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(71) **Applicant: MEDIATEK INC.** [CN/CN]; No. 1, Dusing 1st Rd., Hsinchu Science Park, Hsinchu City, Taiwan 30078 (CN).

(72) **Inventors: TSENG, Hsin-Yi**; No. 1, Dusing 1st Rd., Hsinchu Science Park, Hsinchu City, Taiwan 30078 (CN). **CHIANG, Man-Shu**; No. 1, Dusing 1st Rd., Hsinchu Science Park, Hsinchu City, Taiwan 30078 (CN). **TSAI, Chia-Ming**; No. 1, Dusing 1st Rd., Hsinchu Science Park, Hsinchu City, Taiwan 30078 (CN). **CHUANG, Cheng-Yen**; No. 1, Dusing 1st Rd., Hsinchu Science Park, Hsinchu City, Taiwan 30078 (CN). **CHEN, Guan-Hao**; No. 1, Dusing 1st Rd., Hsinchu Science Park, Hsinchu City, Taiwan 30078 (CN). **HSU, Chih-Wei**; No. 1, Dusing 1st Rd., Hsinchu Science Park, Hsinchu City, Taiwan 30078 (CN). **CHEN, Yi-Wen**; 2840 Junction Ave, San Jose, California 95134 (US). **CHUANG, Tzu-Der**; No. 1, Dusing 1st Rd., Hsinchu Science Park, Hsinchu City, Taiwan 30078 (CN).

(74) **Agent: BEIJING SANYOU INTELLECTUAL PROPERTY AGENCY LTD.**; 16th Fl., Block A, Corporate Square, No. 35 Jinrong Street, Xicheng District, Beijing 100033 (CN).

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(54) **Title:** METHODS AND APPARATUS OF INHERITING CROSS-COMPONENT MODELS FROM RESCALED REFERENCE PICTURE IN VIDEO CODING

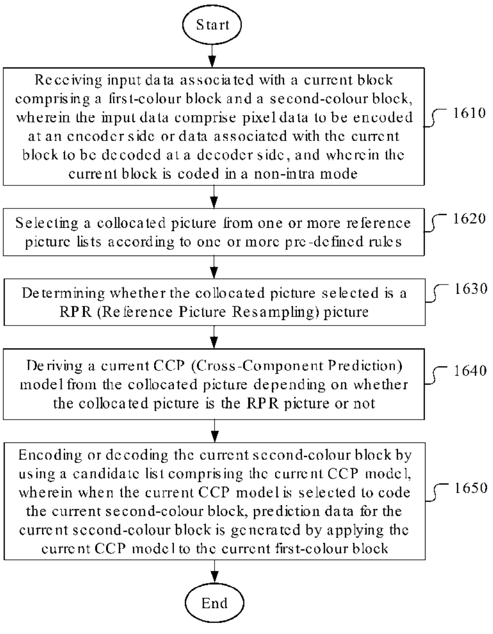

Fig. 16

(57) **Abstract:** A method and apparatus for coding colour pictures or video using coding tools including one or more cross component models related modes are disclosed. According to this method, a collocated picture is selected from one or more reference picture lists according to one or more pre-defined rules. Whether the collocated picture selected is a RPR (Reference Picture Resampling) picture is determined. A current CCP (Cross-Component Prediction) model is derived from the collocated picture depending on whether the collocated picture is the RPR picture or not. The current second-colour block is encoded or decoded by using a candidate list comprising the current CCP model, wherein when the current CCP model is selected to code the current second-colour block, prediction data for the current second-colour block is generated by applying the current CCP model to the current first-colour block.

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METHODS AND APPARATUS OF INHERITING CROSS-COMPONENT MODELS FROM RESCALED REFERENCE PICTURE IN VIDEO CODING

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present invention is a non-Provisional Application of and claims priority to U.S. Provisional Patent Application No. 63/580,407, filed on September 4, 2023. The U.S. Provisional Patent Application is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to video coding system using coding tools including one or more cross component models related modes. In particular, the present invention relates to coding for a chroma component using cross-component model derived from a RPR (Reference Picture Resampling) reference picture.

BACKGROUND AND RELATED ART

[0003] Versatile video coding (VVC) is the latest international video coding standard developed by the Joint Video Experts Team (JVET) of the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG). The standard has been published as an ISO standard: ISO/IEC 23090-3:2021, Information technology - Coded representation of immersive media - Part 3: Versatile video coding, published Feb. 2021. VVC is developed based on its predecessor HEVC (High Efficiency Video Coding) by adding more coding tools to improve coding efficiency and also to handle various types of video sources including 3-dimensional (3D) video signals.

[0004] Fig. 1A illustrates an exemplary adaptive Inter/Intra video encoding system incorporating loop processing. For Intra Prediction 110, the prediction data is derived based on previously coded video data in the current picture. For Inter Prediction 112, Motion Estimation (ME) is performed at the encoder side and Motion Compensation (MC) is performed based on the result of ME to provide prediction data derived from other picture(s) and motion data. Switch 114 selects Intra Prediction 110 or Inter Prediction 112 and the selected prediction data is supplied to Adder 116 to form prediction errors, also called residues. The prediction error is then processed by Transform (T) 118 followed by Quantization (Q) 120. The transformed and quantized residues are then coded by Entropy Encoder 122 to be included in a video bitstream corresponding to the compressed video data. The bitstream associated with the transform coefficients is then packed with side information such as motion and coding modes associated with Intra prediction and Inter prediction, and other information such as parameters associated with loop filters applied to underlying image area. The side information associated with Intra Prediction 110, Inter prediction 112 and in-loop filter 130, is provided to Entropy Encoder 122 as shown in Fig. 1A. When an Inter-prediction mode is used, a reference picture or pictures have to be reconstructed at the encoder end as well. Consequently, the transformed and quantized residues are processed by Inverse Quantization (IQ) 124 and Inverse Transformation (IT) 126 to recover the residues. The residues are then added back to prediction data 136 at Reconstruction (REC) 128 to reconstruct video data. The reconstructed video data may be stored in Reference Picture Buffer 134 and used for prediction of other frames.

[0005] As shown in Fig. 1A, incoming video data undergoes a series of processing in the encoding system. The reconstructed video data from REC 128 may be subject to various impairments due to a series of processing. Accordingly, in-loop filter 130 is often applied to the reconstructed video data before the reconstructed video data are stored in the Reference Picture Buffer 134 in order to improve video quality. For example, deblocking filter (DF), Sample Adaptive Offset (SAO) and Adaptive Loop Filter (ALF) may be used. The loop filter information may need to be incorporated in the bitstream so that a decoder can properly recover the required information. Therefore, loop filter information is also provided to Entropy Encoder 122 for incorporation into the bitstream. In Fig. 1A, Loop filter 130 is applied to the reconstructed video before the reconstructed samples are stored in the reference picture buffer 134. The system in Fig. 1A is intended to illustrate an exemplary structure of a typical video encoder. It may correspond to the High Efficiency Video Coding (HEVC) system, VP8, VP9, H.264 or VVC.

[0006] The decoder, as shown in Fig. 1B, can use similar or portion of the same functional blocks as the encoder except for Transform 118 and Quantization 120 since the decoder only needs Inverse Quantization 124 and Inverse Transform 126. Instead of Entropy Encoder 122, the decoder uses an Entropy Decoder 140 to decode the video bitstream into quantized transform coefficients and needed coding information (e.g. ILPF information, Intra prediction information and Inter prediction information). The Intra prediction 150 at the decoder side does not need to perform the mode search. Instead, the decoder only needs to generate Intra prediction according to Intra prediction information received from the Entropy Decoder 140. Furthermore, for Inter prediction, the decoder only needs to perform motion compensation (MC 152) according to Inter prediction information received from the Entropy Decoder 140 without the need for motion estimation.

[0007] In order to improve the coding performance for a system using cross-component models, methods and apparatus of using cross-component model derived from a RPR (Reference Picture Resampling) reference picture. are disclosed.

BRIEF SUMMARY OF THE INVENTION

[0008] A method and apparatus for coding colour pictures or video using coding tools including one or more cross component models related modes are disclosed. According to this method, input data associated with a current block comprising a first-colour block and a second-colour block is received, wherein the input data comprise pixel data to be encoded at an encoder side or data associated with the current block to be decoded at a decoder side, and wherein the current block is coded in a non-intra mode. A collocated picture is selected from one or more reference picture lists according to one or more pre-defined rules. Whether the collocated picture selected is a RPR (Reference Picture Resampling) picture is determined. A current CCP (Cross-Component Prediction) model is derived from the collocated picture depending on whether the collocated picture is the RPR picture or not. The current second-colour block is encoded or decoded by using a candidate list comprising the current CCP model, wherein when the current CCP model is selected to code the current second-colour block, prediction data for the current second-colour block is generated by applying the current CCP model to the current first-colour block.

[0009] In one embodiment, said one or more pre-defined rules are related to information comprising L0[0], L1[0], POC distance, QP value, or a combination thereof. In one embodiment, whether the collocated picture selected is the RPR picture is indicated by a flag signalled or parsed in a bitstream. In one embodiment, the collocated picture selected is the RPR picture if the collocated picture and a current picture containing the current block have one or more of target parameters different. In one embodiment, said one or more of target parameters comprise picture width in luma samples, picture height in the luma samples, scaling window left offset, scaling window right offset, scaling window top offset, scaling window bottom offset, number of sub pictures, or a combination thereof.

[0010] In one embodiment, the collocated picture is selected from one or more un-rescaled pictures in said one or more reference picture lists. In one embodiment, a target picture is selected from un-rescaled pictures in said one or more reference picture lists as the collocated picture, and wherein the target picture is selected based on POC (Picture order Count) difference with a current picture, POC value, QP difference with a current picture, QP value, reference list or the combination thereof.

[0011] In one embodiment, if the collocated picture selected is the RPR picture, inheriting CCM information from the collocated picture is disabled. In one embodiment, if the collocated picture selected is the RPR picture, CCM information from the collocated picture is retrieved from a scaled position according to a scaling ratio. In one embodiment, the scaling ratio is derived based on a scaling window of a current picture and the collocated picture. In one embodiment, if a current position and the scaling ratio are represented as (x,y) and R respectively, a scaled position is determined according to (x/R,y/R) after a rounding process. In one embodiment, the rounding process corresponds to rounding toward negative infinity, rounding toward positive infinity, rounding toward zero, or rounding to a nearest integer.

[0012] In one embodiment, the current CCP model from the collocated picture is determined according to a motion vector of a neighbouring block, and the neighbouring block is selected from a list of pre-defined positions. In one embodiment, the neighbouring block is selected from the list of pre-defined positions according to a pre-defined checking order. In one embodiment, the pre-defined checking order corresponds to L0 motion vectors or L1 motion vectors being checked first, and a target motion vector associated with a non-scaled reference picture first is selected.

[0013] In one embodiment, if a target reference picture located by a motion vector is the RPR picture, the motion vector is considered as no CCM information is located by the motion vector. In another embodiment, if a target reference picture located by a motion vector is the RPR picture, CCM information is retrieved from the target reference picture at a scaled position according to a scaling ratio.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Fig. 1A illustrates an exemplary adaptive Inter/Intra video coding system incorporating loop processing.

[0015] Fig. 1B illustrates a corresponding decoder for the encoder in Fig. 1A.

[0016] Fig. 2 shows 16 gradient patterns for GLM.

[0017] Fig. 3 illustrates the 6-tap spatial terms corresponding to 6 neighbouring luma samples (i.e., L0, L1, …, L5) around the chroma sample (i.e., C) to be predicted for CCCM mode.

[0018] Fig. 4 shows an exemplary system block diagram for Cross-component residual model (CCRM).

[0019] Fig. 5 illustrates the 5 neighbouring blocks used for deriving spatial merge candidates for VVC.

[0020] Fig. 6 illustrates an exemplary pattern of the adjacent and non-adjacent spatial merge candidates.

[0021] Fig. 7 illustrates an example of temporal candidate derivation, where a scaled motion vector is derived according to POC (Picture Order Count) distances.

[0022] Fig. 8 illustrates the positions for the temporal candidate selected between candidates C_0 and C_1.

[0023] Fig. 9A (Pattern 1) and Fig. 9B (Pattern 2) illustrate two different patterns of non-adjacent spatial neighbouring candidates according to pre-defined positions and a pre-defined order.

[0024] Fig. 10 illustrates examples of CCM information propagation.

[0025] Fig. 11 illustrates examples of mapping positions outside of the collocated CTU row to positions inside the collocated CTU row.

[0026] Fig. 12A-Fig. 12B illustrate the patterns of the n taps in a window region M x N around/including the position (iL, jL) to derive the sourceTermSet0(i, j), where only the centre is used (Fig. 12A) and a 5x5 cross is used (Fig. 12B).

[0027] Fig. 13 illustrates an example of using Sobel filters to derive the gradient information from the predicted samples and/or reconstructed samples of the source.

[0028] Fig. 14A-Fig. 14B illustrate the patterns of the m taps in a window region M2 x N2 around/including the position (iC, jC) to derive the sourceTermSet1(i, j), where only the centre is used (Fig. 14A) and a 5x5 cross is used (Fig. 14B).

[0029] Fig. 15 illustrates an example of neighbouring spatial regions used as reference regions for weighting setting for self-derived cross-component model.

[0030] Fig. 16 illustrates a flowchart of an exemplary video coding system that incorporates inheriting cross-component prediction models from a RPR (Reference Picture Resampling) reference picture according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0031] It will be readily understood that the components of the present invention, as generally described and illustrated in the figures herein, may be arranged and designed in a wide variety of different configurations. Thus, the following more detailed description of the embodiments of the systems and methods of the present invention, as represented in the figures, is not intended to limit the scope of the invention, as claimed, but is merely representative of selected embodiments of the invention. References throughout this specification to "one embodiment," "an embodiment," or similar language mean that a particular feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment of the present invention. Thus, appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment.

[0032] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, etc. In other instances, well-known structures, or operations are not shown or described in detail to avoid obscuring aspects of the invention. The illustrated embodiments of the invention will be best understood by reference to the drawings, wherein like parts are designated by like numerals throughout. The following description is intended only by way of example, and simply illustrates certain selected embodiments of apparatus and methods that are consistent with the invention as claimed herein.

[0033] **Cross-Component Linear Model (CCLM) Prediction**

[0034] To reduce the cross-component redundancy, a cross-component linear model (CCLM) prediction mode is used in the VVC, for which the chroma samples are predicted based on the reconstructed luma samples of the same CU by using a linear model as follows:

$$\mathrm{pred_C}(i,j) = \alpha \cdot \mathrm{rec_L}'(i,j) + \beta \qquad (1)$$

where $\mathrm{pred_C}(i,j)$ represents the predicted chroma samples in a CU and $\mathrm{rec_L}'(i,j)$ represents the downsampled reconstructed luma samples of the same CU.

