

VIDEO ENCODER, VIDEO DECODER, AND CORRESPONDING ENCODING AND DECODING METHODS

[0001] .

TECHNICAL FIELD

5 [0002] Embodiments of the present disclosure are generally related to video data encoding and decoding techniques, and are especially related to techniques for intra prediction using a cross-component linear model (CCLM).

BACKGROUND

[0003] Digital video has been widely used since the introduction of digital versatile disc
10 (DVD). In addition to distributing video programs using DVDs, nowadays video programs can be transmitted using wired computer networks (such as Internet) or wireless communication networks. Before transmitting video data using a transmission medium, the video is encoded. A viewer receives the encoded video and uses a viewing device to decode and display the video. Over the years, the quality of the video has been improved because of higher resolutions, color
15 depths and frame rates, for example. The improved quality in transmitted video data has led into larger data streams, and larger data streams are nowadays commonly transported over the Internet and mobile communication networks.

[0004] Higher resolution videos typically require more bandwidth as they carry more information. In order to reduce bandwidth requirements, video coding schemes involving
20 compression of the video have been introduced. When the video is encoded, the bandwidth requirements (or corresponding memory requirements in case of storage) are reduced compared with unencoded video. Often this reduction comes at the cost of quality. Thus, efforts are made in trying to find a balance between bandwidth requirements and quality in the video coding standards.

25 [0005] As there is a continuous need for improving quality and reducing bandwidth requirements, solutions that maintain the quality with reduced bandwidth requirements, or improve the quality while maintaining the bandwidth requirements are continuously sought.

samples that are left to the luma block are reconstructed neighboring luma samples adjacent to the respective left boundary.

[0012] In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein the set of (down-sampled) reconstructed neighboring luma samples excludes luma samples that are above of a top-left neighbouring luma sample outside the luma block, and/or luma samples that are left of the top-left neighbouring luma sample outside the luma block.

[0013] In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein a coordinate of the top-left luma sample of the luma block is (x_0, y_0) , and wherein the set of (down-sampled) reconstructed neighboring luma samples excludes luma samples having an x-coordinate less than x_0 and a y-coordinate less than y_0 .

[0014] In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein when the N down-sampled reconstructed luma samples with the maximum value and/or the M down-sampled reconstructed luma samples with the minimum value are comprised in the set of down-sampled reconstructed neighboring luma samples, the step of determining two couples of luma value and chroma value, comprises:

determining (or selecting) two couples of luma value and chroma value based on chroma value difference between a chroma value of each of a first plurality of couples of luma value and chroma value and a chroma value of each of a second plurality of couples of luma value and chroma value, wherein said each of the first plurality of couples of luma value and chroma value comprises one of N down-sampled reconstructed luma samples with the maximum value and the corresponding reconstructed neighboring chroma sample, and said each of the second plurality of couples of luma value and chroma value comprises one of M down-sampled reconstructed luma samples with the minimum value and the corresponding reconstructed neighboring chroma sample.

[0015] In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein the smallest chroma value difference is between a chroma value of a first couple of luma value and chroma value and a chroma value of a second couple of luma value and chroma value, and the first couple of luma

reconstructed neighboring luma samples comprises down-sampled reconstructed neighboring luma samples with the luma value being larger than the threshold.

[0032] According to a third aspect the invention relates to a device for decoding video data, the device comprising:

- 5 a video data memory; and
- a video decoder, wherein the video decoder is configured for:
 - determining a luma block that corresponds to a chroma block;
 - determining a set of (down-sampled) reconstructed neighboring luma samples, wherein the set of (down-sampled) reconstructed neighboring luma samples comprise a plurality of
 - 10 (down-sampled) reconstructed luma samples that are above the luma block, and/or a plurality of (down-sampled) reconstructed luma samples that are left to the luma block;
 - determining two couples of luma value and chroma value according to N down-sampled reconstructed luma samples with the maximum value and N reconstructed chroma samples that correspond to the N down-sampled reconstructed luma samples with the maximum values,
 - 15 and/or M down-sampled reconstructed luma samples with the minimum value and M reconstructed chroma samples that correspond to the M down-sampled luma samples with the minimum value, when the N down-sampled reconstructed luma samples with the maximum value and/or the M down-sampled reconstructed luma samples with the minimum value are comprised in the set of down-sampled reconstructed neighboring luma samples, wherein M, N
 - 20 is a positive integer and larger than 1;
 - determining one or more linear model parameters based on the determined two couples of luma value and chroma value;
 - determining a predictive block based on the one or more linear model parameters; and
 - linear model (LM) prediction decoding the chroma block based on the predictive block.

