCr}) + QpBdOffset_C \quad (8-941)$$

8.7.3 Scaling process for transform coefficients

Inputs to this process are:

- a luma location (x_{TbY}, y_{TbY}) specifying the top-left sample of the current luma transform block relative to the top-left luma sample of the current picture,
- a variable $nTbW$ specifying the transform block width,
- a variable $nTbH$ specifying the transform block height,
- a variable $cIdx$ specifying the colour component of the current block,
- a variable $bitDepth$ specifying the bit depth of the current colour component.

Output of this process is the $(nTbW) \times (nTbH)$ array d of scaled transform coefficients with elements $d[x][y]$.

The quantization parameter qP is derived as follows:

- If $cIdx$ is equal to 0 and $transform_skip_flag[x_{TbY}][y_{TbY}]$ is equal to 0, the following applies:

$$qP = Qp'_Y \quad (8-950)$$

- Otherwise, if $cIdx$ is equal to 0 (and $transform_skip_flag[x_{TbY}][y_{TbY}]$ is equal to 1), the following applies:

$$qP = Max(QpPrimeTsMin, Qp'_Y) \quad (8-951)$$

- Otherwise, if $TuCRsMode[x_{TbY}][y_{TbY}]$ is equal to 2, the following applies:

$$qP = Qp'_{CbCr} \quad (8-952)$$

- Otherwise, if $cIdx$ is equal to 1, the following applies:

$$qP = Qp'_{Cb} \quad (8-953)$$

- Otherwise ($cIdx$ is equal to 2), the following applies:

$$qP = Qp'_{Cr} \quad (8-954)$$

3. Drawbacks of existing implementations

[0118] DMVR and BIO do not involve the original signal during refining the motion vectors, which may result in coding blocks with inaccurate motion information. Also, DMVR and BIO sometimes employ the fractional motion vectors after the motion refinements while screen videos usually have integer motion vectors, which makes the current motion information more inaccurate and make the coding performance worse.

1. The interaction between chroma QP table and chroma deblocking may have problems, e.g. chroma QP table should be applied to individual QP but not weighted sum of QPs.
2. The logic of luma deblocking filtering process is complicated for hardware design.
3. The logic of boundary strength derivation is too complicated for both software and hardware design.
4. In the BS decision process, JCCR is treated separately from those blocks coded without JCCT applied. However, JCCR is only a special way to code the residual. Therefore, such design may bring additional complexity without no clear benefits.
5. In chroma edge decision, Qp_Q and Qp_P are set equal to the Qp_Y values of the coding units which include the coding blocks containing the sample $q_{0,0}$ and $p_{0,0}$, respectively. However, in the quantization/de-quantization process, the QP for a chroma sample is derived from the QP of luma block covering the corresponding luma sample of the center position of current chroma CU. When dual tree is enabled, the different locations of luma blocks may result in different QPs. Therefore, in the chroma deblocking process, wrong QPs may be used for filter decision. Such a misalignment may result in visual artifacts. An example is shown in FIG. 9, including Figure 9(a) and Figure 9(b). In FIG. 9, the left side (Figure 9(a)) is the corresponding CTB partitioning for luma block and the right side (Figure 9(b)) in the chroma CTB partitioning under dual tree. When determining the QP for chroma block, denoted by CU_{c1} , the center position of CU_{c1} is firstly derived. Then the corresponding luma sample of the center position of CU_{c1} is identified and luma QP associated with the luma CU that covers the corresponding luma sample, i.e., CU_{Y3} is then utilized to derive the QP for CU_{c1} .

However, when making filter decisions for the depicted three samples (with solid circles), the QPs of CUs that cover the corresponding 3 samples are selected. Therefore, for the 1st, 2nd, and 3rd chroma sample (depicted in Figure 9 (b)), the QPs of CU_{Y2}, CU_{Y3}, CU_{Y4} are utilized, respectively. That is, chroma samples in the same CU may use different QPs for filter decision which may result in wrong decisions.

6. A different picture level QP offset (i.e., pps_joint_cbcr_qp_offset) is applied to JCCR coded blocks which is different from the picture level offsets for Cb/Cr (e.g., pps_cb_qp_offset and pps_cr_qp_offset) applied to non-JCCR coded blocks. However, in the chroma deblocking filter decision process, only those offsets for non-JCCR coded blocks are utilized. The missing of consideration of coded modes may result in wrong filter decision.
7. The TS and non-TS coded blocks employ different QPs in the de-quantization process, which may be also considered in the deblocking process.
8. Different QPs are used in the scaling process (quantization/dequantization) for JCCR coded blocks with different modes. Such a design is not consistent.

4. Example techniques and embodiments

[0119] The detailed embodiments described below should be considered as examples to explain general concepts. These embodiments should not be interpreted narrowly way. Furthermore, these embodiments can be combined in any manner.

[0120] The methods described below may be also applicable to other decoder motion information derivation technologies in addition to the DMVR and BIO mentioned below.

[0121] In the following examples, MVM[i].x and MVM[i].y denote the horizontal and vertical component of the motion vector in reference picture list i (i being 0 or 1) of the block at M (M being P or Q) side. Abs denotes the operation to get the absolute value of an input, and “&&” and “||” denotes the logical operation AND and OR. Referring to FIG. 10, P may denote the samples at P side and Q may denote the samples at Q side. The blocks at P side and Q side may denote the block marked by the dash lines.

Regarding chroma QP in deblocking

1. When chroma QP table is used to derive parameters to control chroma deblocking (e.g., in the decision process for chroma block edges), chroma QP offsets may be applied after applying chroma QP table.

- a. In one example, the chroma QP offsets may be added to the value outputted by a chroma QP table.
 - b. Alternatively, the chroma QP offsets may be not considered as input to a chroma QP table.
 - c. In one example, the chroma QP offsets may be the picture-level or other video unit-level (slice/tile/brick/subpicture) chroma quantization parameter offset (e.g., **pps_cb_qp_offset**, **pps_cr_qp_offset** in the specification).
2. QP clipping may be not applied to the input of a chroma QP table.
 3. It is proposed to consider the picture/slice/tile/brick/subpicture level quantization parameter offsets used for different coding methods in the deblocking filter decision process.
 - a. In one example, selection of picture/slice/tile/brick/subpicture level quantization parameter offsets for filter decision (e.g., the chroma edge decision in the deblocking filter process) may depend on the coded methods for each side.
 - b. In one example, the filtering process (e.g., the chroma edge decision process) which requires to use the quantization parameters for chroma blocks may depend on whether the blocks use JCCR.
 - i. Alternatively, furthermore, the picture/slice-level QP offsets (e.g., **pps_joint_cbr_qp_offset**) applied to JCCR coded blocks may be further taken into consideration in the deblocking filtering process.
 - ii. In one example, the **cQpPicOffset** which is used to decide T_c and β settings may be set to **pps_joint_cbr_qp_offset** instead of **pps_cb_qp_offset** or **pps_cr_qp_offset** under certain conditions:
 1. In one example, when either block in P or Q sides uses JCCR.
 2. In one example, when both blocks in P or Q sides uses JCCR.
 4. The chroma filtering process (e.g., the chroma edge decision process) which requires to access the decoded information of a luma block may utilize the information associated with the same luma coding block that is used to derive the chroma QP in the dequantization/quantization process.
 - a. In one example, the chroma filtering process (e.g., the chroma edge decision process) which requires to use the quantization parameters for luma blocks may utilize the

- luma coding unit covering the corresponding luma sample of the center position of current chroma CU.
- b. An example is depicted in Figure 9 wherein the decoded information of CU_{Y3} may be used for filtering decision of the three chroma samples (1st, 2nd and 3rd) in Figure 9 (b).
5. The chroma filtering process (e.g., the chroma edge decision process) may depend on the quantization parameter applied to the scaling process of the chroma block (e.g., quantization/dequantization).
 - a. In one example, the QP used to derive β and Tc may depend on the QP applied to the scaling process of the chroma block.
 - b. Alternatively, furthermore, the QP used to the scaling process of the chroma block may have taken the chroma CU level QP offset into consideration.
 6. Whether to invoke above bullets may depend on the sample to be filtered is in the block at P or Q side.
 - a. For example, whether to use the information of the luma coding block covering the corresponding luma sample of current chroma sample or use the information of the luma coding block covering the corresponding luma sample of center position of chroma coding block covering current chroma sample may depend on the block position.
 - i. In one example, if the current chroma sample is in the block at the Q side, QP information of the luma coding block covering the corresponding luma sample of center position of chroma coding block covering current chroma sample may be used.
 - ii. In one example, if the current chroma sample is in the block at the P side, QP information of the luma coding block covering the corresponding luma sample of the chroma sample may be used.

Regarding QP settings

7. It is proposed to signal the indication of enabling block-level chroma QP offset (e.g. slice_cu_chroma_qp_offset_enabled_flag) at the slice/tile/brick/subpicture level.
 - a. Alternatively, the signaling of such an indication may be conditionally signaled.

- i. In one example, it may be signaled under the condition of JCCR enabling flag.
 - ii. In one example, it may be signaled under the condition of block-level chroma QP offset enabling flag in picture level.
 - iii. Alternatively, such an indication may be derived instead.
 - b. In one example, the slice_cu_chroma_qp_offset_enabled_flag may be signaled only when the PPS flag of chroma QP offset (e.g. slice_cu_chroma_qp_offset_enabled_flag) is true.
 - c. In one example, the slice_cu_chroma_qp_offset_enabled_flag may be inferred to false only when the PPS flag of chroma QP offset (e.g. slice_cu_chroma_qp_offset_enabled_flag) is false.
 - d. In one example, whether to use the chroma QP offset on a block may be based on the flags of chroma QP offset at PPS level and/or slice level.
8. Same QP derivation method is used in the scaling process (quantization/dequantization) for JCCR coded blocks with different modes.
- a. In one example, for JCCR with mode 1 and 3, the QP is dependent on the QP offset signaled in the picture/slice level (e.g., pps_cbcr_qp_offset, slice_cbcr_qp_offset).

Filtering procedures

9. Deblocking for all color components excepts for the first color component may follow the deblocking process for the first color component.
- a. In one example, when the color format is 4:4:4, deblocking process for the second and third components may follow the deblocking process for the first component.
 - b. In one example, when the color format is 4:4:4 in RGB color space, deblocking process for the second and third components may follow the deblocking process for the first component.
 - c. In one example, when the color format is 4:2:2, vertical deblocking process for the second and third components may follow the vertical deblocking process for the first component.
 - d. In above examples, the deblocking process may refer to deblocking decision process and/or deblocking filtering process.