[0035] The CCLM parameters (α and β) are derived with at most four neighbouring chroma samples and their corresponding down-sampled luma samples. Suppose the current chroma block dimensions are W×H, then W' and H' are set as

- W' = W, H' = H when LM_LA mode is applied;
- W' =W + H when LM_A mode is applied;
- H' = H + W when LM_L mode is applied.

[0036] In this disclosure, the term {LM_LA, LM_A, LM_L} and {CCLM_LT, CCLM_T, CCLM_L} are used interchangeably.

[0037] **Multiple Model CCLM (MMLM)**

[0038] In the JEM (J. Chen, E. Alshina, G. J. Sullivan, J.-R. Ohm, and J. Boyce, Algorithm Description of Joint Exploration Test Model 7, document JVET-G1001, ITU-T/ISO/IEC Joint Video Exploration Team (JVET), Jul. 2017), multiple model CCLM mode (MMLM) is proposed for using two models for predicting the chroma samples from the luma samples for the whole CU. In MMLM, neighbouring luma samples and neighbouring chroma samples of the current block are classified into two groups, each group is used as a training set to derive a linear model (i.e., a particular α and β are derived for a particular group). Furthermore, the samples of the current luma block are also classified based on the same rule for the classification of neighbouring luma samples.

[0039] *Threshold* is calculated as the average value of the neighbouring reconstructed luma samples. A neighbouring sample with $Rec'_L[x,y]$ <= *Threshold* is classified into group 1; while a neighbouring sample with $Rec'_L[x,y]$ > *Threshold* is classified into group 2.

$$\begin{cases} Pred_C[x,y] = \alpha_1 \times Rec'_L[x,y] + \beta_1 & \text{if } Rec'_L[x,y] \le Threshold \\ Pred_C[x,y] = \alpha_2 \times Rec'_L[x,y] + \beta_2 & \text{if } Rec'_L[x,y] > Threshold \end{cases} \quad (2)$$

[0040] **Convolutional Cross-Component Model (CCCM)**

[0041] In CCCM, a convolutional model is applied to improve the chroma prediction performance. The convolutional model has 7-tap filter consisting of a 5-tap plus sign shape spatial component, a nonlinear term and a bias term.

[0042] Output of the filter is calculated as a convolution between the filter coefficients and the input values and clipped to the range of valid chroma samples.

[0043] The filter coefficients are calculated by minimising MSE between predicted and reconstructed chroma samples in the reference area.

[0044] **Gradient Linear Model (GLM)**

[0045] Compared with the CCLM, instead of down-sampled luma values, the GLM utilizes luma sample gradients to derive the linear model. Specifically, when the GLM is applied, the input to the CCLM process, i.e., the down-sampled luma samples L, are replaced by luma sample gradients G. The other parts of the CCLM (e.g., parameter derivation, prediction sample linear transform) are kept unchanged:

$C = \alpha \cdot G + \beta.$

[0046] Fig. 2 shows the 16 gradient filters (210-240) for the gradient calculation.

[0047] **Intra Block Copy**

[0048] Intra block copy (IBC) is a tool adopted in HEVC extensions on screen content coding (SCC). It is well known that it significantly improves the coding efficiency of screen content materials. Since IBC mode is implemented as a block level coding mode, block matching (BM) is performed at the encoder to find the optimal block vector (or motion vector) for each CU. Here, a block vector is used to indicate the displacement from the current block to a reference block, which is already reconstructed inside the current picture. The luma block vector of an IBC-coded CU is in integer precision. The chroma block vector is rounded to integer precision as well. When combined with AMVR, the IBC mode can switch between 1-pel and 4-pel motion vector precisions. An IBC-coded CU is treated as the third prediction mode other than intra or inter prediction modes. The IBC mode is applicable to the CUs with both width and height smaller than or equal to 64 luma samples.

[0049] **CCCM Using Non-Down-sampled Luma Samples**

[0050] CCCM mode with 3x2 filter using non-down-sampled luma samples is used, which consists of 6-tap spatial terms, four nonlinear terms and a bias term. The 6-tap spatial terms correspond to 6 neighbouring luma samples (i.e., L0, L1, …, L5) around the chroma sample (i.e., C) to be predicted, the four non-linear terms are derived from the samples L0, L1, L2, and L3 as shown as follows, where the locations of the non-down-sampled luma samples are shown in Fig. 3.

$$C = \sum_{i=0}^{5} \alpha_i \cdot (L_i - \text{offsetLuma}) + \sum_{i=6}^{9} \alpha_i \cdot (((L_{i-4} - \text{offsetLuma})^2 + \beta) \gg bitDepth) + \alpha_{10} \cdot \beta + \text{offsetChroma}$$

[0051] **Cross-Component Residual Model (CCRM)**

[0052] As in JVET-AD0108 (Pekka Astola, et. al., "AHG12: Cross-component residual model (CCRM) for inter prediction", Joint Video Experts Team (JVET) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29, 30th Meeting, Antalya, TR, 21–28 April 2023, Document: JVET- AD0108), it is to apply cross-component residual model (CCRM) to predict chroma samples from reconstructed luma samples when the block uses inter prediction or intra block copy (IBC). Fig. 4 illustrates the decoder side of the method. The cross-component filters are derived using the prediction signals of luma and chroma. The derived filters are applied to the reconstructed luma signal producing the final chroma predictions. Filter coefficients are derived in step 420 for each chroma component separately using the prediction signals (i.e., predY 410, and predCb 412 or predCr 414) and the filters are applied to the reconstructed luma signal in step 430 as shown in Fig. 4. The reconstructed luma signal is formed by combining the luma prediction (PredY) 410 and residual luma signal (resY) using an adder 422. After applying the filters, the step 430 generates filtered-predicted Cb 440 and filtered-predicted

Cr 450. The reconstructed Cb signal is formed by combining the filtered-predicted Cb 440 and residual Cb signal (i.e., resCb) using an adder 442. Similarly, the reconstructed Cr signal is formed by combining the filtered-predicted Cr 450 and residual Cr signal (i.e., resCr) using an adder 452.

[0053] **Intra Template Matching**

[0054] Intra template matching prediction (IntraTMP) is a special intra prediction mode that copies the best prediction block from the reconstructed part of the current frame, whose L-shaped template matches the current template. For a predefined search range, the encoder searches for the most similar template to the current template in a reconstructed part of the current frame and uses the corresponding block as a prediction block. The encoder then signals the usage of this mode, and the same prediction operation is performed at the decoder side.

[0055] **Extended Merge Prediction**

[0056] In VVC, the merge candidate list is constructed by including the following five types of candidates in order:

1) Spatial MVP from spatial neighbour CUs
2) Temporal MVP from collocated CUs
3) History-based MVP from an FIFO table
4) Pairwise average MVP
5) Zero MVs.

[0057] **Spatial Candidate Derivation**

[0058] The derivation of spatial merge candidates in VVC is the same as that in HEVC except that the positions of first two merge candidates are swapped. A maximum of four merge candidates (B_0, A_0, B_1 and A_1) for current CU 510 are selected among candidates located in the positions depicted in Fig. 5. The order of derivation is B_0, A_0, B_1, A_1 and B_2. Position B_2 is considered only when one or more neighbouring CU of positions B_0, A_0, B_1, A_1 are not available (e.g. belonging to another slice or tile) or is intra coded. After candidate at position A_0 is added, the addition of the remaining candidates is subject to a redundancy check which ensures that candidates with the same motion information are excluded from the list so that coding efficiency is improved.

[0059] In addition to the above-mentioned spatial candidates, the non-adjacent spatial merge candidates as in JVET-L0399 (Yu Han, et al., "CE4.4.6: Improvement on Merge/Skip mode", Joint Video Exploration Team (JVET) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, 12th Meeting: Macao, CN, 3–12 Oct. 2018, Document: JVET- L0399) are inserted after the TMVP in the regular merge candidate list. An example of the pattern of spatial merge candidates is shown in Fig. 6. The distances between non-adjacent spatial candidates and current coding block are based on the width and height of current coding block. The line buffer restriction is not applied.

[0060] **Temporal Candidates Derivation**

[0061] In this step, only one candidate is added to the list. Particularly, in the derivation of this temporal merge candidate for a current CU 710, a scaled motion vector is derived based on the co-located CU 720 belonging to the collocated reference picture as shown in Fig. 7. The reference picture list and the reference index to be used for the derivation of the co-located CU is explicitly signalled in the slice header. The scaled motion vector 730 for the temporal merge candidate is obtained as illustrated by the dotted line in Fig. 7, which is scaled from the motion vector 740 of the co-located CU using the POC (Picture Order Count) distances, tb and td, where tb is defined to be the POC difference between the reference picture of the current picture and the current picture and td is defined to be the POC difference between the reference picture of the co-located picture and the co-located picture. The reference picture index of temporal merge candidate is set equal to zero.

[0062] The position for the temporal candidate is selected between candidates C_0 and C_1, as depicted in Fig. 8. If CU at position C_0 is not available, is intra coded, or is outside of the current row of CTUs, position C_1 is used. Otherwise, position C_0 is used in the derivation of the temporal merge candidate.

[0063] **History-based Merge Candidates Derivation**

[0064] The history-based MVP (HMVP) merge candidates are added to merge list after the spatial MVP and TMVP. In this method, the motion information of a previously coded block is stored in a table and used as MVP for the current CU. The table with multiple HMVP candidates is maintained during the encoding/decoding process. The table is reset (emptied) when a new CTU row is encountered. Whenever there is a non-subblock inter-coded CU, the associated motion information is added to the last entry of the table as a new HMVP candidate.

[0065] **Pair-wise Average Merge Candidates Derivation**

[0066] Pairwise average candidates are generated by averaging predefined pairs of candidates in the existing merge candidate list, using the first two merge candidates. The first merge candidate is defined as p0Cand and the second merge candidate can be defined as p1Cand, respectively. The averaged motion vectors are calculated according to the availability of the motion vector of p0Cand and p1Cand separately for each reference list. If both motion vectors are available in one list, these two motion vectors are averaged even when they point to different reference pictures, and its reference picture is set to the one of p0Cand; if only one motion vector is available, use the one directly; if no motion vector is available, keep this list invalid. Also, if the half-pel interpolation filter indices of p0Cand and p1Cand are different, it is set to 0.

[0067] When the merge list is not full after pair-wise average merge candidates are added, the zero MVPs are inserted in the end until the maximum merge candidate number is encountered.

[0068] **Reference Picture Resampling (RPR)**

[0069] In HEVC, the spatial resolution of pictures cannot change unless a new sequence using a new SPS starts, with an IRAP picture. VVC enables picture resolution change within a sequence at a position without encoding an IRAP picture, which is always intra-coded. This feature is sometimes referred to as reference picture resampling (RPR), as the feature needs resampling of a reference picture used for inter prediction when that reference picture has a different resolution than the current picture being decoded. In order to avoid additional processing steps, the RPR process in VVC is designed to be embedded in the motion compensation process and performed at the block level. In the motion compensation stage, the scaling ratio is used together with motion information to locate the reference samples in the reference picture to be used in the interpolation process.

[0070] In VVC, the scaling ratio is restricted to be larger than or equal to 1/2 (i.e., 2 times downsampling from the reference picture to the current picture), and less than or equal to 8 (i.e., 8 times upsampling). Three sets of resampling filters with different frequency cutoffs are specified to handle various scaling ratios between a reference picture and the current picture. The three sets of resampling filters are applied respectively for the scaling ratio ranging from 1/2 to 1/1.75, from 1/1.75 to 1/1.25, and from 1/1.25 to 8. Each set of resampling filters has 16 phases for luma and 32 phases for chroma which is the same as the case of motion compensation interpolation filters. It is worthy noted that the filter set of normal MC interpolation is used in the case of scaling ratio ranging from 1/1.25 to 8. Actually, the normal MC interpolation process is a special case of the resampling process with scaling ratio ranging from 1/1.25 to 8. In addition to conventional translational block motion, the affine mode has three sets of 6-tap interpolation filters that are used for the luma component to cover the different scaling ratios in RPR. The horizontal and vertical scaling ratios are derived based on picture width and height, and the left, right, top and bottom scaling offsets specified for the reference picture and the current picture.

[0071] **Signalling of Resolution and Cropping Window**

[0072] In VVC, the maximum picture resolution and the corresponding conformance cropping window are signalled in the SPS, while in the PPS the picture resolution of each current picture is signalled. Such signalling arrangement can be used to support RPR. When the picture resolution of the current picture (from PPS) is smaller than the maximum picture resolution (from SPS), it is possible to signal conformance cropping offsets in the PPS that are different from the conformance cropping offsets signalled in the SPS.

[0073] **Miscellaneous Inter Prediction Aspects**

[0074] To reduce memory bandwidth, the 4x4 inter-coded CU is not allowed in VVC. For inter-coded 4x8/8x4 CU, only uni-directional mode is allowed. When the motion information from merge mode is bi-directional, it is converted to uni-directional by keeping only the list 0 motion information.

[0075] In order to improve the coding performance of cross-component prediction, various schemes are disclosed.

[0076] The cross-component information is used to improve prediction accuracy of an inter block. To improve the prediction accuracy of the chroma component of the inter block, the luma information from the corresponding luma component of the current chroma block, and/or the chroma information from the current chroma block, and/or the chroma information from the previous coded chroma component are used.

- The **first scheme** is that for a coding unit (under single tree splitting) including luma (Y) and chroma (Cb and/or Cr) components, the prediction for Cb and/or Cr is improved by applying the cross-component models to information (current reconstructed or predicted) from Y.
- The **second scheme** is that for a coding unit (under single tree splitting) including luma (Y) and chroma (Cb and/or Cr) components or for a coding unit (under chroma dual tree splitting) including chroma (Cb and/or Cr) components, the prediction for Cr is improved by applying the cross-component models to information (current reconstructed or predicted) from Cb.

[0077] In the following, several embodiments related to the first scheme are proposed to use an inherited cross-component mode for the current chroma block with the following steps: Step (1) building a candidate list (modelList) for the current block where the candidate list includes cross-component models; Step (2) selecting one or more sets of model information in the list; and Step (3) using the model information (similar to intra chroma cross-component mode) to generate one or more hypotheses of predictions for the current chroma component (Cb or Cr) by applying and/or modifying the selected model information to the reconstructed or predicted samples for the corresponding luma component.