25 **[0033]** In a possible implementation form of the device according to the third aspect as such, wherein the set of down-sampled reconstructed neighboring luma samples further comprises:

- a top-right neighbouring luma sample outside the luma block and luma samples that are right to the top-right neighbouring luma sample outside the luma block;
- a left-below neighbouring luma sample outside the luma block and luma samples that
- 30 are below of the left-below neighbouring luma sample outside the luma block.

[0038] In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the smallest chroma value difference between a chroma value of a first couple of luma value and chroma value and a chroma value of a second couple of luma value and chroma value, and the first couple of luma value and chroma value and the second couple of luma value and chroma value which have the smallest chroma value difference is chosen as said two couples of luma value and chroma value; or the largest chroma value difference between a chroma value of a third couple of luma value and chroma value and a chroma value of a fourth couple of luma value and chroma value, and the third couple of luma value and chroma value and the fourth couple of luma value and chroma value which have the largest chroma value difference is chosen as said two couples of luma value and chroma value. for example, the first couple of luma value and chroma value is included in the first plurality of couples of luma value and chroma value. for example, the second couple of luma value and chroma value is included in the second plurality of couples of luma value and chroma value. for example, the third couple of luma value and chroma value is included in the first plurality of couples of luma value and chroma value. for example, the fourth couple of luma value and chroma value is included in the second plurality of couples of luma value and chroma value.

[0039] In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein when the N down-sampled reconstructed luma samples with the maximum value and/or the M down-sampled reconstructed luma samples with the minimum value are comprised in the set of down-sampled reconstructed neighboring luma samples, to determine two couples of luma value and chroma value, the video decoder is configured for:

determining a fifth couple of luma value and chroma value and a sixth couple of luma value and chroma value as said two couples of luma value and chroma value,

wherein the corresponding chroma value of the fifth couple of luma value and chroma value is the mean chroma value of the N reconstructed chroma samples that correspond to N down-sampled reconstructed luma samples with the maximum value, and the corresponding chroma value of the sixth couple of luma value and chroma value is the mean chroma value of the M reconstructed chroma samples that correspond to M down-sampled reconstructed luma samples with the minimum value. The luma value of the fifth couple of luma value and chroma value is

the luma value of each of the N down-sampled reconstructed luma samples with the maximum value. The luma value of the sixth couple of luma value and chroma value is the luma value of each of the M down-sampled reconstructed luma samples with the minimum value.

[0040] In a possible implementation form of the method according to any preceding
5 implementation of the third aspect or the third aspect as such, wherein the set of down-sampled reconstructed neighboring luma samples comprise a first set of down-sampled reconstructed neighboring luma samples and a second set of down-sampled reconstructed neighboring luma samples, and wherein the first set of down-sampled reconstructed neighboring luma samples comprises down-sampled reconstructed neighboring luma samples with the luma value being
10 less than or equal to a threshold; and the second set of down-sampled reconstructed neighboring luma samples comprises down-sampled reconstructed neighboring luma samples with the luma value being larger than the threshold.

[0041] In a possible implementation form of the method according to any preceding
15 implementation of the third aspect or the third aspect as such, wherein to LM prediction decode the chroma block based on the predictive block, the video decoder is configured to add the predictive block to a residual block to reconstruct the chroma block.

[0042] In a possible implementation form of the method according to any preceding
implementation of the third aspect or the third aspect as such, wherein the video decoder is configured for:

20 decoding a flag for a current block that includes the luma block and the chroma block, wherein the flag indicates that LM prediction coding is enabled for the chroma block, and wherein decoding the flag comprises decoding the flag based on a context comprising one or more flags that indicate whether the LM prediction coding is enabled for neighboring blocks.