Regarding boundary strength derivation

10. It is proposed to treat JCCR coded blocks as those non-JCCR coded blocks in the boundary strength decision process.
 - a. In one example, the determination of boundary strength (BS) may be independent from the checking of usage of JCCR for two blocks at P and Q sides.
 - a. In one example, the boundary strength (BS) for a block may be determined regardless if the block is coded with JCCR or not.
11. It is proposed to derive the boundary strength (BS) without comparing the reference pictures and/or number of MVs associated with the block at P side with the reference pictures of the block at Q side.
 - b. In one example, deblocking filter may be disabled even when two blocks are with different reference pictures.
 - c. In one example, deblocking filter may be disabled even when two blocks are with different number of MVs (e.g., one is uni-predicted and the other is bi-predicted).
 - d. In one example, the value of BS may be set to 1 when motion vector differences for one or all reference picture lists between the blocks at P side and Q side is larger than or equal to a threshold Th.
 - i. Alternatively, furthermore, the value of BS may be set to 0 when motion vector differences for one or all reference picture lists between the blocks at P side and Q side is smaller than or equal to a threshold Th.
 - e. In one example, the difference of the motion vectors of two blocks being larger than a threshold Th may be defined as $(Abs(MVP[0].x - MVQ[0].x) > Th \parallel Abs(MVP[0].y - MVQ[0].y) > Th \parallel Abs(MVP[1].x - MVQ[1].x) > Th \parallel Abs(MVP[1].y - MVQ[1].y) > Th)$
 - i. Alternatively, the difference of the motion vectors of two blocks being larger than a threshold Th may be defined as $(Abs(MVP[0].x - MVQ[0].x) > Th \&\& Abs(MVP[0].y - MVQ[0].y) > Th \&\& Abs(MVP[1].x - MVQ[1].x) > Th) \&\& Abs(MVP[1].y - MVQ[1].y) > Th)$
 - ii. Alternatively, in one example, the difference of the motion vectors of two blocks being larger than a threshold Th may be defined as $(Abs(MVP[0].x -$

$MVQ[0].x) > Th \parallel Abs(MVP[0].y - MVQ[0].y) > Th) \&\& (Abs(MVP[1].x - MVQ[1].x) > Th) \parallel Abs(MVP[1].y - MVQ[1].y) > Th)$

- iii. Alternatively, in one example, the difference of the motion vectors of two blocks being larger than a threshold Th may be defined as $(Abs(MVP[0].x - MVQ[0].x) > Th \&\& Abs(MVP[0].y - MVQ[0].y) > Th) \parallel (Abs(MVP[1].x - MVQ[1].x) > Th) \&\& Abs(MVP[1].y - MVQ[1].y) > Th)$
- f. In one example, a block which does not have a motion vector in a given list may be treated as having a zero-motion vector in that list.
- g. In the above examples, Th is an integer number (e.g. 4, 8 or 16).
- h. In the above examples, Th may depend on
 - i. Video contents (e.g. screen contents or natural contents)
 - ii. A message signaled in the DPS/SPS/VPS/PPS/APS/picture header/slice header/tile group header/ Largest coding unit (LCU)/Coding unit (CU)/LCU row/group of LCUs/TU/PU block/Video coding unit
 - iii. Position of CU/PU/TU/block/Video coding unit
 - iv. Coded modes of blocks containing the samples along the edges
 - v. Transform matrices applied to the blocks containing the samples along the edges
 - vi. Block dimension/Block shape of current block and/or its neighboring blocks
 - vii. Indication of the color format (such as 4:2:0, 4:4:4, RGB or YUV)
 - viii. Coding tree structure (such as dual tree or single tree)
 - ix. Slice/tile group type and/or picture type
 - x. Color component (e.g. may be only applied on Cb or Cr)
 - xi. Temporal layer ID
 - xii. Profiles/Levels/Tiers of a standard
 - xiii. Alternatively, Th may be signalled to the decoder.
- i. The above examples may be applied under certain conditions.
 - i. In one example, the condition is the *blkP* and *blkQ* are not coded with intra modes.

- ii. In one example, the condition is the *blkP* and *blkQ* have zero coefficients on luma component.
- iii. In one example, the condition is the *blkP* and *blkQ* are not coded with the CIIP mode.
- iv. In one example, the condition is the *blkP* and *blkQ* are coded with a same prediction mode (e.g. IBC or Inter).

Regarding luma deblocking filtering process

12. The deblocking may use different QPs for TS coded blocks and non-TS coded blocks.
 - a. In one example, the QP for TS may be used on TS coded blocks while the QP for non-TS may be used on non-TS coded blocks.
13. The luma filtering process (e.g., the luma edge decision process) may depend on the quantization parameter applied to the scaling process of the luma block.
 - a. In one example, the QP used to derive beta and Tc may depend on the clipping range of transform skip, e.g. as indicated by QpPrimeTsMin.
14. It is proposed to use an identical gradient computation for large block boundaries and smaller block boundaries.
 - a. In one example, the deblocking filter on/off decision described in section 2.1.4 may be also applied for large block boundary.
 - i. In one example, the threshold *beta* in the decision may be modified for large block boundary.
 1. In one example, *beta* may depend on quantization parameter.
 2. In one example, *beta* used for deblocking filter on/off decision for large block boundaries may be smaller than that for smaller block boundaries.
 - a. Alternatively, in one example, *beta* used for deblocking filter on/off decision for large block boundaries may be larger than that for smaller block boundaries.
 - b. Alternatively, in one example, *beta* used for deblocking filter on/off decision for large block boundaries may be equal to that for smaller block boundaries.

3. In one example, *beta* is an integer number and may be based on
 - a. Video contents (e.g. screen contents or natural contents)
 - b. A message signaled in the DPS/SPS/VPS/PPS/APS/picture header/slice header/tile group header/ Largest coding unit (LCU)/Coding unit (CU)/LCU row/group of LCUs/TU/PU block/Video coding unit
 - c. Position of CU/PU/TU/block/Video coding unit
 - d. Coded modes of blocks containing the samples along the edges
 - e. Transform matrices applied to the blocks containing the samples along the edges
 - f. Block dimension of current block and/or its neighboring blocks
 - g. Block shape of current block and/or its neighboring blocks
 - h. Indication of the color format (such as 4:2:0, 4:4:4, RGB or YUV)
 - i. Coding tree structure (such as dual tree or single tree)
 - j. Slice/tile group type and/or picture type
 - k. Color component (e.g. may be only applied on Cb or Cr)
 - l. Temporal layer ID
 - m. Profiles/Levels/Tiers of a standard
 - n. Alternatively, *beta* may be signalled to the decoder.

General

15. The above proposed methods may be applied under certain conditions.
 - a. In one example, the condition is the colour format is 4:2:0 and/or 4:2:2.
 - i. Alternatively, furthermore, for 4:4:4 colour format, how to apply deblocking filter to the two colour chroma components may follow the current design.

- b. In one example, indication of usage of the above methods may be signalled in sequence/picture/slice/tile/brick/a video region-level, such as SPS/PPS/picture header/slice header.
- c. In one example, the usage of above methods may depend on
 - ii. Video contents (e.g. screen contents or natural contents)
 - iii. A message signaled in the DPS/SPS/VPS/PPS/APS/picture header/slice header/tile group header/ Largest coding unit (LCU)/Coding unit (CU)/LCU row/group of LCUs/TU/PU block/Video coding unit
 - iv. Position of CU/PU/TU/block/Video coding unit
 - v. Coded modes of blocks containing the samples along the edges
 - vi. Transform matrices applied to the blocks containing the samples along the edges
 - vii. Block dimension of current block and/or its neighboring blocks
 - viii. Block shape of current block and/or its neighboring blocks
 - ix. Indication of the color format (such as 4:2:0, 4:4:4, RGB or YUV)
 - x. Coding tree structure (such as dual tree or single tree)
 - xi. Slice/tile group type and/or picture type
 - xii. Color component (e.g. may be only applied on Cb or Cr)
 - xiii. Temporal layer ID
 - xiv. Profiles/Levels/Tiers of a standard
 - xv. Alternatively, m and/or n may be signalled to the decoder.

5. Additional Embodiments

[0122] The newly added texts are shown in underlined bold italicized font. The deleted texts are marked by []].

[0123] 5.1. Embodiment #1 on chroma QP in deblocking

8.8.3.6 Edge filtering process for one direction

...

- Otherwise (cIdx is not equal to 0), the filtering process for edges in the chroma coding block of current coding unit specified by cIdx consists of the following ordered steps:

1. The variable cQpPicOffset is derived as follows:

$$cQpPicOffset = cIdx == 1 ? pps_cb_qp_offset : pps_cr_qp_offset \quad (8-1065)$$

8.8.3.6.3 Decision process for chroma block edges

...

The variables Q_{pQ} and Q_{pP} are set equal to the Q_{pY} values of the coding units which include the coding blocks containing the sample $q_{0,0}$ and $p_{0,0}$, respectively.

The variable Q_{pC} is derived as follows:

$$[[q_{Pi} = \text{Clip3}(0, 63, ((Q_{pQ} + Q_{pP} + 1) \gg 1) + cQpPicOffset) \quad (8-1132)$$

$$Q_{pC} = \text{ChromaQpTable}[cIdx - 1][[q_{Pi}]](8-1133)]$$

$$q_{Pi} = (Q_{pQ} + Q_{pP} + 1) \gg 1 \quad (8-1132)$$

$$Q_{pC} = \text{ChromaQpTable}[cIdx - 1][[q_{Pi}]] + cQpPicOffset \quad (8-1133)$$

NOTE – The variable $cQpPicOffset$ provides an adjustment for the value of $pps_cb_qp_offset$ or $pps_cr_qp_offset$, according to whether the filtered chroma component is the Cb or Cr component. However, to avoid the need to vary the amount of the adjustment within the picture, the filtering process does not include an adjustment for the value of $slice_cb_qp_offset$ or $slice_cr_qp_offset$ nor (when $cu_chroma_qp_offset_enabled_flag$ is equal to 1) for the value of $CuQpOffset_{Cb}$, $CuQpOffset_{Cr}$, or $CuQpOffset_{CbCr}$.

The value of the variable β' is determined as specified in Table 8-18 based on the quantization parameter Q derived as follows:

$$Q = \text{Clip3}(0, 63, Q_{pC} + (\text{slice_beta_offset_div2} \ll 1)) \quad (8-1134)$$

where $\text{slice_beta_offset_div2}$ is the value of the syntax element $\text{slice_beta_offset_div2}$ for the slice that contains sample $q_{0,0}$.

The variable β is derived as follows:

$$\beta = \beta' * (1 \ll (\text{BitDepth}_C - 8)) \quad (8-1135)$$

The value of the variable t_c' is determined as specified in Table 8-18 based on the chroma quantization parameter Q derived as follows:

$$Q = \text{Clip3}(0, 65, Q_{pC} + 2 * (bS - 1) + (\text{slice_tc_offset_div2} \ll 1)) \quad (8-1136)$$

where $\text{slice_tc_offset_div2}$ is the value of the syntax element $\text{slice_tc_offset_div2}$ for the slice that contains sample $q_{0,0}$.

The variable t_c is derived as follows:

$$t_c = (\text{BitDepth}_C < 10) ? (t_c' + 2) \gg (10 - \text{BitDepth}_C) : t_c' * (1 \ll (\text{BitDepth}_C - 8)) \quad (8-1137)$$

[0124] 5.2. Embodiment #2 on boundary strength derivation

8.8.3.5 Derivation process of boundary filtering strength

Inputs to this process are:

- a picture sample array recPicture ,
- a location (x_{Cb}, y_{Cb}) specifying the top-left sample of the current coding block relative to the top-left sample of the current picture,
- a variable n_{CbW} specifying the width of the current coding block,

- a variable nCbH specifying the height of the current coding block,
- a variable edgeType specifying whether a vertical (EDGE_VER) or a horizontal (EDGE_HOR) edge is filtered,
- a variable cIdx specifying the colour component of the current coding block,
- a two-dimensional (nCbW)x(nCbH) array edgeFlags.