[0078] When the selected model information refers to traditional cross-component linear model(s), the proposed method is called as inter cross-component linear model (inter CCLM) mode. When the selected model information refers to convolutional cross-component model(s) (CCCM) derived by a regression-based method (e.g. CCCM), the proposed method is called as inter cross-component convolution model (inter CCCM) mode.

[0079] Moreover, in some embodiments, a self-derived (or re-derived) cross-component mode is proposed and can be added into the candidate list in Step (1). In some embodiments, the self-derived cross-component mode is not added into the list and a selection of using the proposed inherited mode and/or using the proposed self-derived mode is designed. In some embodiments, the selection of using the proposed inherited mode and/or using the proposed self-derived mode is determined following an explicit rule, an implicit rule, or both. More details are described in the section entitled “IV. Selection of Using the Proposed Inherited Mode and/or Using the Proposed Self-Derived Mode”.

[0080] In one embodiment, the proposed embodiments can also be used for the second scheme by using the previous coded chroma component (Cb) as the luma component in the first scheme.

[0081] **Storage and Inheritance of the Model**

[0082] In another embodiment, when the current inter block uses the model parameters from the self-derived cross-component mode, the used model parameters can be saved and/or referenced by the following coding blocks. For an example of the self-derived cross-component being CCRM, all or any subset of the model parameters can be saved. In one embodiment, if the following coding block is intra, it is allowed to use the saved model parameters. If the following coding block is inter or any mode-type (e.g., IBC), it is allowed to use the saved model parameters. In another embodiment, if the following coding block and the current block have different mode-types (e.g., one being an inter block and one being not an inter block), it is not allowed to use the saved model parameters.

[0083] In another embodiment, when the current inter block uses the inherited cross-component mode, the used model parameters can be saved and/or referenced by the following coding blocks. For an example of the inherited CCCM, all or any subset of the model parameters can be saved. In one embodiment, if the following coding block is intra, it is allowed to use the saved model parameters. If the following coding block is inter or any mode-type (e.g. IBC), it is allowed to use the saved model parameters. In another embodiment, if the following coding block has different mode-type (e.g., not an inter block), it is not allowed to use the saved model parameters.

[0084] In another embodiment, when the current inter block uses any cross-component models (e.g. the inherited cross-component model, the self-derived cross-component model, cross-component model used in chroma fusion which means the chroma prediction is based on adding one or more hypotheses of cross-component prediction to one or more existing hypotheses of prediction of non-cross-component prediction, or any combination of the above), the used model parameters can be saved and/or referenced by the following coding blocks. For an example of the inherited CCCM, all or any subset of the model parameters can be saved. In one embodiment, if the following coding block is intra, it is allowed to use the saved model parameters. If the following coding block is inter or any mode-type (e.g. IBC), it is allowed to use the saved model parameters. In another embodiment, if the following coding block has a different mode-type (e.g., not an inter block), it is not allowed to use the saved model parameters.

[0085] **I. Building a Candidate List Including Cross-Component Models**

[0086] In one embodiment, when building the merge-like candidate model list (modelList), one or more sets of the following candidate model information are included. For each candidate in the list, it refers to a candidate model information. The definition of the model information can be found in the section entitled: “V.1. Inheriting CCM Information”.

- Spatial model information from spatial neighbour blocks (corresponding to “Spatial MVP from spatial neighbour CUs” for inter)
- Temporal model information from collocated blocks (corresponding to “Temporal MVP from collocated CUs” for inter)

– History-based model information from a FIFO table (corresponding to "History-based MVP from a FIFO table" for inter)
– Pairwise average model information (corresponding to "Pairwise average MVP" for inter)
– Default model information (corresponding to "Zero MVs" for inter)

[0087] In one sub-embodiment of the candidate type being "spatial model information from spatial neighbour blocks" in the above candidate type list, a valid spatial neighbouring block(s) can be from one of spatial adjacent and non-adjacent neighbours (or any subset of the blocks in a neighbouring search region for the current block) which satisfies a pre-defined condition. For an example of non-adjacent neighbours, the pre-defined condition (e.g., valid/available checking) refers that the non-adjacent neighbour is in the available region of non-adjacent spatial candidates. For example, the pre-defined condition is that the neighbour is coded by a cross-component mode or combining with cross-component mode. The cross-component mode refers to modes such as CCLM, MMLM, CCCM, GLM, the mode with mode information inherited from a merge-like candidate list, MH CCLM, and/or any cross-component mode with syntax belonging cross-component branch (containing many cross-component modes) and not belonging to tradition intra prediction modes). Combining with cross-component mode refers to modes such as chroma fusion (or named LM assisted Angular/Planar Mode), inter CCLM, inter CCCM, and/or any traditional mode with syntax not belonging to cross-component branch, but using the cross-component information to generate the prediction. In another sub-embodiment, when checking the validation of a neighbouring coding block, a second-round valid checking is further used when the mentioned valid checking (e.g., neighbouring block not being cross-component mode or neighbouring block not using/combining cross-component mode), the motion vectors and/or block vectors of the neighbouring block can be used to find the cross-component models. Variations of how to use motion vector and/or block vectors to find the model can reference the description of "Temporal model information from collocated blocks" in the above candidate type list. If the model is found, the second-round valid checking for the neighbouring block is satisfied and the found models can be inserted in the list; otherwise, the neighbouring block is not valid for inserting. When scanning the spatial neighbouring blocks, a candidate is added into the list if the candidate is valid.

[0088] In another sub-embodiment of the candidate type being "Temporal model information from collocated blocks", in the first case, the collocated block is from the block in the reference picture or the pre-defined collocated picture as inter mode by using the current block position and/or the current block motion, and/or in the second case, the collocated block is from the block in the reference picture or the pre-defined collocated picture as inter mode by using the current block position and/or the neighbouring block motion. In the first case, for example, when the current block is coded by inter prediction mode, the collocated block is referred by the motion information (including the motion vectors and the reference picture indicated by the reference index) of the current block. If the current block is a subblock motion mode (e.g., affine mode), each subblock in the current block has its own collocated temporal model information. Collocated temporal model information from all or any subset of collocated temporal information that are referred by the different subblock motions (of each subblock) are added into the list. For another example, when the reference picture indicated by the reference index is different from the pre-defined collocated picture, which can be the collocated picture used for temporal motion vector prediction in inter mode or any collocated picture specified in the standard to keep the motion or cross-component model information stored and available for the current block, the temporal information from the reference picture is forbidden to be used. For another example, when the reference picture indicated by the reference index is different from the pre-defined collocated picture, which can be the collocated picture used for temporal motion vector prediction in inter mode or any collocated picture specified in the standard to keep the motion or cross-component model information stored and available for the current block, the motion vector is scaled to refer the pre-defined collocated picture and the scaled motion vector is used to find the collocated block in the collocated picture to get the cross-component model in the collocated block. The scaling process is shown in the section of "Inheriting Temporal Neighbouring Model Parameters" and the section of "Temporal Candidates Derivation". Some examples are described for the second case. For one example, the temporal model information can be from the collocated block referred by the motion information of the neighbouring blocks for the current block. Similar to the first case, the forbidden method or the scaling method can be used in the second case. If the proposed methods are applied to an IBC block or any mode using block vectors (in the first case, the current block being IBC; in the second case, the neighbouring block being IBC), block vector information is used as motion vector where the block vector information is determined by signalling and/or template matching in a pre-defined searching range like intraTMP and/or any implicit or explicit pre-defined rules. More details can be found in the section of "Inheriting Temporal Neighbouring Model Parameters".

[0089] In another sub-embodiment of the candidate type being "History-based model information", a history-based table (the FIFO table) is built and stores the model information from the previous coded blocks. The table can be reset as the beginning and/or the end of a CTU, slice, picture, tile, and/or sequence. One or more history-based candidates can be added into the candidate list by the order from the head to tail of the table or from the tail to head of the table.

[0090] In another sub-embodiment of the candidate type being "Pairwise average model information", the model information of this candidate is derived based on the model information from more than one of the previous candidates in the list. For example, it can average and/or modify the model parameters of more than one candidate as the to-be-applied model parameters. For another example, it can combine more than one prediction as the final prediction, where each of more than one prediction is generated by applying one of models in the candidate list.

[0091] In another sub-embodiment, the default model information is added if the list is not full after inserting all pre-defined candidates. For example, the default model can be CCLM models. The default alpha (or named as α, a, or scaling parameters) are selected from {0, 1/8, -1/8, 2/8, -2/8, 3/8, -3/8, …}, and the beta (or named as β, b, or offset parameter) is based on the selected default alpha, average neighbouring reconstructed luma sample value, and average neighbouring reconstructed chroma (Cb/Cr) sample value.

[0092] In another sub-embodiment, the candidate list for the inter chroma block is unified with the candidate list for intra chroma block and/or can be generated based on the candidate list for intra chroma block by further including inter-specific candidates (e.g., temporal model information referred by the current motion) and/or can be any subset of the candidate list for intra chroma block.

[0093] In another embodiment, when building modelList, one or more self-derived cross-component candidates are included. The self-derived cross-component candidates are described in the section entitled "Self-derived Cross-Component Model". In another sub-embodiment, the self-derived cross-component candidates are added only when the list does not contain enough inherited candidates. For example, the self-derived candidates are added before the default candidates or treated as the default candidates. In another sub-embodiment, the self-derived cross-component candidates are added in any pre-defined position in the modelList. For example, the position is after the spatial adjacent candidates. For another example, the position is after the spatial non-adjacent candidates. For another example, the position is after all or any subset of temporal candidates.

[0094] After building the list, in one embodiment, the list is reordered as the methods defined in the section "Reordering the Candidates in the List."

[0095] **II. Signalling of Enabling or Disabling and Selecting One or More Model Information in the List if Enabled**

[0096] In this section, the term "inter CCLM" refers to "inter CCLM or inter CCCM".

[0097] When not applying the proposed inter CCLM (or inter CCCM), the prediction of the current block is from the original inter prediction.

[0098] In another embodiment, the choice between applying inter CCLM or not applying inter CCLM depends on signalling.

[0099] In one sub-embodiment, the signalling refers to a coded TU/TB/CU/CB level flag. The flag may or may not depend on context to code. Take the TU/TB flag as an example, the flag is signalled only if the TU/TB's luma Cbf is non-zero and the enabling flag for the inter mode is true. Take the CU/CB flag as an example, the flag is signalled only if the CU/CB's luma Cbf is non-zero and the enabling flag for the inter mode is true. The enabling flag for the inter mode means the CU's predMode is MODE_INTER when the proposed inter CCLM (or inter CCCM) is supported for all inter modes. When the proposed inter CCLM (or inter CCCM) is supported for IBC. The enabling flag for IBC is checked first and the signalling for inter CCLM (or inter CCCM) is coded/decoded in response to the CU's predMode being MODE_IBC. When the proposed inter CCLM (or inter CCCM) is supported only for CIIP, the enabling flag for CIIP is checked first and the signalling for inter CCLM (or inter CCCM) is coded/decoded in response to the CIIP flag being true. When the proposed inter CCLM (or inter CCCM) is supported only for merge, the merge flag is checked first and the signalling for inter CCLM (or inter CCCM) is coded/decoded in response to the merge flag being true. When the proposed inter CCLM (or inter CCCM) is supported only for AMVP, the merge flag is checked first and the signalling for inter CCLM (or inter CCCM) is coded/decoded in response to the merge flag being false. The proposed inter CCLM (or inter CCCM) can be supported only for any pre-defined subset of merge modes, any pre-defined subset of inter modes, or any pre-defined subset of non-intra modes.

[0100] In another sub-embodiment, when the signalling indicates to apply inter CCLM (or inter CCCM), additional signalling is used to select one or more models from total candidates. The candidate index is referred as modelIdx in this disclosure. If the modelList containing total candidates (e.g., candidates as described in the section entitled "Building a Candidate List Including Cross-Component Models", CCLM_LT, CCLM_L, CCLM_T, MMLM_LT, MMLM_L, MMLM_T) or any subset of candidates are reordered by the methods in the section "Reordering the candidates in the list", the additional signalling specifies the candidate index in the reordered list. For example, if one LM mode is selected, the LM prediction is generated by the selected one LM. For another example, if more than one LM modes are selected the LM prediction is generated by blending hypotheses of predictions from multiple LM modes.

[0101] In another sub-embodiment, the additional signal is not required and the one or more models are selected according to an implicit rule. For example, the one or more selected models are implicitly determined or the one or more models used for the current block are determined without signalling modelIdx. For example, the first candidate in the list is used. If the list is reordered by the template cost, then, the first candidate is the candidate with the smallest template cost.

[0102] In another embodiment, original inter prediction (generated by motion compensation) is used for luma and the predictions of chroma components are generated by CCLM and/or any other LM modes.

[0103] In one sub-embodiment, the current CU is viewed as an inter CU, intra CU, or a new type of prediction mode (i.e., neither intra nor inter).

[0104] In another embodiment, the one or more LM modes (i.e., cross-component modes) which will be used to generate the one or more hypotheses of predictions for LM assisted Angular/Planar Mode/inter CCLM/inter CCCM/MH CCLM are selected from a pre-defined merging candidate list (i.e., modelList). One modelIdx is signalled to select a candidate from the candidate list (modelList) and the selected candidate is used for the current block. The modelList contains one or more candidates where each candidate refers to a model (or cross-component mode) information. If only one candidate is in the list (i.e., the size of the list being 1), the modelIdx is not signalled and/or can be inferred as 0 or a default value. In one embodiment, the modelIdx is implicitly determined or the one or more models used for the current block are determined without signalling modelIdx. For example, the first candidate in the list is used. If the list is reordered by the template cost, the first candidate is the candidate with the smallest template cost. For another example, the used candidate/model is implicitly selected from the list by using a pre-defined rule depending on the coding information of the block for the to-be-used candidate. This embodiment is denoted as "noteA".

[0105] In one embodiment, when building modelList, one or more predefined candidates are added. The pre-defined candidates can include any subset/extension of the following candidates and/or more candidates in embodiment described in "noteA".

- CCLM family: CCLM_LT, CCLM_L, CCLM_T
- MMLM family: MMLM_LT, MMLM_L, MMLM_T
- CCCM family: CCCM_LT, CCCM_L, CCCM_T

[0106] The above proposed methods can be also applied to IBC blocks or the blocks with any IBC sub-modes (e.g., IBC merge or IBC AMVP or any IBC mode under IBC syntax). The term "inter" in this invention can be changed to IBC. That is, for chroma components, the block vector prediction can be combined or replaced with cross-component prediction.