[0043] According to a fourth aspect the invention relates to a device for decoding video data,
25 the device comprising:

a video data memory, and a video decoder;

wherein the video decoder is configured for:

determining a luma block that corresponds to a chroma block;

determining a set of (down-sampled) reconstructed neighboring luma samples, wherein

30 the set of (down-sampled) reconstructed neighboring luma samples comprise a plurality of

[00124] Mode select unit 40 may select one of the coding modes, intra or inter, e.g., based on error results, and provides the resulting intra- or inter-coded block to an adder 50 to generate residual block data and to an adder 62 to reconstruct the encoded block for use as a reference frame. Mode select unit 40 also provides syntax elements, such as motion vectors, intra-mode indicators, partition information, and other such syntax information, to entropy coding unit 56.

[00125] Motion estimation unit 42 and motion compensation unit 44 may be highly integrated, but are illustrated separately for conceptual purposes. Motion estimation, performed by motion estimation unit 42, is the process of generating motion vectors, which estimate motion for video blocks. A motion vector, for example, may indicate the displacement of a PU of a video block within a current video frame (or a picture) relative to a predictive block within a reference frame (or other coded unit), or may indicate the displacement of a PU of a video block within a current video frame (or a picture) relative to a coded block within the current frame (or other coded unit). A predictive block is a block that is found to closely match the block to be coded, in terms of pixel difference, which may be determined by sum of absolute difference (SAD), sum of square difference (SSD), or other difference metrics. In some examples, video encoder 20 may calculate values for sub-integer pixel positions of reference pictures stored in reference frame memory 64. For example, video encoder 20 may interpolate values of one-quarter pixel positions, one-eighth pixel positions, or other fractional pixel positions of the reference picture. Therefore, motion estimation unit 42 may perform a motion search relative to the full pixel positions and fractional pixel positions and output a motion vector with fractional pixel precision.

[00126] Motion estimation unit 42 calculates a motion vector for a PU of a video block in an inter-coded slice by comparing the position of the PU to the position of a predictive block of a reference picture. The reference picture may be selected from a first reference picture list (e.g. List 0) or a second reference picture list (e.g. List 1), each of which identify one or more reference pictures stored in reference frame memory 64. Motion estimation unit 42 sends the calculated motion vector to entropy encoding unit 56 and motion compensation unit 44.

[00127] Motion compensation, performed by motion compensation unit 44, may involve fetching or generating the predictive block based on the motion vector determined by motion estimation unit 42. Again, motion estimation unit 42 and motion compensation unit 44 may be functionally integrated, in some examples. Upon receiving the motion vector for the PU of the current video block, motion compensation unit 44 may locate the predictive block to which the

- [00238] For example, if the 5th, 7th, 8th, 9th, 11th points are the points with luma value within a range of $[L_{\max}-T_1, L_{\max}]$. The 4th, 6th, 14th, 18th points are the points with luma value within a range of $[L_{\min}, L_{\min}+T_2]$. In an example, the $L_{\max}$ represents the largest luma value in the set P, and $L_{\min}$ represents the smallest luma value in the set P. Then the mean value of p_5, p_7, p_8, p_9 and p_{11} is the maximum luma value used for linear model parameter, and the mean value of q_5, q_7, q_8, q_9 and q_{11} is the maximum chroma value corresponding to the maximum luma value. Then the mean value of p_4, p_6, p_{14} and p_{18} is the minimum luma value used for linear model parameter, and the mean value of q_4, q_6, q_{14} and q_{18} is the minimum chroma value corresponding to the minimum luma value.
- 10 [00239] Note that M and N can be equal, or not equal.
- [00240] Note that T_1 and T_2 can be equal, or not equal.
- [00241] Note that the improved mechanism also can be used in MDLM and MMLM.
- [00242] Fifth improved mechanism: using extended neighboring samples
- [00243] In the existing mechanism, only the top and the left neighboring samples are used to obtain the couple of points for searching the couple of points to derive the linear model parameter. In the fifth improved mechanism, some extended samples can be used to increase the number of couple of points, to improve the robustness of the linear model parameters.
- 15 [00244] For example, the top-right neighboring samples and the left-below neighboring samples are also used to derive the linear model parameters.
- 20 [00245] For example, as shown in FIG. 20, in the existing single mode CCLM mechanism, the down-sampled top neighboring luma samples are represented by A' , and the down-sampled left neighboring luma samples are represented by L' . The top neighboring chroma samples are represented by Ac' , and the left neighboring chroma samples are represented by Lc' .
- [00246] As shown in FIG. 21, in the fifth improved mechanism, the neighboring samples will be extended to top-right and the left-below samples. This means that the reference samples A, L, and Ac, Lc may be used to obtain the max/min luma value and the corresponding chroma value.
- 25 [00247] Here $M>W, N>H$.
- [00248] Here note that, the improved mechanism also can be used in MDLM and MMLM.
- 30 [00249] In the existing CCIP or LM mechanism, to obtain the max/min luma value and the corresponding chroma value, only one pair of points will be used.