Output of this process is a two-dimensional (nCbW)x(nCbH) array bS specifying the boundary filtering strength.

...

For x_{D_i} with $i = 0..xN$ and y_{D_j} with $j = 0..yN$, the following applies:

- If edgeFlags[x_{D_i}][y_{D_j}] is equal to 0, the variable bS[x_{D_i}][y_{D_j}] is set equal to 0.
- Otherwise, the following applies:
 - ...
 - The variable bS[x_{D_i}][y_{D_j}] is derived as follows:
 - If cIdx is equal to 0 and both samples p_0 and q_0 are in a coding block with intra_bdpcm_flag equal to 1, bS[x_{D_i}][y_{D_j}] is set equal to 0.
 - Otherwise, if the sample p_0 or q_0 is in the coding block of a coding unit coded with intra prediction mode, bS[x_{D_i}][y_{D_j}] is set equal to 2.
 - Otherwise, if the block edge is also a transform block edge and the sample p_0 or q_0 is in a coding block with ciip_flag equal to 1, bS[x_{D_i}][y_{D_j}] is set equal to 2.
 - Otherwise, if the block edge is also a transform block edge and the sample p_0 or q_0 is in a transform block which contains one or more non-zero transform coefficient levels, bS[x_{D_i}][y_{D_j}] is set equal to 1.
 - Otherwise, if the block edge is also a transform block edge, cIdx is greater than 0, and the sample p_0 or q_0 is in a transform unit with tu_joint_cbr_residual_flag equal to 1, bS[x_{D_i}][y_{D_j}] is set equal to 1.
 - Otherwise, if the prediction mode of the coding subblock containing the sample p_0 is different from the prediction mode of the coding subblock containing the sample q_0 (i.e. one of the coding subblock is coded in IBC prediction mode and the other is coded in inter prediction mode), bS[x_{D_i}][y_{D_j}] is set equal to 1.
 - Otherwise, if cIdx is equal to 0 and one or more of the following conditions are true, bS[x_{D_i}][y_{D_j}] is set equal to 1:
 - The absolute difference between the horizontal or vertical component of list 0 motion vectors used in the prediction of the two coding subblocks is greater than or equal to 8 in 1/16 luma samples, or the absolute difference between the horizontal or vertical component of the list 1 motion vectors used in the prediction of the two coding subblocks is greater than or equal to 8 in units of 1/16 luma samples.
 - [[The coding subblock containing the sample p_0 and the coding subblock containing the sample q_0 are both coded in IBC prediction mode, and the absolute difference between the horizontal

or vertical component of the block vectors used in the prediction of the two coding subblocks is greater than or equal to 8 in units of 1/16 luma samples.

- For the prediction of the coding subblock containing the sample p_0 different reference pictures or a different number of motion vectors are used than for the prediction of the coding subblock containing the sample q_0 .

NOTE 1 – The determination of whether the reference pictures used for the two coding subblocks are the same or different is based only on which pictures are referenced, without regard to whether a prediction is formed using an index into reference picture list 0 or an index into reference picture list 1, and also without regard to whether the index position within a reference picture list is different.

NOTE 2 – The number of motion vectors that are used for the prediction of a coding subblock with top-left sample covering (x_{Sb} , y_{Sb}), is equal to $\text{PredFlagL0}[x_{Sb}][y_{Sb}] + \text{PredFlagL1}[x_{Sb}][y_{Sb}]$.

- One motion vector is used to predict the coding subblock containing the sample p_0 and one motion vector is used to predict the coding subblock containing the sample q_0 , and the absolute difference between the horizontal or vertical component of the motion vectors used is greater than or equal to 8 in units of 1/16 luma samples.
- Two motion vectors and two different reference pictures are used to predict the coding subblock containing the sample p_0 , two motion vectors for the same two reference pictures are used to predict the coding subblock containing the sample q_0 and the absolute difference between the horizontal or vertical component of the two motion vectors used in the prediction of the two coding subblocks for the same reference picture is greater than or equal to 8 in units of 1/16 luma samples.
- Two motion vectors for the same reference picture are used to predict the coding subblock containing the sample p_0 , two motion vectors for the same reference picture are used to predict the coding subblock containing the sample q_0 and both of the following conditions are true:
 - The absolute difference between the horizontal or vertical component of list 0 motion vectors used in the prediction of the two coding subblocks is greater than or equal to 8 in 1/16 luma samples, or the absolute difference between the horizontal or vertical component of the list 1 motion vectors used in the prediction of the two coding subblocks is greater than or equal to 8 in units of 1/16 luma samples.
 - The absolute difference between the horizontal or vertical component of list 0 motion vector used in the prediction of the coding subblock containing the sample p_0 and the list 1 motion vector used in the prediction of the coding subblock containing the sample q_0 is greater than or equal to 8 in units of 1/16 luma samples, or the absolute difference between the horizontal or vertical component of the list 1 motion vector used in the prediction of

the coding subblock containing the sample p_0 and list 0 motion vector used in the prediction of the coding subblock containing the sample q_0 is greater than or equal to 8 in units of 1/16 luma samples.]]

- Otherwise, the variable $bS[xD_i][yD_j]$ is set equal to 0.

[0125] 5.3. Embodiment #3 on boundary strength derivation

8.8.3.5 Derivation process of boundary filtering strength

Inputs to this process are:

- a picture sample array `recPicture`,
- a location (`xCb`, `yCb`) specifying the top-left sample of the current coding block relative to the top-left sample of the current picture,
- a variable `nCbW` specifying the width of the current coding block,
- a variable `nCbH` specifying the height of the current coding block,
- a variable `edgeType` specifying whether a vertical (`EDGE_VER`) or a horizontal (`EDGE_HOR`) edge is filtered,
- a variable `cIdx` specifying the colour component of the current coding block,
- a two-dimensional (`nCbW`)x(`nCbH`) array `edgeFlags`.

Output of this process is a two-dimensional (`nCbW`)x(`nCbH`) array `bS` specifying the boundary filtering strength.

...

For xD_i with $i = 0..xN$ and yD_j with $j = 0..yN$, the following applies:

- If `edgeFlags[xD_i][yD_j]` is equal to 0, the variable $bS[xD_i][yD_j]$ is set equal to 0.
- Otherwise, the following applies:
 - ...
 - The variable $bS[xD_i][yD_j]$ is derived as follows:
 - If `cIdx` is equal to 0 and both samples p_0 and q_0 are in a coding block with `intra_bdpcm_flag` equal to 1, $bS[xD_i][yD_j]$ is set equal to 0.
 - Otherwise, if the sample p_0 or q_0 is in the coding block of a coding unit coded with intra prediction mode, $bS[xD_i][yD_j]$ is set equal to 2.
 - Otherwise, if the block edge is also a transform block edge and the sample p_0 or q_0 is in a coding block with `ciip_flag` equal to 1, $bS[xD_i][yD_j]$ is set equal to 2.
 - Otherwise, if the block edge is also a transform block edge and the sample p_0 or q_0 is in a transform block which contains one or more non-zero transform coefficient levels, $bS[xD_i][yD_j]$ is set equal to 1.
 - [[Otherwise, if the block edge is also a transform block edge, `cIdx` is greater than 0, and the sample p_0 or q_0 is in a transform unit with `tu_joint_cbr_residual_flag` equal to 1, $bS[xD_i][yD_j]$ is set equal to 1.]]
 - Otherwise, if the prediction mode of the coding subblock containing the sample p_0 is different from the prediction mode of the coding subblock containing the sample q_0 (i.e. one of the coding

subblock is coded in IBC prediction mode and the other is coded in inter prediction mode),

$bS[xD_i][yD_j]$ is set equal to 1:

- Otherwise, if $cIdx$ is equal to 0 and one or more of the following conditions are true, $bS[xD_i][yD_j]$ is set equal to 1:

- The coding subblock containing the sample p_0 and the coding subblock containing the sample q_0 are both coded in IBC prediction mode, and the absolute difference between the horizontal or vertical component of the block vectors used in the prediction of the two coding subblocks is greater than or equal to 8 in units of 1/16 luma samples.
- For the prediction of the coding subblock containing the sample p_0 different reference pictures or a different number of motion vectors are used than for the prediction of the coding subblock containing the sample q_0 .

NOTE 1 – The determination of whether the reference pictures used for the two coding subblocks are the same or different is based only on which pictures are referenced, without regard to whether a prediction is formed using an index into reference picture list 0 or an index into reference picture list 1, and also without regard to whether the index position within a reference picture list is different.

NOTE 2 – The number of motion vectors that are used for the prediction of a coding subblock with top-left sample covering (xSb, ySb), is equal to $PredFlagL0[xSb][ySb] + PredFlagL1[xSb][ySb]$.

- One motion vector is used to predict the coding subblock containing the sample p_0 and one motion vector is used to predict the coding subblock containing the sample q_0 , and the absolute difference between the horizontal or vertical component of the motion vectors used is greater than or equal to 8 in units of 1/16 luma samples.
- Two motion vectors and two different reference pictures are used to predict the coding subblock containing the sample p_0 , two motion vectors for the same two reference pictures are used to predict the coding subblock containing the sample q_0 and the absolute difference between the horizontal or vertical component of the two motion vectors used in the prediction of the two coding subblocks for the same reference picture is greater than or equal to 8 in units of 1/16 luma samples.
- Two motion vectors for the same reference picture are used to predict the coding subblock containing the sample p_0 , two motion vectors for the same reference picture are used to predict the coding subblock containing the sample q_0 and both of the following conditions are true:
 - The absolute difference between the horizontal or vertical component of list 0 motion vectors used in the prediction of the two coding subblocks is greater than or equal to 8 in 1/16 luma samples, or the absolute difference between the horizontal or vertical

component of the list 1 motion vectors used in the prediction of the two coding subblocks is greater than or equal to 8 in units of 1/16 luma samples.

- The absolute difference between the horizontal or vertical component of list 0 motion vector used in the prediction of the coding subblock containing the sample p_0 and the list 1 motion vector used in the prediction of the coding subblock containing the sample q_0 is greater than or equal to 8 in units of 1/16 luma samples, or the absolute difference between the horizontal or vertical component of the list 1 motion vector used in the prediction of the coding subblock containing the sample p_0 and list 0 motion vector used in the prediction of the coding subblock containing the sample q_0 is greater than or equal to 8 in units of 1/16 luma samples.
- Otherwise, the variable $bs[xD_i][yD_j]$ is set equal to 0.

[0126] 5.4. Embodiment #4 on luma deblocking filtering process

8.8.3.6.1 Decision process for luma block edges

Inputs to this process are:

- a picture sample array $recPicture$,
- a location (xCb, yCb) specifying the top-left sample of the current coding block relative to the top-left sample of the current picture,
- a location (xBi, yBi) specifying the top-left sample of the current block relative to the top-left sample of the current coding block,
- a variable $edgeType$ specifying whether a vertical (EDGE_VER) or a horizontal (EDGE_HOR) edge is filtered,
- a variable bS specifying the boundary filtering strength,
- a variable $maxFilterLengthP$ specifying the max filter length,
- a variable $maxFilterLengthQ$ specifying the max filter length.