[0107] **III. Using the Model Information to Generate One or More Hypotheses of Predictions for the Current Chroma Component**

[0108] **III.1. Concept**

[0109] In one embodiment, prediction or reconstruction-based model is used to generate one hypothesis of prediction for the current chroma component.

[0110] In one sub-embodiment of a prediction based linear model, the derived model parameters are applied to the predicted samples for the first component (Y) to get the predicted samples for the second or third component.

$$P(i,j) = a \cdot pred_L'(i,j) + b$$

[0111] The predicted samples for the first component are down-sampled with the downsampling filters, which may be fixed at one-predefined filter or selected among some candidate filters.

[0112] In another sub-embodiment of a reconstruction based linear model, the derived model parameters are applied to the reconstructed samples for the first component (Y) to get the predicted samples for the second or third component.

$$P(i,j) = a \cdot reco_L'(i,j) + b$$

[0113] The reconstructed samples for the first component are down-sampled with the downsampling filters, which may be fixed at one-predefined filter or selected among some candidate filters.

[0114] Prediction or reconstruction based convolution model is similar to the proposed methods for the prediction or reconstruction based linear model. The main difference is that the model coefficient pattern follows CCCM (not CCLM) and the luma samples may or may not be down-sampled first.

[0115] In another embodiment, multiple hypotheses (MH) of cross-component predictions are blended or multiple models are used to generate a hypothesis of prediction for the current block. Multiple-hypothesis CCLM is proposed to blend the predictions from multiple CCLM methods. The term "CCLM methods" can refer all the cross-component modes. The to-be-blended CCLM methods can be from (but are not limited to) the above mentioned CCLM methods (e.g., CCLM, MMLM, CCCM, GLM, CCRM, …) and/or models defined in the embodiment described in noteA. A weighting scheme is used for blending.

[0116] **III.2. CCLM for Inter Block**

[0117] The term "CCLM for inter block" can also be named as "inter CCLM" and "CCLM" can be extended to any LM mode (or any cross-component mode) or replaced with any LM mode (or any cross-component mode). When convolutional cross-component models derived by a regression-based method is used, CCLM for inter block can also be named as inter CCCM.

[0118] In one embodiment, for chroma components, in addition to original inter prediction (generated by motion compensation which can be uni-prediction and/or bi-prediction, multiple hypotheses of prediction from multiple motion candidates which may refer to one or more merge candidates, one or more AMVP candidates, any combination of above, or which can be only uni-prediction), one or more hypotheses of predictions (generated by CCLM and/or any other LM modes) are used to generate the current prediction.

[0119] In one sub-embodiment, the current prediction is the weighted sum of inter prediction and CCLM prediction.

[0120] In another embodiment, the inter prediction can be generated by any inter mode mentioned above. For example, the inter mode can be regular merge mode. For another example, the inter mode can be CIIP mode. For another example, the inter mode can be GPM or any GPM variations (e.g., GPM intra referring one prediction unit using intra prediction).

[0121] In another embodiment, inter CCLM is supported only when one or more of the pre-defined inter modes are used for the current block, or inter CCLM is supported when any one (or more than one) of the enabling flag(s) of the pre-defined inter mode is(are) indicated as enabled. The meaning of supporting inter CCLM is that the prediction of the current block can be chosen between applying inter CCLM or not applying inter CCLM.

[0122] When applying inter CCLM, the prediction of the current block is generated by:

- In one sub-embodiment: blending one or more hypotheses of predictions: (generated by CCLM and/or any other LM modes) with original inter prediction
  - Blending the chroma prediction for existing inter mode and the prediction from LM
  - Blending: Predfinal = (wInter * PredInter + wLM * PredLM + 2) >> 2
  - Weighting rule: wInter and wLM, for example,
    - If both top and left are intra (or any cross-component mode), (wInter, wLM) = (1, 3)
    - Otherwise, if one of top and left is intra, (wInter, wLM) = (2, 2)
    - Otherwise, (wInter, wLM) = (3, 1)
    - For another example, the weighting follows CIIP weighting rules.
  - For example, predInter = inter prediction after OBMC (if OBMC is used)
  - For another example, predInter = inter prediction before OBMC (OBMC can be applied after blending)
- In another sub-embodiment: replacing original inter prediction with one or more hypotheses of predictions (generated by CCLM and/or any other cross-component modes)

[0123] For another example, if CCLM mode is used for generating the chroma prediction samples and luma prediction is from an inter coding tool, a flag is used to indicate if the CCLM model used for the chroma prediction is inherited from the CCLM models used in the previous coded blocks or the CCLM model is from a predetermined CCLM mode. If the CCLM model is inherited from the CCLM models used in the previous coded blocks, an index is used to indicate which model in the list is inherited or modified. Otherwise, a predetermined CCLM mode is used to implicitly derive the CCLM model for the current chroma prediction.

[0124] **IV. Selection of Using the Proposed Inherited Mode and/or Using the Proposed Self-Derived Mode**

[0125] In one embodiment, a flag can be signalled to indicate/select if the re-derived model is used. If the flag is 0, the cross-component model used to encode the neighbour merge candidate is inherited. If the flag is 1, the re-derived method is used.

[0126] In another embodiment, an implicit rule (not using the additional flag) is used to determine whether to use the re-derived model.

[0127] In another embodiment, if no model can be inherited during building the modelList, or the spatial adjacent/non-adjacent candidates, history candidates, temporal candidates, or all or any subset (e.g., before default candidates) of mentioned candidates in this invention are not available, use the re-derived model.

[0128] In another embodiment, when the proposed inherited method is used. The candidate with the smallest cost (e.g., the first candidate in the modelList) is implicitly selected to generate the cross-component prediction. For another example, an index is signalled to select one or more candidates from the modelList. More details can be found in Section II.

[0129] **V. Details of the Cross-Component Mode (Including Model Information) in the Candidate List**

[0130] **V.1. Inheriting CCM Information**

[0131] In one embodiment, the cross-component model (CCM) information of inherited cross-component model can be stored together with the inherited model parameters. The CCM information can be inherited together with the inherited model parameters. The prediction of the current block can be generated based on the inherited CCM information and inherited model parameters. The CCM information can include, but not limited to, prediction mode (e.g., CCLM, MMLM, CCCM, 2-parameter GLM, 3-parameter GLM (GLM model with luma term), model index for indicating which model shape is used in the convolutional model, classification threshold for multi-model, information to indicate that non-downsampled samples are used in the convolutional model, down-sampling filter flag (whether to do down-sampling), down-sampling filtering index when multiple down-sampling filters are used, number of neighbouring lines used to derive the model, types of templates used to derive model, post-filtering flag, and model parameters.

[0132] In one embodiment, a mixed CCCM model consisting of various terms (e.g., spatial term, gradient term, location term, non-linear term and bias term) can be inherited. In addition to storing model parameters, a prediction mode can be stored in the CCM information to indicate that the inherited model is a mixed CCCM model consisting of various terms. If there are multiple types of mixed CCCM models, a model index can also be stored in the CCM information to indicate which type of mixed CCCM model is inherited. For example, gradient and location based CCCM (GL-CCCM) proposed in JVET-AB0119 (Ramin G. Youvalari, et al., "Non-EE2: Gradient and location based convolutional cross-component model (GL-CCCM) for intra prediction", Joint Video Exploration Team (JVET) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, 28th Meeting, Mainz, DE, 20–28 October 2022, Document: JVET- AB0119) is a mixed CCCM model which consists of one spatial term in the centre position, two gradient terms for the horizontal direction and vertical direction, two location terms X and Y for the relative horizontal location and relative vertical location, one non-linear term and one bias term. A prediction mode can be stored in the CCM information to indicate that the inherited model is a GL-CCCM model.

[0133] **V.2. Inheriting Spatial Neighbouring Model Parameters**

[0134] In one embodiment, the inherited model parameters can be from a block that is an immediate neighbouring block. The models from blocks at pre-defined positions are added into the candidate list in a pre-defined order. The pre-defined order can be any possible order of the spatial neighbouring block.

[0135] In one embodiment, the pre-defined positions and the pre-defined order can be the same as those of spatial candidates for inter merge mode.

[0136] In one embodiment, the pre-defined positions can be the positions depicted in Fig. 5 (also as in the section "Spatial Candidate Derivation"). The pre-defined order can be B0, A0, B1, A1 and B2.

[0137] In one embodiment, assume the position, width and height of the current block are (x, y), W and H respectively, the pre-defined positions can include positions immediate above the current block, such as (x + W >> 1, y-1) or (x + (W+1) >> 1, y-1), if W is greater than or equal to a threshold TH. The pre-defined positions can also include positions immediate left to the current blocks, such as (x-1, y+H>>1) or (x-1, y+(H+1)>>1), if H is greater than or equal to a threshold TH. TH can be 2, 4, 8, 16, 32, or 64. The pre-defined positions include the positions at the immediate above (W >> 1) or ((W >> 1) – 1) position if W is greater than or equal to TH, and the positions at the immediate left (H >> 1) or ((H >> 1) – 1) position if H is greater than or equal to TH.

[0138] In one embodiment, there is a maximum number of inherited models from spatial neighbours that can be added into the candidate list, and the maximum number is smaller than the number of pre-defined positions.

[0139] **V.3. Inheriting Temporal Neighbouring Model Parameters**

[0140] In one embodiment, if the current slice/picture is a non-intra slice/picture, the inherited model parameters can be from the block in the previous coded slices/pictures.

[0141] In one embodiment, the current block position is at (x, y) and the block size is $w \times h$. The inherited model parameters can be from the block at some pre-defined positions of the previous coded slices/picture.

[0142] In one sub-embodiment, the pre-defined positions can be the same as the pre-defined positions of temporal candidates of inter merge mode.

[0143] In one sub-embodiment, the pre-defined positions can be $(x + \Delta x,\ y + \Delta y)$ or $(x_{mid} + \Delta x, y_{mid} + \Delta y)$, where $(x_{mid}, y_{mid}) = (x + w/2, y + h/2)$. The two value sets α_x and α_y are defined as:

$$\alpha_x = \{\alpha_{x1}, \alpha_{x2}, \alpha_{x3}, \dots, \alpha_{xn}\}, \alpha_{xi} < \alpha_{xj}\ if\ i < j,$$

$$\alpha_y = \{\alpha_{y1}, \alpha_{y2}, \alpha_{y3}, \dots, \alpha_{yn}\}, \alpha_{yi} < \alpha_{yj}\ if\ i < j.$$

[0144] All values in α_x and α_y are positive numbers.

[0145] For example, $(\Delta x,\ \Delta y)$ can be $(\pm\alpha_{xi} \times w,\ \pm\alpha_{yi} \times h), (\pm\alpha_{xi} \times w, 0), (0, \pm\alpha_{yi} \times h)$.

[0146] For example, $\alpha_x = \alpha_y$. For example, $\alpha_x = \alpha_y = \{1, 2, 3, 4, 5\}$.

[0147] For example, $\alpha_x \neq \alpha_y$. For example, $\alpha\_x = \{1/2, 1, 3/2, 2, 5/2\}$ and $\alpha_y =$

$\{1, 2, 3, 4, 5\}$.

[0148] In one sub-embodiment, the pre-defined positions (x', y') are inside the corresponding area of the current encoding block, i.e., $x \leq x' < x + w$ and $y \leq y' < y + h$. The pre-defined positions can be $(x, y), (x + w - 1, y), (x, y + h - 1), (x + w - 1, y + h - 1), (x + w/2, y + h/2), (x, y + h/2), (x + w/2, y)$.

[0149] In one sub-embodiment, the pre-defined positions (x', y') are outside of the corresponding area of the current encoding block, i.e., $x' < x + or\ x' \geq x + w$, and $y' < y\ or\ y' \geq y + h$. The pre-defined positions can be $(x - 1, y), (x, y - 1), (x - 1, y - 1), (x + w, y), (x + w - 1, y - 1), (x + w, y - 1), (x, y + h), (x - 1, y + h - 1), (x - 1, y + h), (x + w, y + h - 1), (x + w - 1, y + h), (x + w, y + h)$.

[0150] In one embodiment, the models from the positions closer to (x, y) are added into the final merge candidate list first.

[0151] The previous coded picture, from which the inherited parameter model is obtained, is referred to as the collocated picture hereafter.

[0152] In one embodiment, the previous coded picture where the inherited parameter model is from (i.e., the collocated picture), is one of the pictures in the reference lists.

[0153] In one embodiment, the collocated picture can be the same as the collocated picture of inter merge mode.

[0154] In one embodiment, the collocated picture is signalled in the picture/slice header. The reference list and the reference index are signalled in the picture/slice header. For example, the collocated picture is selected as L0[0]. For another example, the collocated picture is selected as L1[0].

[0155] In one embodiment, the collocated picture is selected as the picture in the reference lists whose POC difference between the respective picture and the current picture is the smallest.

[0156] In another sub-embodiment, the collocated picture is selected as the picture in the reference lists whose QP is larger or smaller.

[0157] In one embodiment, if one picture in the reference list is rescaled (i.e, the RprConstraintsActiveFlag of the collocated picture is true), the picture is not selected as the collocated picture. A rescaled reference picture rescaled means that the collocated picture has one or more of the following seven parameters different than that of the current picture: 1) the picture width in luma samples (pps_pic_width_in_luma_samples), 2) the picture height in luma samples (pps_pic_height_in_luma_samples), 3) the scaling window left offset (pps_scaling_win_left_offset), 4) the scaling window right offset (pps_scaling_win_right_offset), 5) the scaling window top offset (pps_scaling_win_top_offset), 6) the scaling window botton offset (pps_scaling_win_bottom_offset), and 7) the number of sub pictures -1 (sps_num_subpics_minus1).

[0158] In one embodiment, the rules to select/not select the collocated pictures described in the paragraphs above can be combined. For example, the collocated picture is selected out of the un-rescaled pictures in the reference lists. The collocated picture is selected as the picture whose POC difference between it and the current picture is the smallest.

[0159] In one embodiment, when the collocated picture is rescaled, inheriting CCM information from the collocated picture is disabled.

[0160] In one embodiment, when the collocated picture is rescaled, the positions where the inherited model are from can be scaled according to the scaling ratio. The scaling ratio is derived based on the scaling window of the current picture and the collocated picture. Let the position be (x, y), the scaled position be (x', y') and the scaling ratio be R. The scaled position can be (x/R, y/R) or (x/R, y/R) after rounding. The rounding method used can be, but not limited to, the following methods: rounding toward negative infinity, rounding toward positive infinity, rounding toward zero, or rounding to the nearest integer (e.g., rounding away from zero, rounding half up, rounding half down, ...).