[00288] The difference between the embodiment 4 and the embodiment 1 lies in:

[00289] N couples of points will be used to calculate the maximum luma value, and the corresponding chroma value. The selected N couples of points have luma values within a range of [MaxlumaValue-T₁, MaxlumaValue]. The mean luma value of the selected N couples of points will be used as the maximum luma value, and the mean chroma value of the selected N couples of points will be used as the chroma value corresponding to the maximum luma value.

[00290] M couples of points will be used to calculate the minimum luma value, and the corresponding chroma value. The selected M couples of points have luma values within a range of [MinlumaValue, MinlumaValue+T₂]. The mean luma value of the selected M couples of points will be used as the minimum luma value, and the mean chroma value of the selected M couples of points will be used as the chroma value corresponding to the minimum luma value.

[00291] For details, please refer to the improved mechanism 4 described above.

[00292] The improved mechanism 4 can also be used in MDLM and MMLM. For example, to MDLM/MMLM, only the max/min luma value and corresponding chroma value are used for deriving the linear model parameters. The improved mechanism 4 is used for deriving the max/min luma value and corresponding chroma value.

[00293] The method for cross-component prediction of a block according to embodiment 5 (corresponding to the fifth improved mechanism) of the present disclosure is provided by reference with FIG. 22.

[00294] The difference between the embodiment 5 and the embodiment 1 lies in:

[00295] Some extended samples can be used to increase the number of couple of points, to improve the robustness of the linear model parameters.

[00296] For example, the top-right neighboring samples and the left-below neighboring samples are also used to derive the linear model parameters.

[00297] For details, please refer to improved mechanism 5 described above.

[00298] The improved mechanism 5 can also be used in MMLM. For example, for MMLM, only the max/min luma value and corresponding chroma value are used for deriving the linear model parameters. The improved mechanism 5 is used for deriving the max/min luma values and corresponding chroma values.

[00304] At step 2360, the chroma block 901 is reconstructed based on the predictive block. For example, adding the predictive block to a residual block to reconstruct the chroma block 901.

[00305] It should be noted that in the case of MDLM intra-prediction using CCIP_A mode 1700, the set of reconstructed neighboring luma samples include a plurality of reconstructed luma samples that are above the luma block but does not include a plurality of reconstructed luma samples that are left to the luma block. In the case of MDLM intra-prediction using CCIP_L mode 1800, the set of reconstructed neighboring luma samples does not include a plurality of reconstructed luma samples that are above the luma block and include a plurality of reconstructed luma samples that are left to the luma block. In the case of CCLM intra-prediction, the set of reconstructed neighboring luma samples include a plurality of reconstructed luma samples that are above the luma block and a plurality of reconstructed luma samples that are left to the luma block.

[00306] FIG. 24 is a flowchart of an example method 240 of encoding video data. At step 2410, a luma block 911, 1211, 1311, 1411, and 1511 that corresponds to a chroma block 901 is determined.