Outputs of this process are:

- the variables dE, dEp and dEq containing decisions,
- the modified filter length variables $maxFilterLengthP$ and $maxFilterLengthQ$,
- the variable tC .

...

The following ordered steps apply:

...

1. 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:

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

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

- Otherwise, the following applies:]]

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

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

$$[[maxFilterLengthP = 3 \quad (8-1091)]]$$

$$\underline{maxFilterLengthP = sidePisLargeBlk ? maxFilterLengthP : 3}$$

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

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

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

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

- Otherwise, the following applies:]]

$$dq0L = dq0 \quad (8-1094)$$

$$dq3L = dq3 \quad (8-1095)$$

$$\underline{maxFilterLengthO = sidePisLargeBlk ? maxFilterLengthO : 3}$$

...

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

...

[0127] 5.5. Embodiment #5 on chroma deblocking filtering process

8.8.3.6.3 Decision process for chroma block edges

This process is only invoked when ChromaArrayType is not equal to 0.

Inputs to this process are:

- a chroma picture sample array recPicture,
- a chroma location (xCb, yCb) specifying the top-left sample of the current chroma coding block relative to the top-left chroma sample of the current picture,
- a chroma location (xBl, yBl) specifying the top-left sample of the current chroma block relative to the top-left sample of the current chroma coding block,
- a variable edgeType specifying whether a vertical (EDGE_VER) or a horizontal (EDGE_HOR) edge is filtered,
- a variable cIdx specifying the colour component index,
- a variable cQpPicOffset specifying the picture-level chroma quantization parameter offset,
- a variable bS specifying the boundary filtering strength,
- a variable maxFilterLengthCbCr.

Outputs of this process are

- the modified variable maxFilterLengthCbCr,
- the variable tC.

The variable maxK is derived as follows:

- If edgeType is equal to EDGE_VER, the following applies:

$$\text{maxK} = (\text{SubHeightC} = 1) ? 3 : 1 \quad (8-1124)$$

– Otherwise (edgeType is equal to EDGE_HOR), the following applies:

$$\text{maxK} = (\text{SubWidthC} = 1) ? 3 : 1 \quad (8-1125)$$

The values p_i and q_i with $i = 0.. \text{maxFilterLengthCbCr}$ and $k = 0.. \text{maxK}$ are derived as follows:

– If edgeType is equal to EDGE_VER, the following applies::

$$q_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} + i][\text{yCb} + \text{yBl} + k] \quad (8-1126)$$

$$p_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} - i - 1][\text{yCb} + \text{yBl} + k] \quad (8-1127)$$

$$\text{subSampleC} = \text{SubHeightC} \quad (8-1128)$$

– Otherwise (edgeType is equal to EDGE_HOR), the following applies:

$$q_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} + k][\text{yCb} + \text{yBl} + i] \quad (8-1129)$$

$$p_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} + k][\text{yCb} + \text{yBl} - i - 1] \quad (8-1130)$$

$$\text{subSampleC} = \text{SubWidthC} \quad (8-1131)$$

When ChromaArrayType is not equal to 0 and treeType is equal to SINGLE TREE or DUAL TREE CHROMA, the following applies:

– When treeType is equal to DUAL TREE CHROMA, the variable Op_Y is set equal to the luma quantization parameter Op_Y of the luma coding unit that covers the luma location $(\text{xCb} + \text{cbWidth} / 2, \text{yCb} + \text{cbHeight} / 2)$.

– The variables qP_{Cb} , qP_{Cr} and qP_{CbCr} are derived as follows:

$$qP_{iChroma} = \text{Clip3}(-OpBdOffset_C, 63, Op_Y) \quad (8-935)$$

$$qP_{iCb} = \text{ChromaOpTable}[0][qP_{iChroma}] \quad (8-936)$$

$$qP_{iCr} = \text{ChromaOpTable}[1][qP_{iChroma}] \quad (8-937)$$

$$qP_{iCbCr} = \text{ChromaOpTable}[2][qP_{iChroma}] \quad (8-938)$$

– The chroma quantization parameters for the Cb and Cr components, Op'_{Cb} and Op'_{Cr} , and joint Cb-Cr coding Op'_{CbCr} are derived as follows:

$$Op'_{Cb} = \text{Clip3}(-OpBdOffset_C, 63, qP_{Cb} + pps_cb_qp_offset + slice_cb_qp_offset + CuOpOffset_{Cb}) \quad (8-939)$$

$$Op'_{Cr} = \text{Clip3}(-OpBdOffset_C, 63, qP_{Cr} + pps_cr_qp_offset + slice_cr_qp_offset + CuOpOffset_{Cr}) \quad (8-940)$$

$$Op'_{CbCr} = \text{Clip3}(-OpBdOffset_C, 63, qP_{CbCr} + pps_cbcr_qp_offset + slice_cbcr_qp_offset + CuOpOffset_{CbCr}) \quad (8-941)$$

The variables Op_O and Op_P are set equal to the corresponding Op'_{Cb} or Op'_{Cr} or Op'_{CbCr} values of the coding units which include the coding blocks containing the sample $q_{0,0}$ and $p_{0,0}$, respectively.

The variable Op_C is derived as follows:

$$Op_C = (Op_O + Op_P + 1) >> 1 \quad (8-1133)$$

The value of the variable β' is determined as specified in Table t-18 based on the quantization parameter Q derived as follows:

$$Q = \text{Clip3}(0, 63, Op_C + (slice_beta_offset_div2 << 1)) \quad (8-1134)$$

where slice_beta_offset_div2 is the value of the syntax element slice_beta_offset_div2 for the slice that contains sample $q_{0,0}$.

The variable β is derived as follows:

$$\beta = \beta' * (1 \ll (\text{BitDepth}_C - 8)) \quad (8-1135)$$

The value of the variable t_c' is determined as specified in Table 8-18 based on the chroma quantization parameter Q derived as follows:

$$Q = \text{Clip3}(0, 65, Q_{pC} + 2 * (bS - 1) + (\text{slice_tc_offset_div2} \ll 1)) \quad (8-1136)$$

where slice_tc_offset_div2 is the value of the syntax element slice_tc_offset_div2 for the slice that contains sample $q_{0,0}$.

The variable t_c is derived as follows:

$$t_c = (\text{BitDepth}_C < 10) ? (t_c' + 2) \gg (10 - \text{BitDepth}_C) : t_c' * (1 \ll (\text{BitDepth}_C - 8)) \quad (8-1137)$$

When maxFilterLengthCbCr is equal to 1 and bS is not equal to 2, maxFilterLengthCbCr is set equal to 0.

5.6. Embodiment #6 on chroma QP in deblocking

8.8.3.6.3 Decision process for chroma block edges

This process is only invoked when ChromaArrayType is not equal to 0.

Inputs to this process are:

- a chroma picture sample array recPicture,
- a chroma location (xCb, yCb) specifying the top-left sample of the current chroma coding block relative to the top-left chroma sample of the current picture,
- a chroma location (xBl, yBl) specifying the top-left sample of the current chroma block relative to the top-left sample of the current chroma coding block,
- a variable edgeType specifying whether a vertical (EDGE_VER) or a horizontal (EDGE_HOR) edge is filtered,
- a variable cIdx specifying the colour component index,
- a variable cQpPicOffset specifying the picture-level chroma quantization parameter offset,
- a variable bS specifying the boundary filtering strength,
- a variable maxFilterLengthCbCr.

Outputs of this process are

- the modified variable maxFilterLengthCbCr,
- the variable t_c .

The variable maxK is derived as follows:

- If edgeType is equal to EDGE_VER, the following applies:

$$\text{maxK} = (\text{SubHeightC} == 1) ? 3 : 1 \quad (8-1124)$$

- Otherwise (edgeType is equal to EDGE_HOR), the following applies:

$$\text{maxK} = (\text{SubWidthC} == 1) ? 3 : 1 \quad (8-1125)$$

The values p_i and q_i with $i = 0.. \text{maxFilterLengthCbCr}$ and $k = 0.. \text{maxK}$ are derived as follows:

- If edgeType is equal to EDGE_VER, the following applies::

$$q_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} + i][\text{yCb} + \text{yBl} + k] \quad (8-1126)$$

$$p_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} - i - 1][\text{yCb} + \text{yBl} + k] \quad (8-1127)$$

$$\text{subSampleC} = \text{SubHeightC} \quad (8-1128)$$

– Otherwise (edgeType is equal to EDGE_HOR), the following applies:

$$q_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} + k][\text{yCb} + \text{yBl} + i] \quad (8-1129)$$

$$p_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} + k][\text{yCb} + \text{yBl} - i - 1] \quad (8-1130)$$

$$\text{subSampleC} = \text{SubWidthC} \quad (8-1131)$$

The variables Q_{pQ} and Q_{pP} are set equal to the Q_{pY} values of the coding units which include the coding blocks containing the sample $q_{0,0}$ and $p_{0,0}$, respectively.

The variables j_{cCr} flag and j_{cCr} flag₀ are set equal to the tu joint cbr residual flag values of the coding units which include the coding blocks containing the sample $q_{0,0}$ and $p_{0,0}$, respectively.

The variable Q_{pC} is derived as follows:

$$[[q_{Pi} = \text{Clip3}(0, 63, ((Q_{pQ} + Q_{pP} + 1) \gg 1) + c_{QpPicOffset})] \quad (8-1132)]$$

$$\underline{q_{Pi} = \text{Clip3}(0, 63, ((Q_{pQ} + (j_{cCr} \text{ flag} ? \text{pps joint cbr qp offset} : c_{OpPicOffset}) + Q_{pP} + (j_{cCr} \text{ flag}_0 ? \text{pps joint cbr qp offset} : c_{OpPicOffset}) + 1) \gg 1))}$$

$$Q_{pC} = \text{ChromaQpTable}[\text{cIdx} - 1][q_{Pi}] \quad (8-1133)$$

NOTE – The variable $c_{QpPicOffset}$ provides an adjustment for the value of pps_cb_qp_offset or pps_cr_qp_offset , according to whether the filtered chroma component is the Cb or Cr component. However, to avoid the need to vary the amount of the adjustment within the picture, the filtering process does not include an adjustment for the value of $\text{slice_cb_qp_offset}$ or $\text{slice_cr_qp_offset}$ nor (when $\text{cu_chroma_qp_offset_enabled_flag}$ is equal to 1) for the value of CuQpOffset_{Cb} , CuQpOffset_{Cr} , or CuQpOffset_{CbCr} .

...

5.7. Embodiment #7 on chroma QP in deblocking

8.8.3.6.3 Decision process for chroma block edges

This process is only invoked when ChromaArrayType is not equal to 0.

Inputs to this process are:

- a chroma picture sample array recPicture ,
- a chroma location (xCb , yCb) specifying the top-left sample of the current chroma coding block relative to the top-left chroma sample of the current picture,
- ...

Outputs of this process are

- the modified variable $\text{maxFilterLength}_{CbCr}$,
- the variable t_c .