[0161] In one embodiment, the positions in the previous coded slices/pictures, where the inherited parameter model is from, is determined by the motion vector of a neighbouring block. Let Δx and Δy be the horizontal and vertical displacement determined based on the selected motion vector of the neighbouring block, the current block position is at (x, y) and the block size is $w \times h$. The inherited model parameters can be from the block at position (x', y'), where x' = x + Δx and y' = y + Δy, or where x' = x + w/2 +Δx and y' = y + h/2 +Δy.

[0162] In one embodiment, when selecting the neighbouring block, there can be a list of pre-defined positions. The positions in the list are checked in the pre-defined checking order. For each position, the L0 motion vector is first checked, and then the L1 motion vector. For another example, the L1 motion vector is first checked, and then the L0 motion vector. The selected motion vector is the first one whose reference picture is not rescaled.

[0163] **V.4. Inheriting Non-Adjacent Spatial Neighbouring Models**

[0164] In one embodiment, the inherited model parameters can be from blocks that are non-adjacent spatial neighbouring blocks. The models from blocks at pre-defined positions are added into the candidate list in a pre-defined order.

[0165] In one sub-embodiment, the pre-defined positions and the pre-defined order are the same as those of non-adjacent spatial neighbouring candidates for inter merge mode.

[0166] In one sub-embodiment, the pre-defined positions and the pre-defined order are as depicted in Fig. 9A and Fig. 9B. The positions of the numbered squares are the pre-defined positions. The number inside each square indicate the pre-defined order. Positions in Pattern 1 (Fig. 9A) is added into the list before positions in Pattern 2 (Fig. 9B). The distance between each pre-defined positions are proportional to the width and height of the current block.

[0167] In one embodiment, there is a maximum number of inherited models from non-adjacent spatial neighbours that can be added into the candidate list, and the maximum number is smaller than the number of pre-defined positions.

[0168] **V.5. Inheriting Model Parameters from History Table**

[0169] In one embodiment, the inherited model parameters can be from a cross-component model history table. The history table stores CCM information of valid previous coded blocks. The valid previous coded block refers to any blocks containing valid CCM information. The cross-component models in the history table can be added into the candidate list according to a pre-defined order. In one embodiment, the adding order of historical candidate can be from the beginning of the table to the end of the table. In another embodiment, the adding order of historical candidate can be from the end of the table to the beginning of the table.

[0170] In one embodiment, one cross-component model history table can be maintained for storing the previous cross-component model (i.e., CCM information), and the cross-component model history table can be reset at the start of the current picture, current slice, current tile, every M CTU rows or every N CTUs, N and M can be any value greater than 0. In another embodiment, the cross-component model history table can be reset at the end of the current picture, current slice, current tile, current CTU row or current CTU.

[0171] In another embodiment, multiple history table are used for storing different type of cross-component model. For example, the first history table is used for storing single model, and the second history table is used for storing multi-model. For another example, the first history table is used for storing gradient model, and the second history table is used for storing non-gradient model. For another example, the first history table is used for storing simple linear model (e.g., $y = ax + b$), and the second history table is used for storing complicated model (e.g., CCCM).

[0172] In one embodiment, when adding historical candidates from multiple history tables to the candidate list, the adding order can be from the beginning of to the end of a certain table, and then the next history table is added in the same order or in a reversed order.

[0173] **V.6. Vector Propagated CCM Information**

[0174] In one embodiment, after encoding/decoding a block, the cross-component model (CCM) information of the current block is derived and stored in the current block. The stored CCM information can be referenced by the following coding blocks. The following coding blocks can inherit CCM information from the current block. The definition of CCM information is in the section “Inheriting CCM Information”. The stored CCM information can be inherited as, but not limited to, the following types of candidates: spatial candidates (as in the section “Inheriting Spatial Neighbouring Model Parameters”), non-adjacent candidates (as in the section “Inheriting Non-Adjacent Spatial Neighbouring Models”), temporal candidates (as in the section “Inheriting Temporal Neighbouring Model Parameters”), historical candidates (as in the section “Inheriting Model Parameters from History Table”).

[0175] In one embodiment, if the current block is not CCP coded and there are motion vectors available in the current block (e.g., the current luma block is inter-coded), the CCM information of the current block can be derived by copying the CCM information of its reference block in a reference picture, located by the motion vectors of the current block. For example, as shown in Fig. 10, block B is not CCP coded and there are motion vectors available at block B. The reference block A is located by the motion vector. The CCM information of the reference block A, which uses cross-component model, is copied and stored in block B. For one embodiment, if the reference block located by the motion vector is also not CCP coded, but there is CCM information stored in the reference block, the CCM information of the current block can be derived by copying the CCM information stored in the reference block. That is, even when the reference block is not CCP coded, as long as it has valid stored CCM information, the stored CCM information can be referenced by the current block. For example, as shown in Fig. 10, the current block C has motion vector available, and its reference block B, which is not CCP coded, has CCM information stored. The CCM information of block B is copied and stored in block C. Since the CCM information stored in block B was copied from block A, the CCM information stored in block C in originally from block A (i.e., the CCM information of block A is propagated to block C). By only accessing block B, block C can retrieve CCM information originally from block A. For one embodiment, if the reference block located by the motion vector is not CCP coded and does not have CCM information stored, no CCM information is stored for the current block.

[0176] For one embodiment, when the current block is inter-coded with bi-directional prediction, to derive the CCM information of the current block, if only one of the reference blocks located by the motion vectors has CCM information, the CCM information from the reference block that has CCM information is copied to and stored in the current block. For example, as shown in Fig. 10, suppose block F is inter-coded with bi-directional prediction. The two reference blocks located by the motion vectors are block G and block H. Block G has stored CCM information and block H does not. The CCM information of block G is copied to and stored in block F.

[0177] For another embodiment, when the current block is inter-coded with bi-directional prediction, and both reference blocks located by the motion vectors has stored CCM information, the CCM information of the current block is derived by combining of all or a subset of the CCM models of its reference blocks.

[0178] For another embodiment, when the current block is inter-coded with bi-directional prediction, and both reference blocks located by the motion vectors have stored CCM information, one of the reference blocks is selected based on a set of pre-defined rules. The CCM information of the selected reference block is then copied and stored in the current block.

[0179] For one sub-embodiment, the reference block which is CCP coded is selected.

[0180] For one sub-embodiment, the reference block which is intra coded is selected.

[0181] For one sub-embodiment, the reference block which is inter coded is selected.

[0182] For one sub-embodiment, the reference block whose reference picture (i.e., the picture the reference block is in) has the smaller POC distance to the current picture is selected.

[0183] For one sub-embodiment, the reference block whose reference picture has the smaller QP difference from the current picture is selected.

[0184] For one sub-embodiment, the reference block whose reference picture has the smaller QP value is selected. For another sub-embodiment, the reference block whose reference picture has the larger QP values is selected.

[0185] For one sub-embodiment, the reference block that is indicated by the L0 motion vector is selected.

[0186] For one sub-embodiment, the reference block that is indicated by the L1 motion vector is selected.

[0187] For one sub-embodiment, the rules described previously can be combined and not all the rules described previously need to be applied. For example, the reference block that is CCP coded is selected. If both blocks are CCP coded, then the block whose reference picture has the smaller POC distance to the current picture is selected. If both blocks are CCP coded and have the same POC distance to the current picture, the reference block whose reference picture has the smaller QP difference from the current picture is selected. If both blocks are CCP coded and have the same POC distance to the current picture, and have the same QP difference from the current picture, then the reference block whose reference picture has the smaller QP value is selected. For another example, the block whose reference picture has the smaller POC distance to the current picture is selected. If both blocks have the same POC distance to the current picture, the reference block whose reference picture has the smaller QP difference from the current picture is selected. If both blocks have the same POC distance to the current picture and have the same QP difference from the current picture, then the reference block whose reference picture has the smaller QP value is selected.

[0188] In one embodiment, when the reference picture located by the motion vector is rescaled (i.e, the RprConstraintsActiveFlag of the reference picture is true), it is considered as that no CCM information can be located by this motion vector. Thus, no CCM information is retrieved and stored. The reference picture rescaled means the reference picture has one or more of the following seven parameters different than that of the current picture: 1) the picture width in luma samples (pps_pic_width_in_luma_samples), 2) the picture height in luma samples (pps_pic_height_in_luma_samples), 3) the scaling window left offset (pps_scaling_win_left_offset), 4) the scaling window right offset (pps_scaling_win_right_offset), 5) the scaling window top offset (pps_scaling_win_top_offset), 6) the scaling window botton offset (pps_scaling_win_bottom_offset), and 7) the number of sub pictures -1 (sps_num_subpics_minus1).

[0189] In one embodiment, when the reference picture located by the motion vector is rescaled, the position of the reference block can be scaled according to the scaling ratio. The scaling ratio is derived based on the scaling window of the current picture and the collocated picture. Let the position of the reference block be (x, y), the scaled position of the reference block be (x', y') and the scaling ratio be R. The scaled position can be (x/R, y/R) or (x/R, y/R) after rounding. The rounding method used can be, but not limited to, the following methods: rounding toward negative infinity, rounding toward positive infinity, rounding toward zero, or rounding to the nearest integer (e.g., rounding away from zero, rounding half up, rounding half down, …).

[0190] In one embodiment, the position located by the motion vector of a collocated block 1130 has to be in the collocated CTU row 1120 in the reference picture 1110 of the current CTU row in Fig. 11. As depicted in Fig. 11, if the position 1140 located by the motion vector is above the collocated CTU row, the position is mapped to a corresponding position (labelled as (Xm,Y1)) in the top line of the collocated CTU row. If the position 1142 located by the motion vector is below the current CTU row, the position is mapped to a corresponding position (labelled as (Xm,Y2)) in the bottom line of the collocated CTU row. The CCM information from the mapped position is then copied and stored in the current block. Assume the minimum and the maximum vertical position of the current CTU row are Y1 and Y2 respectively. Assume the position located by the motion vector is (Xm, Ym). If Xm < Y1, then the position is changed to (Xm, Y1). The CCM information at position (Xm, Y1) is copied to current block and stored. If Ym > Y2, then the position is changed to (Xm, Y2). The CCM information at position (Xm, Y2) is copied to current block and stored.

[0191] **V.7. Inheriting from Fusion Mode**

[0192] Fusion mode refers to mode that fuses two predictions to generate the final prediction. In the chroma intra fusion mode, a chroma intra prediction that is not generated using a cross-component prediction (CCP) coding tool (e.g., CCLM, MMLM, CCCM) is fused with another chroma intra prediction generated using a cross-component prediction coding tool. For example, a non-CCLM coded intra prediction and a CCLM coded intra prediction are fused together to obtain the final intra prediction.

[0193] In one embodiment, when inheriting the cross-component model parameters from the block/position coded by a chroma intra fusion mode, the model parameters for obtaining the CCP coded intra prediction are inherited and further refined.

[0194] In one embodiment, in addition to inheriting and refining the CCP model parameters, the fusion weight and the coding mode of non-CCP coded intra prediction are also inherited. That is, the chroma intra fusion mode is inherited.

[0195] **VI. Constructing a Candidate List**

[0196] **VI.1. Reordering the Candidates in the List**

[0197] The candidates in the list can be reordered to reduce the syntax overhead when signalling the selected candidate index or to bypass the syntax for signalling the selected candidate index by using implicit rule to select the one or more candidates.

[0198] In one embodiment, the reordering rules can depend on the coding information of neighbouring blocks or the model error. For example, if neighbouring above or left blocks are coded by MMLM, the MMLM candidates in the list can be moved to the head of the current list.

[0199] In one embodiment, the reordering rule is based on the model error by applying the candidate model to the neighbouring templates of the current block, and then compare the error with the reconstructed samples of the neighbouring template.

[0200] **VII. Self-derived Cross-Component Model**

[0201] In one embodiment, an example of the self-derived cross-component model is CCRM. When doing the self-derivation, the model (filtering shape/pattern, parameter terms) is unified with the cross-component models in regular intra mode. For example, CCRM model can be unified with any pre-defined existing intra cross-component model (e.g. CCCM using non-downsampled luma samples, GLM, MMLM) and/or the self-derivation only means the input of deriving model parameters is from the current chroma and collocated luma samples (for example, motion compensation results if the current block is inter).

[0202] In another embodiment, the self-derived cross-component candidate refers to one or more models and the models are used to generate the cross-component prediction of the current block as follows. The cross-component prediction (used for generating target predicted samples) of the current bock is formed by combining one or more proposed source terms and the models (referring to a proposed weighting setting). As shown in equation (3), pred(i, j) is a target (predicted) sample in the current block which can be obtained after our proposed mechanism, sourceTermSet0 includes one or more source terms from luma component, sourceTermSet1 includes one or more source terms from chroma components, and biasTermSet includes one or more bias terms.

[0203] Equation (3) is just an example and our proposed mechanism can use any subset or extension of sourceTermSet0, sourceTermSet1, and biasTermSet. Each sample or any subset of samples in the current block gets its target (predicted) sample according to the equation (3). In the following, the content of sourceTermSet0 is described in Section VII.1, "Content of sourceTermSet0(i, j)", the content of sourceTermSet1 is described in Section VII.2, "Content of sourceTermSet1(i, j)", the content of biasTermSet is described in Section VII.3, "Content of biasTermSet", and the predictor derivation using the proposed source terms and the proposed weighting setting is described in Section VII.4, "Predictor derivation for sample (i, j)". Several examples with our proposed mechanism are shown in Section VII.4, "Predictor derivation for sample (i, j)". Several examples with our proposed mechanism are shown in Section VII.4.

$$\text{pred}(i,j) = (\text{sourceTermSet0}(i,j) + \text{sourceTermSet1}(i,j) + \ldots + \text{biasTermSet}) \text{ with the proposed weighting setting where } (i,j) \text{ is a sample position in the current block.} \quad (3)$$

[0204] **VII.1. Content of sourceTermSet0(i, j)**

[0205] SourceTermSet0(i, j) includes one or more luma source terms denoted as sourceTerm00, sourceTerm01, …, and/or sourceTerm0n-1. The value of n means the number of taps for the source term set.

[0206] In one embodiment, the source terms can be linear terms and/or non-linear terms, only linear terms, and/or only non-linear terms.

[0207] In another embodiment, n is a pre-defined value, such as 1, 2, …or any positive integer. For example, the pre-defined value is fixed in the standard.

[0208] In another embodiment, n is determined by coding information of the current block and/or sample position (i, j). For example, when the current block is coded by a specific coding tool, n can be fixed at a pre-defined value for that specific coding tool.