[00307] At step 2420, a set of down-sampled samples of reconstructed neighboring luma samples is determined, wherein the reconstructed neighboring luma samples include a plurality of reconstructed luma samples that are above the luma block and/or a plurality of reconstructed luma samples that are left to the luma block.

[00308] At step 2430, two pairs of luma value and chroma value are determined according to N down-sampled neighboring luma samples and N reconstructed neighboring chroma samples that correspond to the N down-sampled neighboring luma samples, and/or M down-sampled neighboring luma samples and M reconstructed neighboring chroma samples that correspond to the M down-sampled neighboring luma samples. The minimum value of the N down-sampled neighboring luma samples is not less than the luma value of the remaining down-sampled neighboring luma samples of the set of down-sampled samples of reconstructed neighboring luma samples. The maximum value of the M down-sampled neighboring luma samples is not larger than the luma value of the remaining down-sampled neighboring luma samples of the set of down-sampled samples of reconstructed neighboring luma samples, and M, N is a positive integer and larger than 1. In particular, a first pair of luma value and chroma value is determined

luma samples with the minimum value, wherein M, N is a positive integer and larger than 1.

[00316] At step 2540, one or more linear model parameters are determined based on the two pairs of luma value and chroma value.

5 **[00317]** At step 2550, a predictive block is determined based on the one or more linear model parameters, for example, predicted chroma values of the chroma block 901 are generated based on the linear model parameters and the down-sampled luma block 1212, 1312, 1412, and 1512.

[00318] At step 2560, the chroma block 901 is reconstructed based on the predictive block. For example, adding the predictive block to a residual block to reconstruct the chroma block
10 901.

[00319] It should be noted that in the case of MDLM intra-prediction using CCIP_A mode 1700, the set of reconstructed neighboring luma samples includes a plurality of reconstructed luma samples that are above the luma block but does not include a plurality of reconstructed luma samples that are left to the luma block. In the case of MDLM intra-prediction using
15 CCIP_L mode 1800, the set of reconstructed neighboring luma samples does not include a plurality of reconstructed luma samples that are above the luma block and includes a plurality of reconstructed luma samples that are left to the luma block. In the case of CCLM intra-prediction, the set of reconstructed neighboring luma samples includes a plurality of reconstructed luma samples that are above the luma block and a plurality of reconstructed
20 luma samples that are left to the luma block CCLM intra-prediction.

[00320] FIG. 26 is a flowchart of an example method 260 of encoding video data. At step 2610, a luma block 911 that corresponds to a chroma block 901 is determined.

[00321] At step 2620, a set of down-sampled samples of reconstructed neighboring luma samples is determined, wherein the reconstructed neighboring luma samples include a plurality
25 of reconstructed luma samples that are above the luma block and/or a plurality of reconstructed luma samples that are left to the luma block.

[00322] At step 2630, when N down-sampled neighboring luma samples with the maximum value and/or M down-sampled neighboring luma samples with the minimum value are included in the set of down-sampled samples of reconstructed neighboring luma samples, two pairs of
30 luma value and chroma value are determined according to N down-sampled neighboring luma

samples is not larger than the luma value of the remaining down-sampled neighboring luma samples of the set of down-sampled samples, and M, N is a positive integer and larger than 1.

33. The device of claim 31 or 32, wherein the set of down-sampled samples of reconstructed
5 neighboring luma samples consists of:

the N down-sampled neighboring luma samples and the M down-sampled neighboring luma samples.

34. The device of any one of claims 31 to 33, wherein M and N are equal.

10 35. The device of claim 34, wherein $M=N=2$.

36. A decoding apparatus, comprising:

a memory storage comprising instructions; and

one or more processors in communication with the memory,

15 wherein the one or more processors, by executing the instructions, perform the method according to any one of claims 1 to 15.

37. An encoding apparatus, comprising:

a memory storage comprising instructions; and

20 one or more processors in communication with the memory,

wherein the one or more processors, by executing the instructions, perform the method according to any one of claims 16 to 30.

38. A computer program product storing instructions which, when executed by a processor in
25 a device, cause the device to perform the method according to any of claims 1 to 30.