The variable maxK is derived as follows:

- If edgeType is equal to EDGE_VER , the following applies:

$$\text{maxK} = (\text{SubHeightC} = 1) ? 3 : 1 \quad (8-1124)$$

- Otherwise (edgeType is equal to EDGE_HOR), the following applies:

$$\text{maxK} = (\text{SubWidthC} = 1) ? 3 : 1 \quad (8-1125)$$

The values p_i and q_i with $i = 0.. \text{maxFilterLengthCbCr}$ and $k = 0.. \text{maxK}$ are derived as follows:

- If edgeType is equal to EDGE_VER, the following applies::

$$q_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} + i][\text{yCb} + \text{yBl} + k] \quad (8-1126)$$

$$p_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} - i - 1][\text{yCb} + \text{yBl} + k] \quad (8-1127)$$

$$\text{subSampleC} = \text{SubHeightC} \quad (8-1128)$$

- Otherwise (edgeType is equal to EDGE_HOR), the following applies:

$$q_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} + k][\text{yCb} + \text{yBl} + i] \quad (8-1129)$$

$$p_{i,k} = \text{recPicture}[\text{xCb} + \text{xBl} + k][\text{yCb} + \text{yBl} - i - 1] \quad (8-1130)$$

$$\text{subSampleC} = \text{SubWidthC} \quad (8-1131)$$

[[The variables Q_{pQ} and Q_{pP} are set equal to the Q_{pY} values of the coding units which include the coding blocks containing the sample $q_{0,0}$ and $p_{0,0}$, respectively.]]

The variables Op_0 is set equal to the luma quantization parameter Op_Y of the luma coding unit that covers the luma location $(\text{xCb} + \text{cbWidth} / 2, \text{yCb} + \text{cbHeight} / 2)$ wherein cbWidth specifies the width of the current chroma coding block in luma samples, and cbHeight specifies the height of the current chroma coding block in luma samples.

The variables Op_P is set equal to the luma quantization parameter Op_Y of the luma coding unit that covers the luma location $(\text{xCb}' + \text{cbWidth}' / 2, \text{yCb}' + \text{cbHeight}' / 2)$ wherein $(\text{xCb}', \text{yCb}')$ the top-left sample of the chroma coding block covering $q_{0,0}$ relative to the top-left chroma sample of the current picture, $\text{cbWidth}'$ specifies the width of the current chroma coding block in luma samples, and $\text{cbHeight}'$ specifies the height of the current chroma coding block in luma samples.

The variable Q_{pC} is derived as follows:

$$q_{p_i} = \text{Clip3}(0, 63, ((Q_{pQ} + Q_{pP} + 1) \gg 1) + cQpPicOffset) \quad (8-1132)$$

$$Q_{pC} = \text{ChromaQpTable}[\text{cIdx} - 1][q_{p_i}] \quad (8-1133)$$

NOTE – The variable $cQpPicOffset$ provides an adjustment for the value of pps_cb_qp_offset or pps_cr_qp_offset , according to whether the filtered chroma component is the Cb or Cr component. However, to avoid the need to vary the amount of the adjustment within the picture, the filtering process does not include an adjustment for the value of $\text{slice_cb_qp_offset}$ or $\text{slice_cr_qp_offset}$ nor (when $\text{cu_chroma_qp_offset_enabled_flag}$ is equal to 1) for the value of CuQpOffsetCb , CuQpOffsetCr , or CuQpOffsetCbCr .

The value of the variable β' is determined as specified in Table 8-18 based on the quantization parameter Q derived as follows:

$$Q = \text{Clip3}(0, 63, Q_{pC} + (\text{slice_beta_offset_div2} \ll 1)) \quad (8-1134)$$

where $\text{slice_beta_offset_div2}$ is the value of the syntax element $\text{slice_beta_offset_div2}$ for the slice that contains sample $q_{0,0}$.

The variable β is derived as follows:

$$\beta = \beta' * (1 \ll (\text{BitDepth}_C - 8)) \quad (8-1135)$$

The value of the variable tc' is determined as specified in Table 8-18 based on the chroma quantization parameter Q derived as follows:

$$Q = \text{Clip3}(0, 65, Q_{pc} + 2 * (bS - 1) + (\text{slice_tc_offset_div2} < 1)) \quad (8-1136)$$

where $\text{slice_tc_offset_div2}$ is the value of the syntax element $\text{slice_tc_offset_div2}$ for the slice that contains sample $q_{0,0}$.

5.8. Embodiment #8 on chroma QP in deblocking

When making filter decisions for the depicted three samples (with solid circles), the QPs of the luma CU that covers the center position of the chroma CU including the three samples is selected. Therefore, for the 1st, 2nd, and 3rd chroma sample (depicted in FIG. 11), only the QP of CU_{Y3} is utilized, respectively.

In this way, how to select luma CU for chroma quantization/dequantization process is aligned with that for chroma filter decision process.

5.9. Embodiment #9 on QP used for JCCR coded blocks

8.7.3 Scaling process for transform coefficients

Inputs to this process are:

- a luma location ($xTbY, yTbY$) specifying the top-left sample of the current luma transform block relative to the top-left luma sample of the current picture,
- a variable $nTbW$ specifying the transform block width,
- a variable $nTbH$ specifying the transform block height,
- a variable $cIdx$ specifying the colour component of the current block,
- a variable $bitDepth$ specifying the bit depth of the current colour component.

Output of this process is the $(nTbW) \times (nTbH)$ array d of scaled transform coefficients with elements $d[x][y]$.

The quantization parameter qP is derived as follows:

- If $cIdx$ is equal to 0 and $\text{transform_skip_flag}[xTbY][yTbY]$ is equal to 0, the following applies:

$$qP = Qp'_Y \quad (8-950)$$
- Otherwise, if $cIdx$ is equal to 0 (and $\text{transform_skip_flag}[xTbY][yTbY]$ is equal to 1), the following applies:

$$qP = \text{Max}(QpPrimeTsMin, Qp'_Y) \quad (8-951)$$
- Otherwise, if $\text{TuCRResMode}[xTbY][yTbY]$ is unequal to 0 [[equal to 2]], the following applies:

$$qP = Qp'_{CbCr} \quad (8-952)$$
- Otherwise, if $cIdx$ is equal to 1, the following applies:

$$qP = Qp'_{Cb} \quad (8-953)$$
- Otherwise ($cIdx$ is equal to 2), the following applies:

$$qP = Qp'_{Cr} \quad (8-954)$$

6. Example implementations of the disclosed technology

[0128] FIG. 12 is a block diagram of a video processing apparatus 1200. The apparatus 1200 may be used to implement one or more of the methods described herein. The apparatus 1200 may be embodied in a smartphone, tablet, computer, Internet of Things (IoT) receiver, and so on. The apparatus 1200 may include one or more processors 1202, one or more memories 1204 and video processing hardware 1206. The processor(s) 1202 may be configured to implement one or more methods described in the present document. The memory (memories) 1204 may be used for storing data and code used for implementing the methods and techniques described herein. The video processing hardware 1206 may be used to implement, in hardware circuitry, some techniques described in the present document, and may be partly or completely be a part of the processors 1202 (e.g., graphics processor core GPU or other signal processing circuitry).

[0129] In the present document, the term “video processing” may refer to video encoding, video decoding, video compression or video decompression. For example, video compression algorithms may be applied during conversion from pixel representation of a video to a corresponding bitstream representation or vice versa. The bitstream representation of a current video block may, for example, correspond to bits that are either co-located or spread in different places within the bitstream, as is defined by the syntax. For example, a macroblock may be encoded in terms of transformed and coded error residual values and also using bits in headers and other fields in the bitstream.

[0130] It will be appreciated that the disclosed methods and techniques will benefit video encoder and/or decoder embodiments incorporated within video processing devices such as smartphones, laptops, desktops, and similar devices by allowing the use of the techniques disclosed in the present document.

[0131] FIG. 13 is a flowchart for an example method 1300 of video processing. The method 1300 includes, at 1310, performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that when a chroma quantization parameter (QP) table is used to derive parameters of the deblocking filter, processing by the chroma QP table is performed on individual chroma QP values.

[0132] Some embodiments may be described using the following clause-based format.

[0133] 1. A method of video processing, comprising:

[0134] performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit

such that when a chroma quantization parameter (QP) table is used to derive parameters of the deblocking filter, processing by the chroma QP table is performed on individual chroma QP values.

[0135] 2. The method of clause 1, wherein chroma QP offsets are added to the individual chroma QP values subsequent to the processing by the chroma QP table.

[0136] 3. The method of any of clauses 1-2, wherein the chroma QP offsets are added to values outputted by the chroma QP table.

[0137] 4. The method of any of clauses 1-2, wherein the chroma QP offsets are not considered as input to the chroma QP table.

[0138] 5. The method of clause 2, wherein the chroma QP offsets are at a picture-level or at a video unit-level.

[0139] 6. A method of video processing, comprising:

[0140] performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that chroma QP offsets are used in the deblocking filter, wherein the chroma QP offsets are at picture/slice/tile/brick/subpicture level.

[0141] 7. The method of clause 6, wherein the chroma QP offsets used in the deblocking filter are associated with a coding method applied on a boundary of the video unit.

[0142] 8. The method of clause 7, wherein the coding method is a joint coding of chrominance residuals (JCCR) method.

[0143] 9. A method of video processing, comprising:

[0144] performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that chroma QP offsets are used in the deblocking filter, wherein information pertaining to a same luma coding unit is used in the deblocking filter and for deriving a chroma QP offset.

[0145] 10. The method of clause 9, wherein the same luma coding unit covers a corresponding luma sample of a center position of the video unit, wherein the video unit is a chroma coding unit.

[0146] 11. The method of clause 9, wherein a scaling process is applied to the video unit, and wherein one or more parameters of the deblocking filter depend at least in part on quantization/dequantization parameters of the scaling process.

[0147] 12. The method of clause 11, wherein the quantization/dequantization parameters of the scaling process include the chroma QP offset.

[0148] 13. The method of any of clauses 9-12, wherein the luma sample in the video unit is in the P side or Q side.

[0149] 14. The method of clause 13, wherein the information pertaining to the same luma coding unit depends on a relative position of the coding unit with respect to the same luma coding unit.

[0150] 15. A method of video processing, comprising:

[0151] performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that chroma QP offsets are used in the deblocking filter, wherein an indication of enabling usage of the chroma QP offsets is signaled in the bitstream representation.

[0152] 16. The method of clause 15, wherein the indication is signaled conditionally in response to detecting one or more flags.

[0153] 17. The method of clause 16, wherein the one or more flags are related to a JCCR enabling flag or a chroma QP offset enabling flag.

[0154] 18. The method of clause 15, wherein the indication is signaled based on a derivation.

[0155] 19. A method of video processing, comprising:

[0156] performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that chroma QP offsets are used in the deblocking filter, wherein the chroma QP offsets used in the deblocking filter are identical of whether JCCR coding method is applied on a boundary of the video unit or a method different from the JCCR coding method is applied on the boundary of the video unit.

[0157] 20. A method of video processing, comprising:

[0158] performing a conversion between a video unit and a bitstream representation of the video unit, wherein, during the conversion, a deblocking filter is used on boundaries of the video unit such that chroma QP offsets are used in the deblocking filter, wherein a boundary strength (BS) of the deblocking filter is calculated without comparing reference pictures and/or a number of motion

vectors (MVs) associated with the video unit at a P side boundary with reference pictures and/or a number of motion vectors (MVs) associated with the video unit at a Q side.