[0209] In another embodiment, the pattern of the n taps refers to a pattern defined as any subset of a window region M x N around/including the position (iL, jL) as shown in Fig. 12A. If the target sample is luma, (iL,jL) is (i, j). If the target sample is chroma (e.g., Cb or Cr), (iL, jL) is the collocated luma position from (i, j).

[0210] For one example, only the centre (iL,jL) of the window is used as shown in Fig. 12A.

[0211] For another example of the pattern being 5x5 cross including or not excluding (iL,jL) as shown in Fig. 12B.

[0212] For a source term in the source term set, the following embodiments are used to determine generation of the source content.

[0213] In one embodiment, the source content is based on a predicted sample generated by a prediction mode and/or a reconstructed sample generated based on the predicted sample by a prediction mode and a reconstructed residual.

[0214] In another sub-embodiment, the source content is the filtered source or the source with any pre-processing. For example, the source content is the predicted/reconstructed sample after filtering with a pre-defined model or filter.

[0215] In another sub-embodiment, the source content is gradient information from the predicted samples and/or reconstructed samples. If the target sample (i, j) belongs to chroma and gradient information of the collocated luma sample (as the centre circle) is calculated with any one of the following Sobel filters (1310-1340) in Fig. 13 or any pre-defined filter. Each value around the centre circle is multiplied with the corresponding predicted/reconstructed samples in the collocated luma block and then added with each other to form the gradient information for the source term of the target sample (i, j).

[0216] In another sub-embodiment, since the target sample belongs to a chroma sample (e.g., Cb or Cr)), the predicted sample and/or the reconstructed sample is located within the collocated (luma) block from the current (chroma) block. The predicted sample and/or the reconstructed sample is treated as an initial sample and used as source content to generate the target sample.

[0217] In another embodiment, the source term may further include location information. For example, if the target sample refers to luma, the horizontal location (i) of (i, j) is used in a source term and the vertical location (j) of (i, j) is used in a source term; otherwise, the horizontal location of the collocated luma block from the sample (i, j) is used in a source term and the vertical location of the collocated luma block from the sample (i, j) is used in a source term.

[0218] In another embodiment, the source term may further include location information. For example, if the target sample refers to chroma, the horizontal location of the collocated luma from the sample (i, j) is used in a source term, and the vertical location of the collocated luma from the sample (i, j) is used in a source term.

[0219] **VII.2. Content of sourceTermSet1(i, j)**

[0220] SourceTermSet1(i, j) includes one or more chroma (Cb or Cr) source terms denoted as sourceTerm00, sourceTerm01, …, and/or sourceTerm0m-1. The value of m means the number of taps for the source term set. In one embodiment, the source terms can be linear terms and/or non-linear terms, only linear terms, and/or only non-linear terms. In another embodiment, m is a pre-defined value such as 1, 2, …or any positive integer. For example, the pre-defined value is fixed in the standard.

[0221] In another embodiment, m is determined according to coding information of the current block and/or sample position (i, j). For example, when the current block is coded by a specific coding tool, m is fixed at a pre-defined value for that specific tool.

[0222] In another embodiment, the pattern of the m taps refers to a pattern defined as any subset of an M2 x N2 window region around/including the position (iC, jC) as shown in Fig. 14A. If the target sample is chroma (Cb or Cr), (iC,jC) is (i, j). If the target sample is luma, (iC, jC) is the collocated chroma position from (i, j).

[0223] For one example, only the centre (iC,jC) of the window is used as shown in Fig. 14A.

[0224] For another example of the pattern being 5x5 cross: (including or not excluding (iC,jC)) as shown in Fig. 14B.

[0225] For a source term in the source term set, the following embodiments are used to determine generation of the source content.

[0226] In one embodiment, the source content is based on a predicted sample generated by a prediction mode and/or a reconstructed sample generated based on the predicted sample based on a prediction mode and a reconstructed residual.

[0227] In another sub-embodiment, the source content is the filtered source or the source with any pre-processing. For example, the source content is the predicted/reconstructed sample after filtering with a pre-defined model or filter.

[0228] In another sub-embodiment, the source content is gradient information from the predicted samples and/or reconstructed samples. If the target sample (i, j) belongs to luma, gradient information of the collocated chroma sample is calculated with any one of the Sobel filters or any pre-defined filter.

[0229] In another sub-embodiment, if the target sample belongs to a chroma sample, the predicted sample and/or the reconstructed sample is located within the current block. The predicted sample and/or the reconstructed sample is treated as an initial sample and used as the source content to generate the target sample.

[0230] In another embodiment, the source term may further include location information. For example, if the target sample refers to chroma, the horizontal location (i) of (i, j) is used in a source term and the vertical location (j) of (i, j) is used in a source term.

[0231] **VII.3. Content of biasTermSet**

[0232] Bias term is a pre-defined value. In one embodiment, the bias term is a midValue according to bitDepth specified in the standard. For example, the bias term is set as $(1 \ll (bitDepth - 1))$. In another embodiment, the bias term is the same for each sample in the current block. That is, the bias term is independent of the position (i, j).

[0233] **VII.4. Predictor Derivation for Sample (i, j)**

[0234] VII.4.1. Proposed Weighting Setting

[0235] The proposed weighting setting is to estimate the relationship (e.g. minimizing the distortion) between "the predicted and/or reconstructed samples on the reference region of the current (chroma) block" and "the predicted and/or reconstructed samples on the reference region of the corresponding luma block" by a pre-defined regression method, and to generate a weighting (referring to model parameters) according to the regression method. The weighting derived is then applied on the source terms to get the target (predicted) samples in the current block. In one embodiment, the pre-defined regression method can be linear minimum mean square error (LMMSE) method for CCLM or can be any unified method with the regression method used for CCLM. In another embodiment, the pre-defined regression method can be the LDL decomposition method for CCCM or can be any unified method with the regression method used for CCCM. In another embodiment, the pre-defined regression method can be Gaussian elimination.

[0236] In one embodiment, the reference region of the current block is the spatial neighbouring region of the current block 1510 as shown in Fig. 15. The spatial neighbouring region of the current block includes above reference region 1520, left reference region 1530, above-left reference region 1540, and/or any subset of the above. The size of the above reference region is A_W x A_H, the size of the left reference region is L_W x L_H, and the size of the above-left reference is AL_W x AL_H, where

- A_W = block width of the current block (W), k*W, W + block height of the current block (H), any pre-defined value, or any adaptive value depending on the block position, block width, block height, and/or block area of the current block.

- A_H or AL_H = H, any pre-defined value (1, 2, 4, ...), or any adaptive value depending on the block position, block width, block height, and/or block area of the current block.
- L_W or AL_W = W, any pre-defined value (1, 2, 4, ...), or any adaptive value depending on the block position, block width, block height, and/or block area of the current block.
- L_H = H, k*H, H + W, any pre-defined value, or any adaptive value depending on the block position, block width, block height, and/or block area of the current block.

[0237] The reference region of the corresponding luma block is the spatial neighbouring region of the corresponding luma block.

[0238] In another embodiment, the reference region of the current block is the vector-collocated region of the current block and the reference region of the corresponding luma block is the vector-collocated region of the corresponding luma block. For inter coding unit containing luma and chroma blocks, the vector- collocated region of the current block refers to the motion compensated results obtained by using the motion information (motion vectors and reference pictures) of the current block, and the vector-collocated region of the corresponding luma block refers to the motion compensated results obtained by using the motion information (motion vectors and reference pictures) of the corresponding luma block. For IBC or intraTMP, the vector-collocated region of the current block refers to the motion compensated results obtained by using the motion information (e.g. block vectors and current picture) of the current block, and the vector-collocated region of the corresponding luma block refers to the motion compensated results obtained by using the motion information (e.g. block vectors and current picture) of the corresponding luma block.

[0239] In another embodiment, the above-proposed two kinds of the reference region of the current block can be used together. For example, generally, samples in the vector-collocated region of the current block are used as input samples during deriving model parameters; however, for a smaller block, samples in the spatial neighbouring reference region are used as additional input samples when deriving model parameters.

[0240] The term “block” in this invention can refer to TU/TB, CU/CB, PU/PB, or CTU/CTB.

[0241] The term “LM” in this invention can be viewed as one kind of CCLM/MMLM modes or any other extension/variation of CCLM (e.g. the proposed CCLM extension/variation in this invention). One variation is MMLM which uses thresholds to decide different models for different samples in the current chroma component. Another variation is that for Cb (or Cr), deriving model parameters from multiple collocated luma blocks. The following show more possible variations. The variations of CCLM here mean that some optional modes can be selected when the block indication refers to using one of cross-component modes (e.g. CCLM_LT, MMLM_LT, CCLM_L, CCLM_T, MMLM_L, MMLM_T, and/or an intra prediction mode, which is not one of traditional DC, planar, and angular modes) for the current block. The following shows an example of using the convolutional cross-component mode (CCCM) as an optional mode. When this optional mode is applied to the current block, cross-component information with a model, including non-linear term, is used to generate the chroma prediction. The optional mode may follow the template selection of CCLM, so CCCM family includes CCCM_LT CCCM_L, and/or CCCM_T.

[0242] The proposed methods (for CCLM) in this invention can be used for any other cross-component modes.

[0243] Any combination of the proposed methods in this invention can be applied.

[0244] Any of the foregoing proposed methods of cross-component prediction by using cross-component prediction models derived from a RPR (Reference Picture Resampling) reference picture can be implemented in encoders and/or decoders. For example, any of the proposed methods can be implemented in an inter, intra, prediction, IBC, transform, quantization module or a combination of them at an encoder side, and/or an inter, intra/prediction, IBC, transform, quantization module or a combination of them at a decoder side. Alternatively, any of the proposed methods can be implemented as a circuit coupled to the inter, intra, prediction, transform, quantization module or a combination of them at the encoder and/or the inter, intra, prediction, IBC, transform, quantization module of the decoder, so as to provide the information needed by the inter/intra/prediction/IBC/transform/quantization module.

[0245] The cross-component prediction models derived from a RPR (Reference Picture Resampling) reference picture as described above can be implemented in an encoder side or a decoder side. For example, any of the proposed method can be implemented in an Intra/Inter coding module (e.g. Intra Pred. 150/MC 152 in Fig. 1B) in a decoder or an Intra/Inter coding module is an encoder (e.g. Intra Pred. 110/Inter Pred. 112 in Fig. 1A). Any of the proposed methods can also be implemented as a circuit coupled to the intra/inter coding module at the decoder or the encoder. However, the decoder or encoder may also use additional processing unit to implement the proposed method. While the Intra Pred./MC units (e.g. unit 110/112 in Fig. 1A and unit 150/152 in Fig. 1B) are shown as individual processing units, they may correspond to executable software or firmware codes stored on a media, such as hard disk or flash memory, for a CPU (Central Processing Unit) or programmable devices (e.g. DSP (Digital Signal Processor) or FPGA (Field Programmable Gate Array)).

[0246] Fig. 16 illustrates a flowchart of an exemplary video coding system that incorporates cross-component prediction models derived from a RPR reference picture according to an embodiment of the present invention. The steps shown in the flowchart may be implemented as program codes executable on one or more processors (e.g., one or more CPUs) at the encoder or decoder side. The steps shown in the flowchart may also be implemented based hardware such as one or more electronic devices or processors arranged to perform the steps in the flowchart. According to this method, input data associated with a current block comprising a first-colour block and a second-colour block is received in step 1610, wherein the input data comprise pixel data to be encoded at an encoder side or data associated with the current block to be decoded at a decoder side, and wherein the current block is coded in a non-intra mode. A collocated picture is selected from one or more reference picture lists according to one or more pre-defined rules in step 1620. Whether the collocated picture selected is a RPR (Reference Picture Resampling) picture is determined in step 1630. A current CCP (Cross-Component Prediction) model is derived from the collocated picture depending on whether the collocated picture is the RPR picture or not in step 1640. The current second-colour block is encoded or decoded by using a candidate list comprising the current CCP model in step 1650, wherein when the current CCP model is selected to code the current second-colour block, prediction data for the current second-colour block is generated by applying the current CCP model to the current first-colour block.

[0247] The flowchart shown is intended to illustrate an example of video coding according to the present invention. A person skilled in the art may modify each step, re-arranges the steps, split a step, or combine steps to practice the present invention without departing from the spirit of the present invention. In the disclosure, specific syntax and semantics have been used to illustrate examples to implement embodiments of the present invention. A skilled person may practice the present invention by substituting the syntax and semantics with equivalent syntax and semantics without departing from the spirit of the present invention.

[0248] The above description is presented to enable a person of ordinary skill in the art to practice the present invention as provided in the context of a particular application and its requirement. Various modifications to the described embodiments will be apparent to those with skill in the art, and the general principles defined herein may be applied to other embodiments. Therefore, the present invention is not intended to be limited to the particular embodiments shown and described, but is to be accorded the widest scope consistent with the principles and novel features herein disclosed. In the above detailed description, various specific details are illustrated in order to provide a thorough understanding of the present invention. Nevertheless, it will be understood by those skilled in the art that the present invention may be practiced.

[0249] Embodiment of the present invention as described above may be implemented in various hardware, software codes, or a combination of both. For example, an embodiment of the present invention can be one or more circuit circuits integrated into a video compression chip or program code integrated into video compression software to perform the processing described herein. An embodiment of the present invention may also be program code to be executed on a Digital Signal Processor (DSP) to perform the processing described herein. The invention may also involve a number of functions to be performed by a computer processor, a digital signal processor, a microprocessor, or field programmable gate array (FPGA). These processors can be configured to perform particular tasks according to the invention, by executing machine-readable software code or firmware code that defines the particular methods embodied by the invention. The software code or firmware code may be developed in different programming languages and different formats or styles. The software code may also be compiled for different target platforms. However, different code formats, styles and languages of software codes and other means of configuring code to perform the tasks in accordance with the invention will not depart from the spirit and scope of the invention.

[0250] The invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described examples are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

CLAIMS:

1. A method of coding colour pictures using coding tools including one or more cross component models related modes, the method comprising:

receiving input data associated with a current block comprising a current first-colour block and a current second-colour block, wherein the input data comprise pixel data to be encoded at an encoder side or data associated with the current block to be decoded at a decoder side, and wherein the current block is coded in a non-intra mode;

selecting a collocated picture from one or more reference picture lists according to one or more pre-defined rules;

determining whether the collocated picture selected is a RPR (Reference Picture Resampling) picture;

deriving a current CCP (Cross-Component Prediction) model from the collocated picture depending on whether the collocated picture is the RPR picture or not; and

encoding or decoding the current second-colour block by using a candidate list comprising the current CCP model, wherein when the current CCP model is selected to code the current second-colour block, prediction data for the current second-colour block is generated by applying the current CCP model to the current first-colour block.