[0159] 21. The method of clause 20, wherein the deblocking filter is disabled under one or more conditions.

[0160] 22. The method of clause 21, wherein the one or more conditions are associated with: a magnitude of the motion vectors (MVs) or a threshold value.

[0161] 23. The method of clause 22, wherein the threshold value is associated with at least one of: i. contents of the video unit, ii. a message signaled in DPS/SPS/VPS/PPS/APS/picture header/slice header/tile group header/ Largest coding unit (LCU)/Coding unit (CU)/LCU row/group of LCUs/TU/PU block/Video coding unit, iii. a position of CU/PU/TU/block/Video coding unit, iv. a coded mode of blocks with samples along the boundaries, v. a transform matrix applied to the video units with samples along the boundaries, vi. a shape or dimension of the video unit, vii. an indication of a color format, viii. a coding tree structure, ix. a slice/tile group type and/or picture type, x. a color component, xi. a temporal layer ID, or xii. a profile/level/tier of a standard.

[0162] 24. The method of clause 20, wherein different QP offsets are used for TS coded video units and non-TS coded video units.

[0163] 25. The method of clause 20, wherein a QP used in a luma filtering step is related to a QP used in a scaling process of a luma block.

[0164] 26. A video decoding apparatus comprising a processor configured to implement a method recited in one or more of clauses 1 to 25.

[0165] 27. A video encoding apparatus comprising a processor configured to implement a method recited in one or more of clauses 1 to 25.

[0166] 28. A computer program product having computer code stored thereon, the code, when executed by a processor, causes the processor to implement a method recited in any of clauses 1 to 25.

[0167] 29. A method, apparatus or system described in the present document.

[0168] FIG. 14 is a block diagram showing an example video processing system 1400 in which various techniques disclosed herein may be implemented. Various implementations may include some or all of the components of the system 1400. The system 1400 may include input 1402 for receiving video content. The video content may be received in a raw or uncompressed format, e.g., 8

or 10 bit multi-component pixel values, or may be in a compressed or encoded format. The input 1902 may represent a network interface, a peripheral bus interface, or a storage interface. Examples of network interface include wired interfaces such as Ethernet, passive optical network (PON), etc. and wireless interfaces such as Wi-Fi or cellular interfaces.

[0169] The system 1400 may include a coding component 1404 that may implement the various coding or encoding methods described in the present document. The coding component 1404 may reduce the average bitrate of video from the input 1402 to the output of the coding component 1404 to produce a bitstream representation of the video. The coding techniques are therefore sometimes called video compression or video transcoding techniques. The output of the coding component 1404 may be either stored, or transmitted via a communication connected, as represented by the component 1406. The stored or communicated bitstream (or coded) representation of the video received at the input 1402 may be used by the component 1408 for generating pixel values or displayable video that is sent to a display interface 1410. The process of generating user-viewable video from the bitstream representation is sometimes called video decompression. Furthermore, while certain video processing operations are referred to as “coding” operations or tools, it will be appreciated that the coding tools or operations are used at an encoder and corresponding decoding tools or operations that reverse the results of the coding will be performed by a decoder.

[0170] Examples of a peripheral bus interface or a display interface may include universal serial bus (USB) or high definition multimedia interface (HDMI) or Displayport, and so on. Examples of storage interfaces include SATA (serial advanced technology attachment), PCI, IDE interface, and the like. The techniques described in the present document may be embodied in various electronic devices such as mobile phones, laptops, smartphones or other devices that are capable of performing digital data processing and/or video display.

[0171] FIG. 15 is a flowchart representation of a method 1500 of video processing in accordance with the present technology. The method 1500 includes, at operation 1510, performing a conversion between a block of a chroma component of a video and a bitstream representation of the video. During the conversion, a deblocking filtering process is applied to at least some samples along an edge of the block, and chroma quantization parameter (QP) offsets are added to outputs from a chroma QP table to determine parameters for the deblocking filter process.

[0172] In some embodiments, the chroma QP offsets are indicated by syntax elements at least at a picture-level or a video unit-level in the bitstream representation. In some embodiments, the video unit comprises a slice, a tile, a brick, a subpicture, or a block. In some embodiments, the chroma QP offsets comprise at least pps_cb_qp_offset and/or pps_cr_qp_offset. In some embodiments, a QP clipping process is disabled for an input of the chroma QP table. In some embodiments, the chroma component includes a Cr component of the video. In some embodiments, the chroma component includes a Cb component of the video.

[0173] FIG. 16 is a flowchart representation of a method 1600 of video processing in accordance with the present technology. The method 1600 includes, at operation 1610, determining, for a conversion between a block of a chroma component of a video and a bitstream representation of the video, whether or how to apply a filtering process to an edge of the block based on a first quantization information for a first video region comprising samples on one side of the edge and/or a second quantization information for a second video region comprising samples on the other side of the edge according to a rule. The rule is based on a coding mode applicable to the block for coding the samples on the one side or the samples on the other side of the edge. The rule specifies that multiple QP offsets at different video unit levels are used to determine the first quantization information or the second quantization information. The method 1600 also includes, at operation 1620, performing the conversion based on the determining.

[0174] In some embodiments, wherein the different video unit levels comprise at least a picture level, a slice level, a tile level, a brick level, or a subpicture level. In some embodiments, the multiple QP offsets comprises offsets for a Cb component of the video. In some embodiments, the multiple QP offsets comprises offsets for a Cr component of the video.

[0175] In some embodiments, the rule specifies that selection of the multiple QP offsets is based on the coding mode. In some embodiments, the coding mode comprises a joint coding of chroma residuals (JCCR) coding mode. In some embodiments, in case the block is coded in the JCCR coding mode, the multiple QP offsets comprise at least a picture level QP offset or a slice level QP offset. In some embodiments, the multiple QP offsets that are used to determine threshold values β and tC for the filtering process include a QP offset value for the JCCR coding mode in case at least one of the first video region or the second video region is coded using the JCCR coding mode.

[0176] In some embodiments, information of a corresponding block of a luma component is used to determine the first quantization information for the first video region or the second quantization information for the second video region. In some embodiments, for filtering a current chroma sample in the block of the chroma component, information of a luma coding unit that covers a luma sample corresponding to the current chroma sample is used to determine the first quantization information for the first video region or the second quantization information for the second video region.

[0177] In some embodiments, whether or how to apply the filtering process is based on a scaling process applicable to the block. In some embodiments, the first quantization information for the first video region or the second quantization information for the second video region used to determine threshold values β and tC is based on quantization information used in the scaling process. In some embodiments, one or more coding unit level QP offsets are used to determine the quantization information used in the scaling process.

[0178] In some embodiments, applicability of the method is based on whether the block is on the one side of the edge or the other side of the edge. In some embodiments, whether information of the corresponding block of the luma component is used for the filtering process is based on a position of the block. In some embodiments, in case the block is on the other side of the edge, the information of the corresponding block of the luma component is used for the filtering process. In some embodiments, in case the block is on the one side of the edge, the information of the corresponding block of the luma component is used for the filtering process.

[0179] FIG. 17 is a flowchart representation of a method 1700 of video processing in accordance with the present technology. The method 1700 includes, at operation 1710, determining, for a conversion between a current block of a video and a bitstream representation of the video, whether to enable usage of a chroma quantization parameter (QP) offset for the current block according to a syntax element at a level of a video unit. The video unit includes the current block and a second block of the video. The method 1700 also includes, at operation 1720, performing the conversion based on the determining.

[0180] In some embodiments, the video unit comprises a slice. In some embodiments, the video unit further comprises a tile, a brick, or a subpicture.

[0181] In some embodiments, the syntax element is conditionally included in the bitstream representation at the level of the video unit. In some embodiments, the syntax element is conditionally included in the bitstream representation based on whether a joint coding of chroma residuals mode is enabled. In some embodiments, the syntax element is included in the bitstream representation at the level of the video unit based on a second syntax element at a picture level that indicates the usage of the chroma quantization parameter (QP) offset at a block level. In some embodiments, the syntax element is omitted in the bitstream representation, and the usage of the chroma quantization parameter (QP) offset at a block level is determined to be disabled in case a second syntax element at a picture level indicates the usage of the chroma quantization parameter (QP) offset at a block level is disabled. In some embodiments, the usage of the chroma quantization parameter (QP) offset for the current block is determined based on both the syntax element at the slice level and the second syntax element at the picture level.

[0182] FIG. 18 is a flowchart representation of a method 1800 of video processing in accordance with the present technology. The method 1800 includes, at operation 1810, performing a conversion between a video comprising a first chroma component and a second chroma component and a bitstream representation of the video. Residuals of a first chroma block of the first chroma component and a second chroma block of the second chroma component are jointly coded in the bitstream representation using a coding mode according to a rule. The rule specifies that a manner of deriving a quantization parameter (QP) for the conversion is independent of the coding mode. In some embodiments, the QP for the conversion is derived based on a QP offset signaled at a picture level or a slice level in the bitstream representation.

[0183] FIG. 19 is a flowchart representation of a method 1900 of video processing in accordance with the present technology. The method 1900 includes, at operation 1910, performing a conversion between a first block of a video and a bitstream representation of the video. The video has a color format of multiple color components and the first block is associated with a first color component of the video. During the conversion, a deblocking filtering process is applied to at least some samples along an edge of the first block. The method 1900 includes, at operation 1920, performing subsequent conversions between blocks associated with remaining color components of the video and the bitstream representation of the video. During the subsequent conversions, the

deblocking filter process is applied to at least some samples along an edge of each of the blocks in a same manner as the conversion of the first block.

[0184] In some embodiments, the color format is 4:4:4. In some embodiments, the color format is 4:4:4 in Red-Green-Blue (RGB) color space. In some embodiments, the color format is 4:2:2, and the deblocking filter process is applied in a vertical direction. In some embodiments, the deblocking filter process comprises a decision process and/or a filtering process.

[0185] FIG. 20 is a flowchart representation of a method 2000 of video processing in accordance with the present technology. The method 2000 includes, at operation 2010, determining, for a conversion between a video and a bitstream representation of the video, a boundary strength of a boundary between two blocks of a video. The boundary strength is determined regardless of whether any one of the two blocks is coded in a joint coding of chroma residuals (JCCR) mode. The method 2000 includes, at operation 2020, performing the conversion based on the determining.

[0186] In some embodiments, in case a block of the two block is coded in the JCCR mode, the block is treated as coded in a non-JCCR mode for determining the boundary strength. In some embodiments, the boundary strength is determined independently from usage of the JCCR for the two blocks.

[0187] FIG. 21 is a flowchart representation of a method 2100 of video processing in accordance with the present technology. The method 2100 includes, at operation 2110, determining, for a conversion between a video and a bitstream representation of the video, a boundary strength of a boundary between a first block and a second block. The determining is performed without comparing information of the first block with corresponding information of the second block. The information comprises a reference picture and/or a number motion vectors of a corresponding block, and the boundary strength is used to determine whether a deblocking filtering process is applicable to the boundary. The method 2100 also includes, at operation 2120, performing the conversion based on the determining.

[0188] In some embodiments, the boundary strength indicates that the deblocking filtering process is disabled in case the reference picture of the first block is different than the reference picture of the second block. In some embodiments, the boundary strength indicates that the deblocking filtering process is disabled in case the number of motion vectors of the first block is different than the number of motion vectors of the second block.

[0189] In some embodiments, the boundary strength is set to 1 in case a difference between one or more motion vectors of the first block and one or more motion vectors of the second block is greater than or equal to a threshold, the threshold being an integer. In some embodiments, the one or more motion vectors of the first block are denoted as MVP[0] and MVP[1], and the one or more motion vectors of the second block are denoted as MVQ[0] and MVQ[1]. The difference is greater than or equal to the threshold Th in case $(\text{Abs}(\text{MVP}[0].x - \text{MVQ}[0].x) > \text{Th} \parallel \text{Abs}(\text{MVP}[0].y - \text{MVQ}[0].y) > \text{Th} \parallel \text{Abs}(\text{MVP}[1].x - \text{MVQ}[1].x) > \text{Th} \parallel \text{Abs}(\text{MVP}[1].y - \text{MVQ}[1].y) > \text{Th})$. In some embodiments, the difference is greater than or equal to the threshold Th in case $(\text{Abs}(\text{MVP}[0].x - \text{MVQ}[0].x) > \text{Th} \&\& \text{Abs}(\text{MVP}[0].y - \text{MVQ}[0].y) > \text{Th} \&\& \text{Abs}(\text{MVP}[1].x - \text{MVQ}[1].x) > \text{Th} \&\& \text{Abs}(\text{MVP}[1].y - \text{MVQ}[1].y) > \text{Th})$. In some embodiments, the difference is greater than or equal to the threshold Th in case $(\text{Abs}(\text{MVP}[0].x - \text{MVQ}[0].x) > \text{Th} \parallel \text{Abs}(\text{MVP}[0].y - \text{MVQ}[0].y) > \text{Th}) \&\& (\text{Abs}(\text{MVP}[1].x - \text{MVQ}[1].x) > \text{Th} \parallel \text{Abs}(\text{MVP}[1].y - \text{MVQ}[1].y) > \text{Th})$. In some embodiments, the difference is greater than or equal to the threshold Th in case $(\text{Abs}(\text{MVP}[0].x - \text{MVQ}[0].x) > \text{Th} \&\& \text{Abs}(\text{MVP}[0].y - \text{MVQ}[0].y) > \text{Th}) \parallel (\text{Abs}(\text{MVP}[1].x - \text{MVQ}[1].x) > \text{Th} \&\& \text{Abs}(\text{MVP}[1].y - \text{MVQ}[1].y) > \text{Th})$. In some embodiments, the boundary strength is set to 0 in case a difference between a motion vector of the first block and a motion vector of the second block is smaller than or equal to a threshold, the threshold being an integer. In some embodiments, the threshold is 4, 8, or 16. In some embodiments, the threshold is based on a characteristic of the video.

[0190] In some embodiments, applicability of the method is determined based on a condition. In some embodiments, the method is applicable in case the first block and the second block are not coded with an intra prediction mode. In some embodiments, the method is applicable in case the first block and the second block have zero coefficients for a luma component. In some embodiments, the method is applicable in case the first block and the second blocks are not coded with a combined inter and intra prediction mode. In some embodiments, the method is applicable in case the first block and the second block are coded with a same prediction mode, the same prediction mode being an intra block copy prediction mode or an inter prediction mode.

[0191] FIG. 22 is a flowchart representation of a method 2200 of video processing in accordance with the present technology. The method 2200 includes, at operation 2210, determining, for a conversion between a video block of a video and a bitstream representation of the video, a quantization parameter (QP) used for applying a deblocking filtering on the video block according to

a rule. The rule specifies that a first QP is used for the determining in case that the video block is coded using a transform skip (TS) mode in which a residue of the video block is coded in the bitstream representation by skipping application of a transform. A second QP that is different from the first QP is used for the determining in case that the video block is coded using a non-transform skip mode in which the residue of the video block is coded in the bitstream representation after applying the transform. The method 2200 also includes, at operation 2220, performing the conversion based on the determining.

[0192] In some embodiments, for a conversion of a luma block, a filtering process applicable to the luma block is based on a QP applied to a scaling process of the luma block. In some embodiments, the QP used to determine whether the filtering process is applicable to the luma block is determined based on a clipping range of the TS mode.

[0193] FIG. 23 is a flowchart representation of a method 2300 of video processing in accordance with the present technology. The method 2300 includes, at operation 2310, determining, for a conversion between a video block of a video and a bitstream representation of the video, a gradient for determining applicability of a deblocking filtering process to at least some samples of an edge of the video block according to a rule. The rule specifies that a manner in which the gradient is determined is independent of a size of the video block. The method 2300 also includes, at operation 2320, performing the conversion based on the determining.

[0194] In some embodiments, a threshold for determining whether the deblocking filtering process is enabled is adjusted for blocks having different boundary sizes, the threshold being an integer. In some embodiments, the threshold is based on a quantization parameter determined for the deblocking filtering process. In some embodiments, the threshold for the block that has a large boundary is smaller than a second threshold for a block that has a small boundary. In some embodiments, the threshold for the block that has a large boundary is greater than a second threshold for a block that has a small boundary. In some embodiments, the threshold for the block that has a large boundary is equal to a second threshold for a block that has a small boundary. In some embodiments, the threshold is based on a characteristic of the video.

[0195] In some embodiments, applicability of one or more of the above methods is based on a characteristic of the video. In some embodiments, the characteristic of the video comprises a content of the video. In some embodiments, the characteristic of the video comprises information signaled in

a decoder parameter set, a slice parameter set, a video parameter set, a picture parameter set, an adaptation parameter set, a picture header, a slice header, a tile group header, a largest coding unit (LCU), a coding unit, a LCU row, a group of LCUs, a transform unit, a picture unit, or a video coding unit in the bitstream representation. In some embodiments, the characteristic of the video comprises a position of a coding unit, a picture unit, a transform unit, a block, or a video coding unit within the video. In some embodiments, the characteristic of the video comprises a coding mode of a block that includes the at least some samples along the edge. In some embodiments, the characteristic of the video comprises a transform matrix that is applied to a block that includes the at least some samples along the edge. In some embodiments, the characteristic of a current block or neighboring blocks of the current block comprises a dimension of the current block or a dimension of the neighboring block of the current block. In some embodiments, the characteristic of a current block or neighboring blocks of the current block comprises a shape of the current block or a shape of the neighboring block of the current block. In some embodiments, the characteristic of the video comprises an indication of a color format of the video. In some embodiments, the characteristic of the video comprises a coding tree structure applicable to the video. In some embodiments, the characteristic of the video comprises a slice type, a tile group type, or a picture type of the video. In some embodiments, the characteristic of the video comprises a color component of the video. In some embodiments, the characteristic of the video comprises a temporal layer identifier of the video. In some embodiments, the characteristic of the video comprises a profile, a level, or a tier of a video standard.

[0196] In some embodiments, the conversion includes encoding the video into the bitstream representation. In some embodiments, the conversion includes decoding the bitstream representation into the video.

[0197] FIG. 24 is a block diagram that illustrates an example video coding system 100 that may utilize the techniques of this disclosure.

[0198] As shown in FIG. 24, video coding system 100 may include a source device 110 and a destination device 120. Source device 110 generates encoded video data which may be referred to as a video encoding device. Destination device 120 may decode the encoded video data generated by source device 110 which may be referred to as a video decoding device.

[0199] Source device 110 may include a video source 112, a video encoder 114, and an input/output (I/O) interface 116.

[0200] Video source 112 may include a source such as a video capture device, an interface to receive video data from a video content provider, and/or a computer graphics system for generating video data, or a combination of such sources. The video data may comprise one or more pictures. Video encoder 114 encodes the video data from video source 112 to generate a bitstream. The bitstream may include a sequence of bits that form a coded representation of the video data. The bitstream may include coded pictures and associated data. The coded picture is a coded representation of a picture. The associated data may include sequence parameter sets, picture parameter sets, and other syntax structures. I/O interface 116 may include a modulator/demodulator (modem) and/or a transmitter. The encoded video data may be transmitted directly to destination device 120 via I/O interface 116 through network 130a. The encoded video data may also be stored onto a storage medium/server 130b for access by destination device 120.

[0201] Destination device 120 may include an I/O interface 126, a video decoder 124, and a display device 122.

[0202] I/O interface 126 may include a receiver and/or a modem. I/O interface 126 may acquire encoded video data from the source device 110 or the storage medium/ server 130b. Video decoder 124 may decode the encoded video data. Display device 122 may display the decoded video data to a user. Display device 122 may be integrated with the destination device 120, or may be external to destination device 120 which be configured to interface with an external display device.

[0203] Video encoder 114 and video decoder 124 may operate according to a video compression standard, such as the High Efficiency Video Coding (HEVC) standard, Versatile Video Coding (VVC) standard and other current and/or further standards.

[0204] FIG. 25 is a block diagram illustrating an example of video encoder 200, which may be video encoder 114 in the system 100 illustrated in FIG. 24.

[0205] Video encoder 200 may be configured to perform any or all of the techniques of this disclosure. In the example of FIG. 25, video encoder 200 includes a plurality of functional components. The techniques described in this disclosure may be shared among the various components of video encoder 200. In some examples, a processor may be configured to perform any or all of the techniques described in this disclosure.

[0206] The functional components of video encoder 200 may include a partition unit 201, a predication unit 202 which may include a mode select unit 203, a motion estimation unit 204, a motion

compensation unit 205 and an intra prediction unit 206, a residual generation unit 207, a transform unit 208, a quantization unit 209, an inverse quantization unit 210, an inverse transform unit 211, a reconstruction unit 212, a buffer 213, and an entropy encoding unit 214.

[0207] In other examples, video encoder 200 may include more, fewer, or different functional components. In an example, predication unit 202 may include an intra block copy (IBC) unit. The IBC unit may perform predication in an IBC mode in which at least one reference picture is a picture where the current video block is located.

[0208] Furthermore, some components, such as motion estimation unit 204 and motion compensation unit 205 may be highly integrated, but are represented in the example of FIG. 5 separately for purposes of explanation.

[0209] Partition unit 201 may partition a picture into one or more video blocks. Video encoder 200 and video decoder 300 may support various video block sizes.

[0210] Mode select unit 203 may select one of the coding modes, intra or inter, e.g., based on error results, and provide the resulting intra- or inter-coded block to a residual generation unit 207 to generate residual block data and to a reconstruction unit 212 to reconstruct the encoded block for use as a reference picture. In some example, Mode select unit 203 may select a combination of intra and inter predication (CIIP) mode in which the predication is based on an inter predication signal and an intra predication signal. Mode select unit 203 may also select a resolution for a motion vector (e.g., a sub-pixel or integer pixel precision) for the block in the case of inter-predication.

[0211] To perform inter prediction on a current video block, motion estimation unit 204 may generate motion information for the current video block by comparing one or more reference frames from buffer 213 to the current video block. Motion compensation unit 205 may determine a predicted video block for the current video block based on the motion information and decoded samples of pictures from buffer 213 other than the picture associated with the current video block.