2. The method of Claim 1, wherein said one or more pre-defined rules are related to information comprising L0[0], L1[0], POC distance, QP value, or a combination thereof.

3. The method of Claim 1, wherein whether the collocated picture selected is the RPR picture is indicated by a flag signalled or parsed in a bitstream.

4. The method of Claim 1, wherein the collocated picture selected is the RPR picture if the collocated picture and a current picture containing the current block have one or more of target parameters different.

5. The method of Claim 4, wherein said one or more of target parameters comprise picture width in luma samples, picture height in the luma samples, scaling window left offset, scaling window right offset, scaling window top offset, scaling window bottom offset, number of sub pictures, or a combination thereof.

6. The method of Claim 1, wherein the collocated picture is selected from one or more un-rescaled pictures in said one or more reference picture lists.

7. The method of Claim 1, wherein a target picture is selected from un-rescaled pictures in said one or more reference picture lists as the collocated picture, and wherein the target picture is selected based on POC (Picture order Count) difference with a current picture, POC value, QP difference with a current picture, QP value, reference list or the combination thereof.

8. The method of Claim 1, wherein if the collocated picture selected is the RPR picture, inheriting CCM information from the collocated picture is disabled.

9. The method of Claim 1, wherein if the collocated picture selected is the RPR picture, CCM information from the collocated picture is retrieved from a scaled position according to a scaling ratio.

10. The method of Claim 9, wherein the scaling ratio is derived based on a scaling window of a current picture and the collocated picture.

11. The method of Claim 10, wherein if a current position and the scaling ratio are represented as (x,y) and R respectively, a scaled position is determined according to (x/R,y/R) after a rounding process.

12. The method of Claim 11, wherein the rounding process corresponds to rounding toward negative infinity, rounding toward positive infinity, rounding toward zero, or rounding to a nearest integer.

13. The method of Claim 1, wherein the current CCP model from the collocated picture is determined according to a motion vector of a neighbouring block, and the neighbouring block is selected from a list of pre-defined positions.

14. The method of Claim 13, wherein the neighbouring block is selected from the list of pre-defined positions according to a pre-defined checking order.

15. The method of Claim 14, wherein the pre-defined checking order corresponds to L0 motion vectors or L1 motion vectors being checked first, and a target motion vector associated with a non-scaled reference picture first is selected.

16. The method of Claim 1, wherein if a target reference picture located by a motion vector is the RPR picture, the motion vector is considered as no CCM information is located by the motion vector.

17. The method of Claim 1, wherein if a target reference picture located by a motion vector is the RPR picture, CCM information is retrieved from the target reference picture at a scaled position according to a scaling ratio.

18. An apparatus for coding colour pictures or video using coding tools including one or more cross component models related modes, the apparatus comprising one or more electronic circuits or processors arranged to:

receive input data associated with a current block comprising a current first-colour block and a current second-colour block, wherein the input data comprise pixel data to be encoded at an encoder side or data associated with the current block to be decoded at a decoder side, and wherein the current block is coded in a non-intra mode;

select a collocated picture from one or more reference picture lists according to one or more pre-defined rules;

determine whether the collocated picture selected is a RPR (Reference Picture Resampling) picture;

derive a current CCP (Cross-Component Prediction) model from the collocated picture depending on whether the collocated picture is the RPR picture or not; and

encode or decode the current second-colour block by using a candidate list comprising the current CCP model, wherein when the current CCP model is selected to code the current second-colour block, prediction data for the current second-colour block is generated by applying the current CCP model to the current first-colour block.

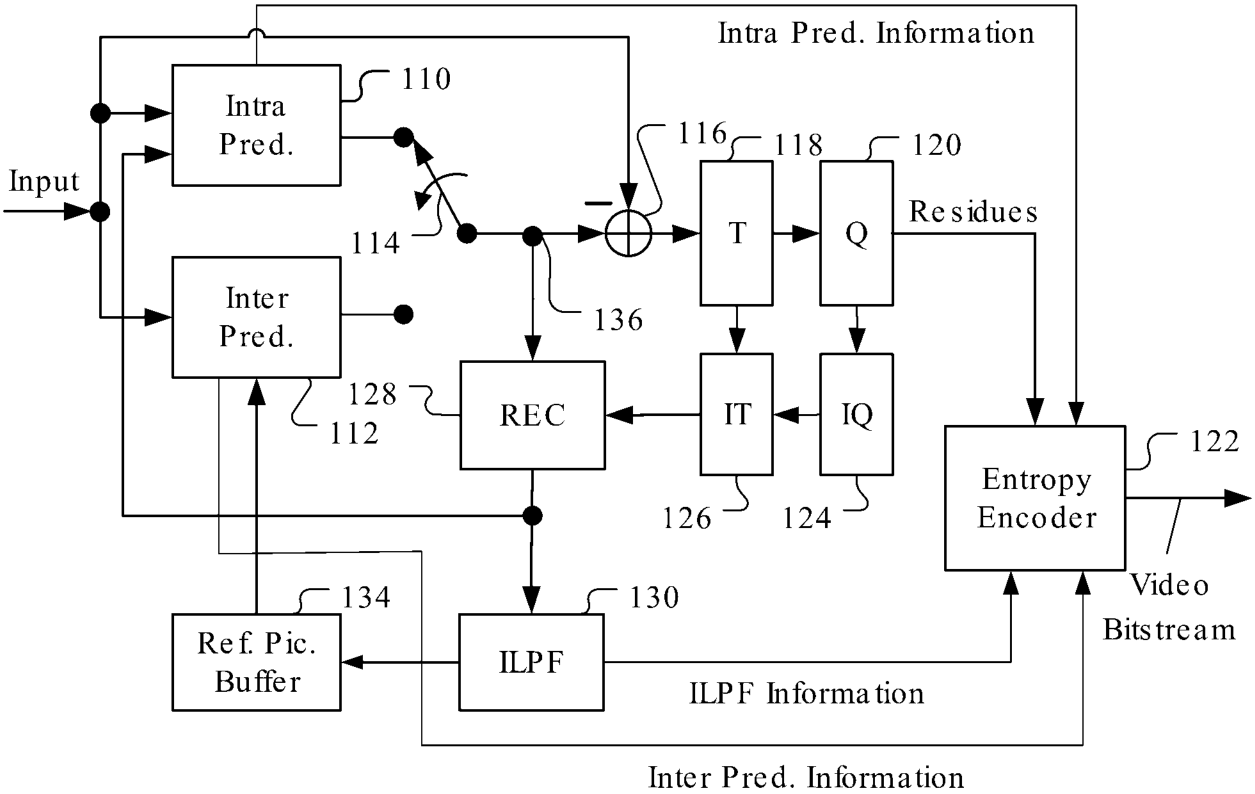
Intra Pred. Information
Intra Pred.
110
Input
116
118
120
T
Q
Residues
114
136
Inter Pred.
128
REC
IT
IQ
112
Entropy Encoder
122
126
124
Video Bitstream
134
130
Ref. Pic. Buffer
ILPF
ILPF Information
Inter Pred. Information

Fig. 1A

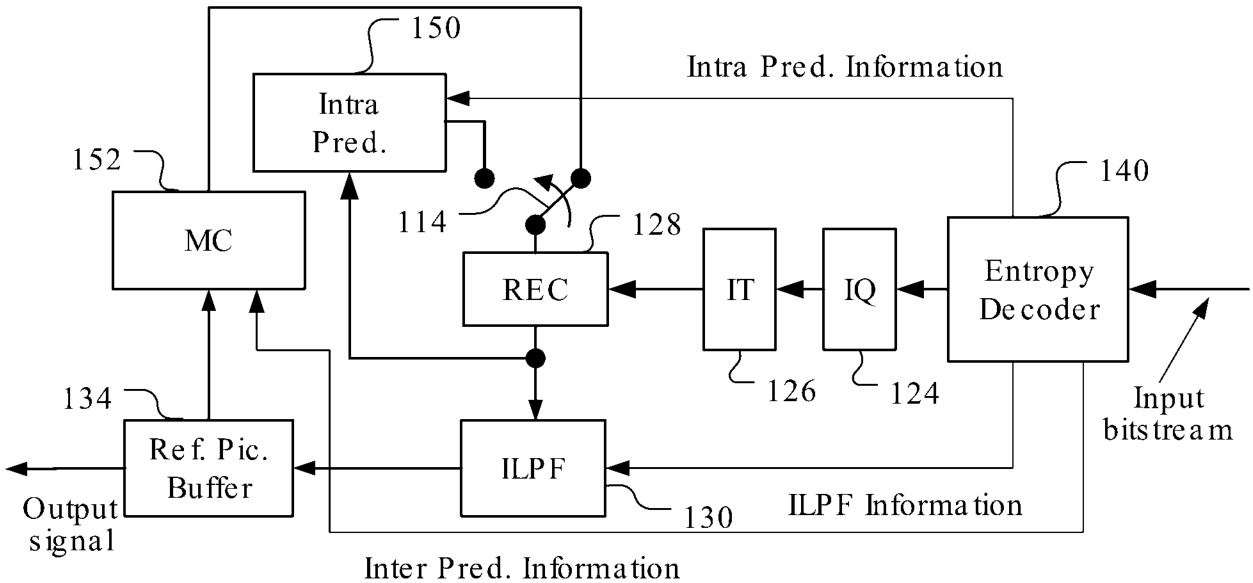
150
Intra Pred. Information
Intra Pred.
152
140
MC
114
128
REC
IT
IQ
Entropy Decoder
126
124
134
Input bitstream
Ref. Pic. Buffer
ILPF
Output signal
130
ILPF Information
Inter Pred. Information