[0212] Motion estimation unit 204 and motion compensation unit 205 may perform different operations for a current video block, for example, depending on whether the current video block is in an I slice, a P slice, or a B slice.

[0213] In some examples, motion estimation unit 204 may perform uni-directional prediction for the current video block, and motion estimation unit 204 may search reference pictures of list 0 or list 1 for a reference video block for the current video block. Motion estimation unit 204 may then

generate a reference index that indicates the reference picture in list 0 or list 1 that contains the reference video block and a motion vector that indicates a spatial displacement between the current video block and the reference video block. Motion estimation unit 204 may output the reference index, a prediction direction indicator, and the motion vector as the motion information of the current video block. Motion compensation unit 205 may generate the predicted video block of the current block based on the reference video block indicated by the motion information of the current video block.

[0214] In other examples, motion estimation unit 204 may perform bi-directional prediction for the current video block, motion estimation unit 204 may search the reference pictures in list 0 for a reference video block for the current video block and may also search the reference pictures in list 1 for another reference video block for the current video block. Motion estimation unit 204 may then generate reference indexes that indicate the reference pictures in list 0 and list 1 containing the reference video blocks and motion vectors that indicate spatial displacements between the reference video blocks and the current video block. Motion estimation unit 204 may output the reference indexes and the motion vectors of the current video block as the motion information of the current video block. Motion compensation unit 205 may generate the predicted video block of the current video block based on the reference video blocks indicated by the motion information of the current video block.

[0215] In some examples, motion estimation unit 204 may output a full set of motion information for decoding processing of a decoder.

[0216] In some examples, motion estimation unit 204 may do not output a full set of motion information for the current video. Rather, motion estimation unit 204 may signal the motion information of the current video block with reference to the motion information of another video block. For example, motion estimation unit 204 may determine that the motion information of the current video block is sufficiently similar to the motion information of a neighboring video block.

[0217] In one example, motion estimation unit 204 may indicate, in a syntax structure associated with the current video block, a value that indicates to the video decoder 300 that the current video block has the same motion information as the another video block.

[0218] In another example, motion estimation unit 204 may identify, in a syntax structure associated with the current video block, another video block and a motion vector difference (MVD). The motion vector difference indicates a difference between the motion vector of the current video

block and the motion vector of the indicated video block. The video decoder 300 may use the motion vector of the indicated video block and the motion vector difference to determine the motion vector of the current video block.

[0219] As discussed above, video encoder 200 may predictively signal the motion vector. Two examples of predictive signaling techniques that may be implemented by video encoder 200 include advanced motion vector predication (AMVP) and merge mode signaling.

[0220] Intra prediction unit 206 may perform intra prediction on the current video block. When intra prediction unit 206 performs intra prediction on the current video block, intra prediction unit 206 may generate prediction data for the current video block based on decoded samples of other video blocks in the same picture. The prediction data for the current video block may include a predicted video block and various syntax elements.

[0221] Residual generation unit 207 may generate residual data for the current video block by subtracting (e.g., indicated by the minus sign) the predicted video block(s) of the current video block from the current video block. The residual data of the current video block may include residual video blocks that correspond to different sample components of the samples in the current video block.

[0222] In other examples, there may be no residual data for the current video block for the current video block, for example in a skip mode, and residual generation unit 207 may not perform the subtracting operation.

[0223] Transform processing unit 208 may generate one or more transform coefficient video blocks for the current video block by applying one or more transforms to a residual video block associated with the current video block.

[0224] After transform processing unit 208 generates a transform coefficient video block associated with the current video block, quantization unit 209 may quantize the transform coefficient video block associated with the current video block based on one or more quantization parameter (QP) values associated with the current video block.

[0225] Inverse quantization unit 210 and inverse transform unit 211 may apply inverse quantization and inverse transforms to the transform coefficient video block, respectively, to reconstruct a residual video block from the transform coefficient video block. Reconstruction unit 212 may add the reconstructed residual video block to corresponding samples from one or more

predicted video blocks generated by the predication unit 202 to produce a reconstructed video block associated with the current block for storage in the buffer 213.

[0226] After reconstruction unit 212 reconstructs the video block, loop filtering operation may be performed reduce video blocking artifacts in the video block.

[0227] Entropy encoding unit 214 may receive data from other functional components of the video encoder 200. When entropy encoding unit 214 receives the data, entropy encoding unit 214 may perform one or more entropy encoding operations to generate entropy encoded data and output a bitstream that includes the entropy encoded data.

[0228] FIG. 26 is a block diagram illustrating an example of video decoder 300 which may be video decoder 114 in the system 100 illustrated in FIG. 24.

[0229] The video decoder 300 may be configured to perform any or all of the techniques of this disclosure. In the example of FIG. 26, the video decoder 300 includes a plurality of functional components. The techniques described in this disclosure may be shared among the various components of the video decoder 300. In some examples, a processor may be configured to perform any or all of the techniques described in this disclosure.

[0230] In the example of FIG. 26, video decoder 300 includes an entropy decoding unit 301, a motion compensation unit 302, an intra prediction unit 303, an inverse quantization unit 304, an inverse transformation unit 305, and a reconstruction unit 306 and a buffer 307. Video decoder 300 may, in some examples, perform a decoding pass generally reciprocal to the encoding pass described with respect to video encoder 200 (e.g., FIG. 25).

[0231] Entropy decoding unit 301 may retrieve an encoded bitstream. The encoded bitstream may include entropy coded video data (e.g., encoded blocks of video data). Entropy decoding unit 301 may decode the entropy coded video data, and from the entropy decoded video data, motion compensation unit 302 may determine motion information including motion vectors, motion vector precision, reference picture list indexes, and other motion information. Motion compensation unit 302 may, for example, determine such information by performing the AMVP and merge mode.

[0232] Motion compensation unit 302 may produce motion compensated blocks, possibly performing interpolation based on interpolation filters. Identifiers for interpolation filters to be used with sub-pixel precision may be included in the syntax elements.

[0233] Motion compensation unit 302 may use interpolation filters as used by video encoder 20 during encoding of the video block to calculate interpolated values for sub-integer pixels of a reference block. Motion compensation unit 302 may determine the interpolation filters used by video encoder 200 according to received syntax information and use the interpolation filters to produce predictive blocks.

[0234] Motion compensation unit 302 may use some of the syntax information to determine sizes of blocks used to encode frame(s) and/or slice(s) of the encoded video sequence, partition information that describes how each macroblock of a picture of the encoded video sequence is partitioned, modes indicating how each partition is encoded, one or more reference frames (and reference frame lists) for each inter-encoded block, and other information to decode the encoded video sequence.

[0235] Intra prediction unit 303 may use intra prediction modes for example received in the bitstream to form a prediction block from spatially adjacent blocks. Inverse quantization unit 303 inverse quantizes, i.e., de-quantizes, the quantized video block coefficients provided in the bitstream and decoded by entropy decoding unit 301. Inverse transform unit 303 applies an inverse transform.

[0236] Reconstruction unit 306 may sum the residual blocks with the corresponding prediction blocks generated by motion compensation unit 202 or intra-prediction unit 303 to form decoded blocks. If desired, a deblocking filter may also be applied to filter the decoded blocks in order to remove blockiness artifacts. The decoded video blocks are then stored in buffer 307, which provides reference blocks for subsequent motion compensation/intra prediction and also produces decoded video for presentation on a display device.

[0237] Some embodiments of the disclosed technology include making a decision or determination to enable a video processing tool or mode. In an example, when the video processing tool or mode is enabled, the encoder will use or implement the tool or mode in the processing of a block of video, but may not necessarily modify the resulting bitstream based on the usage of the tool or mode. That is, a conversion from the block of video to the bitstream representation of the video will use the video processing tool or mode when it is enabled based on the decision or determination. In another example, when the video processing tool or mode is enabled, the decoder will process the bitstream with the knowledge that the bitstream has been modified based on the video processing tool or mode. That is, a conversion from the bitstream representation of the video to the block of video

will be performed using the video processing tool or mode that was enabled based on the decision or determination.

[0238] Some embodiments of the disclosed technology include making a decision or determination to disable a video processing tool or mode. In an example, when the video processing tool or mode is disabled, the encoder will not use the tool or mode in the conversion of the block of video to the bitstream representation of the video. In another example, when the video processing tool or mode is disabled, the decoder will process the bitstream with the knowledge that the bitstream has not been modified using the video processing tool or mode that was enabled based on the decision or determination.

[0239] The disclosed and other solutions, examples, embodiments, modules and the functional operations described in this document can be implemented in digital electronic circuitry, or in computer software, firmware, or hardware, including the structures disclosed in this document and their structural equivalents, or in combinations of one or more of them. The disclosed and other embodiments can be implemented as one or more computer program products, i.e., one or more modules of computer program instructions encoded on a computer readable medium for execution by, or to control the operation of, data processing apparatus. The computer readable medium can be a machine-readable storage device, a machine-readable storage substrate, a memory device, a composition of matter effecting a machine-readable propagated signal, or a combination of one or more them. The term “data processing apparatus” encompasses all apparatus, devices, and machines for processing data, including by way of example a programmable processor, a computer, or multiple processors or computers. The apparatus can include, in addition to hardware, code that creates an execution environment for the computer program in question, e.g., code that constitutes processor firmware, a protocol stack, a database management system, an operating system, or a combination of one or more of them. A propagated signal is an artificially generated signal, e.g., a machine-generated electrical, optical, or electromagnetic signal, that is generated to encode information for transmission to suitable receiver apparatus.

[0240] A computer program (also known as a program, software, software application, script, or code) can be written in any form of programming language, including compiled or interpreted languages, and it can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment. A computer

program does not necessarily correspond to a file in a file system. A program can be stored in a portion of a file that holds other programs or data (e.g., one or more scripts stored in a markup language document), in a single file dedicated to the program in question, or in multiple coordinated files (e.g., files that store one or more modules, sub programs, or portions of code). A computer program can be deployed to be executed on one computer or on multiple computers that are located at one site or distributed across multiple sites and interconnected by a communication network.

[0241] The processes and logic flows described in this document can be performed by one or more programmable processors executing one or more computer programs to perform functions by operating on input data and generating output. The processes and logic flows can also be performed by, and apparatus can also be implemented as, special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application specific integrated circuit).

[0242] Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and any one or more processors of any kind of digital computer. Generally, a processor will receive instructions and data from a read only memory or a random-access memory or both. The essential elements of a computer are a processor for performing instructions and one or more memory devices for storing instructions and data. Generally, a computer will also include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto optical disks, or optical disks. However, a computer need not have such devices. Computer readable media suitable for storing computer program instructions and data include all forms of non-volatile memory, media and memory devices, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto optical disks; and CD ROM and DVD-ROM disks. The processor and the memory can be supplemented by, or incorporated in, special purpose logic circuitry.

[0243] While this patent document contains many specifics, these should not be construed as limitations on the scope of any subject matter or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular techniques. Certain features that are described in this patent document in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately

or in any suitable subcombination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a subcombination or variation of a subcombination.

[0244] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. Moreover, the separation of various system components in the embodiments described in this patent document should not be understood as requiring such separation in all embodiments.

[0245] Only a few implementations and examples are described and other implementations, enhancements and variations can be made based on what is described and illustrated in this patent document.