Fig. 1B

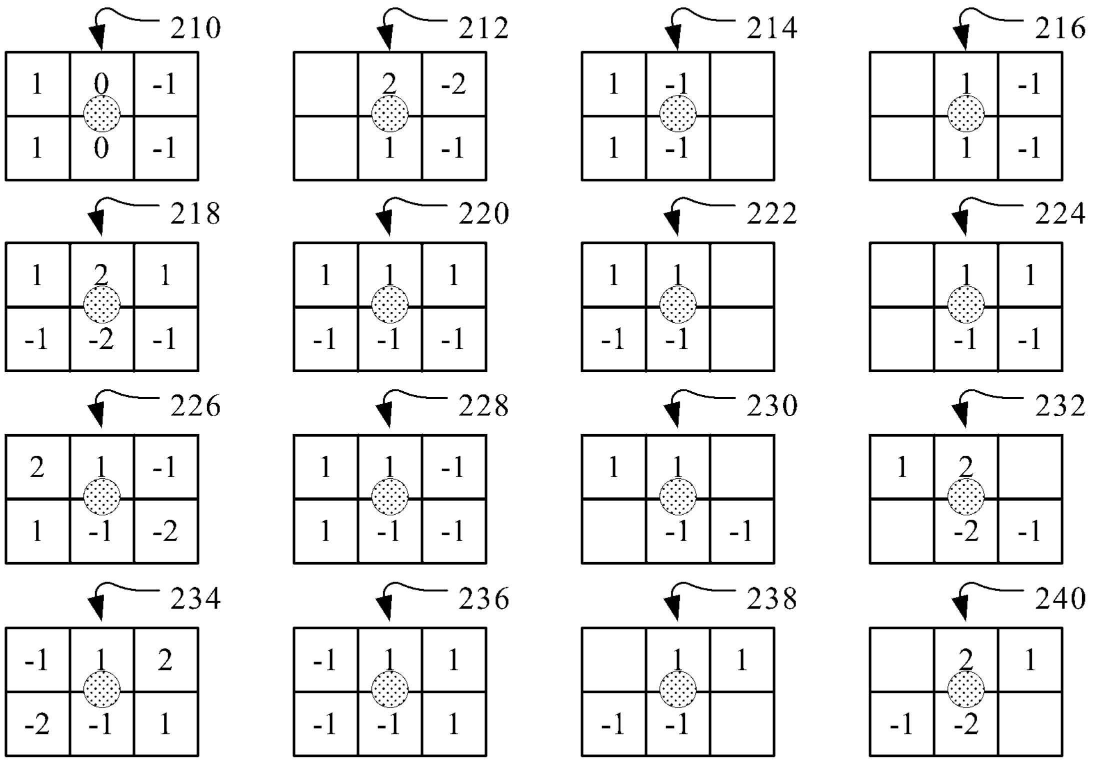

Fig. 2

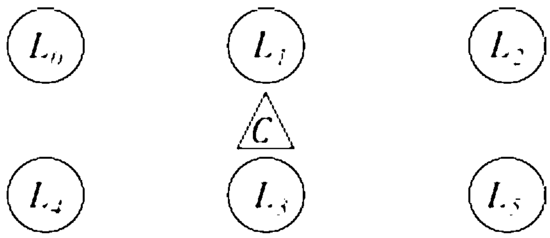

Fig. 3

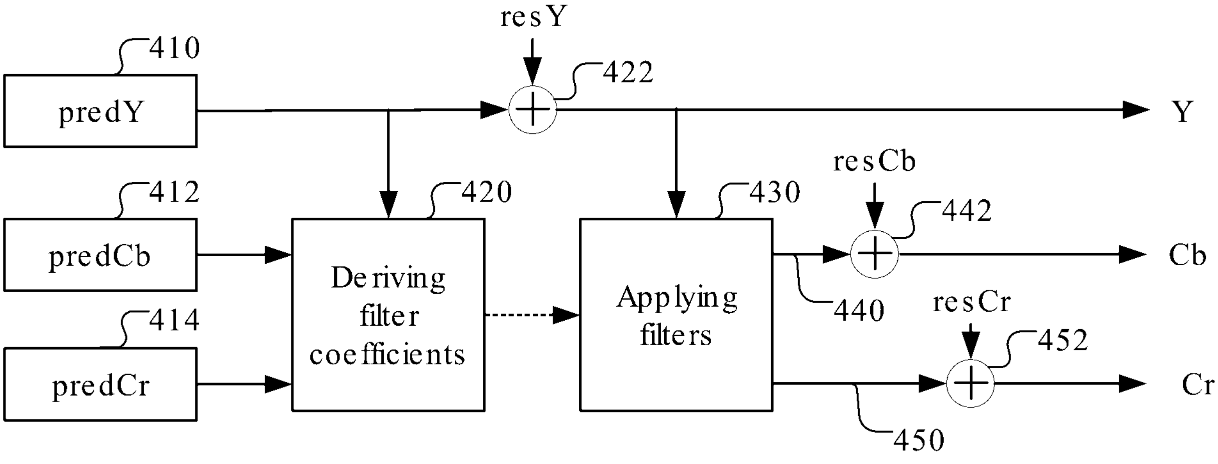

Fig. 4

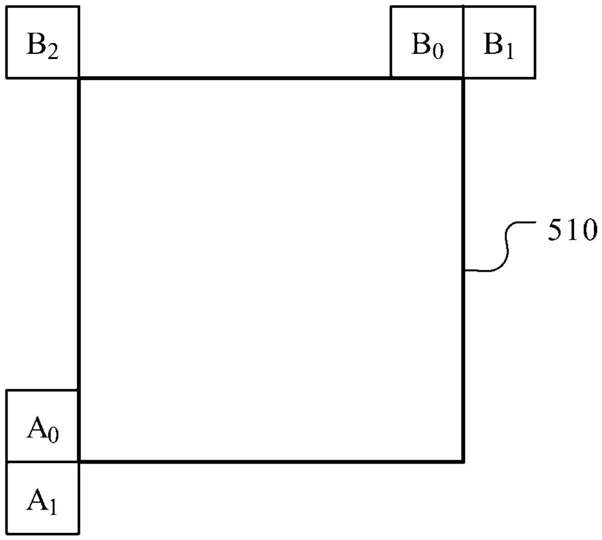
B2
B0
B1
510
A0
A1

Fig. 5

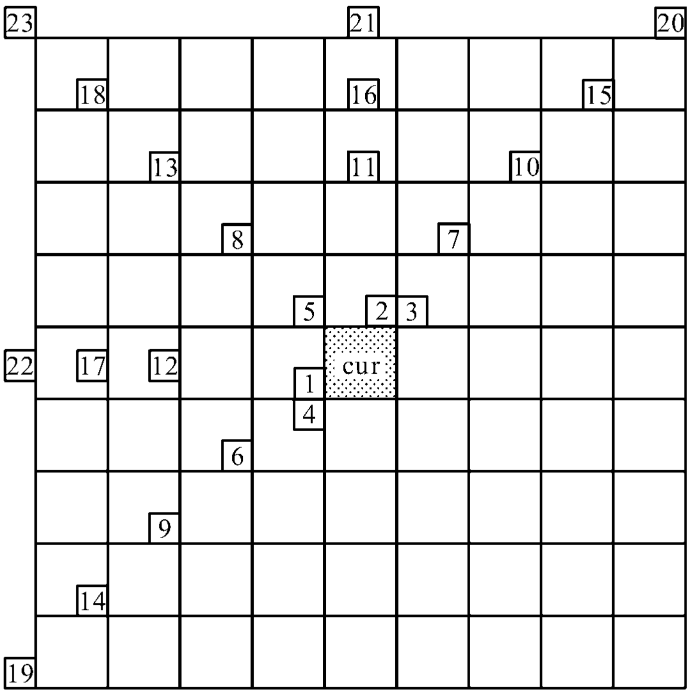
23
21
20
18
16
15
13
11
10
8
7
5
2
3
22
17
12
cur
1
4
6
9
14
19

Fig. 6

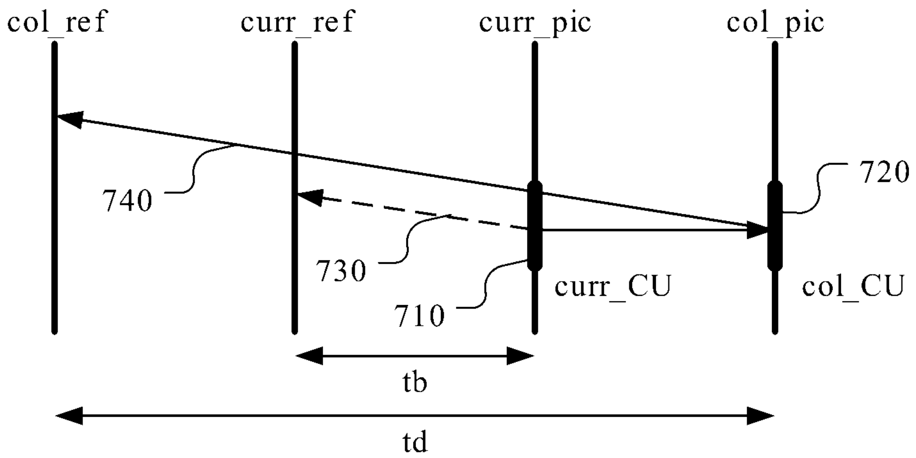
col_ref
curr_ref
curr_pic
col_pic
720
740
730
curr_CU
col_CU
710
tb
td

Fig. 7

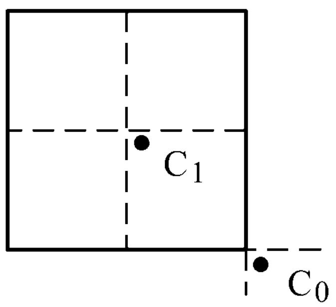
C1
C0

Fig. 8

Pattern 1

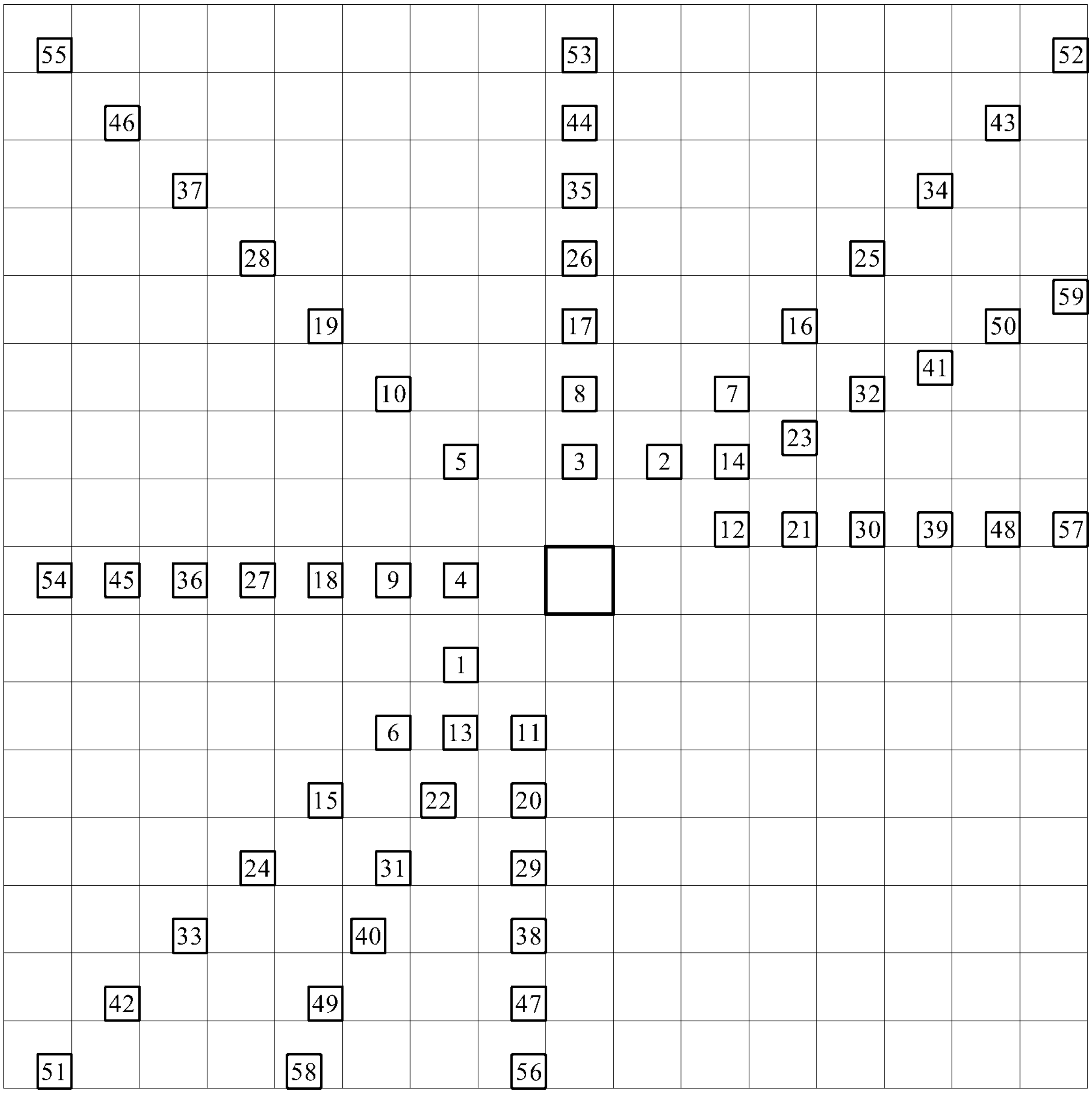

Fig. 9A

Pattern 2

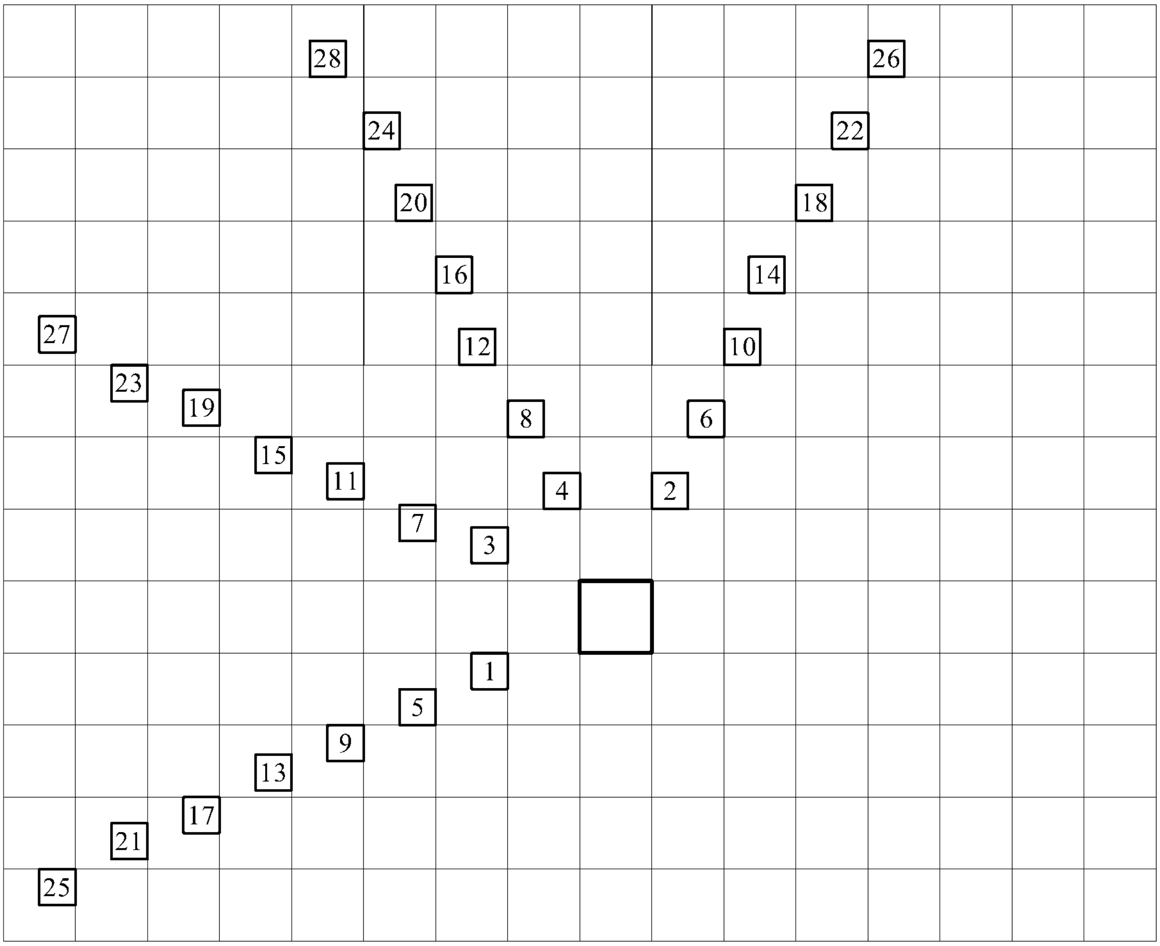

Fig. 9B

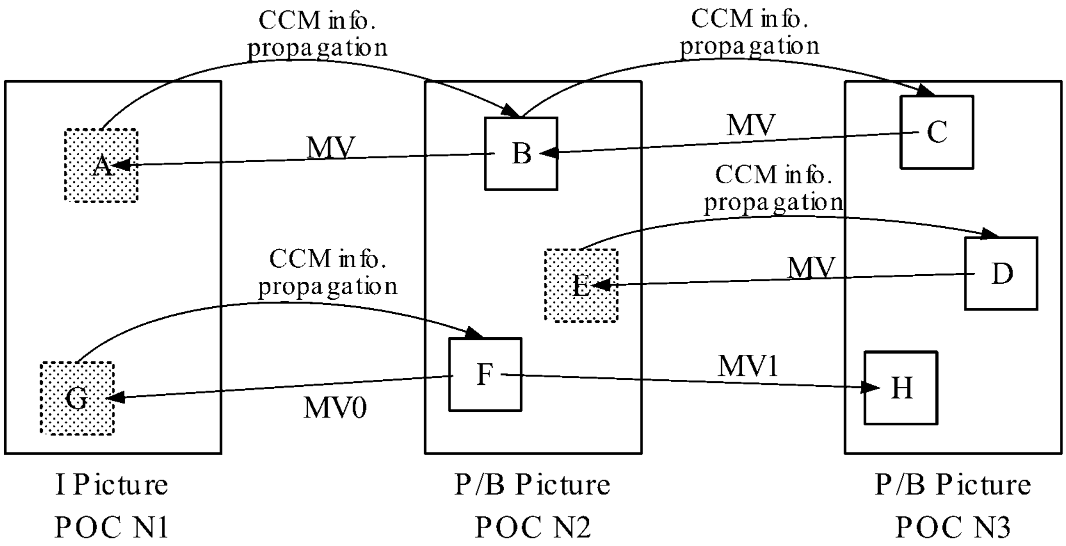
CCM info.
propagation
CCM info.
propagation
A
MV
B
MV
C
CCM info.
propagation
E
MV
D
CCM info.
propagation
G
MV0
F
MV1
H
I Picture
POC N1
P/B Picture
POC N2
P/B Picture
POC N3

Fig. 10

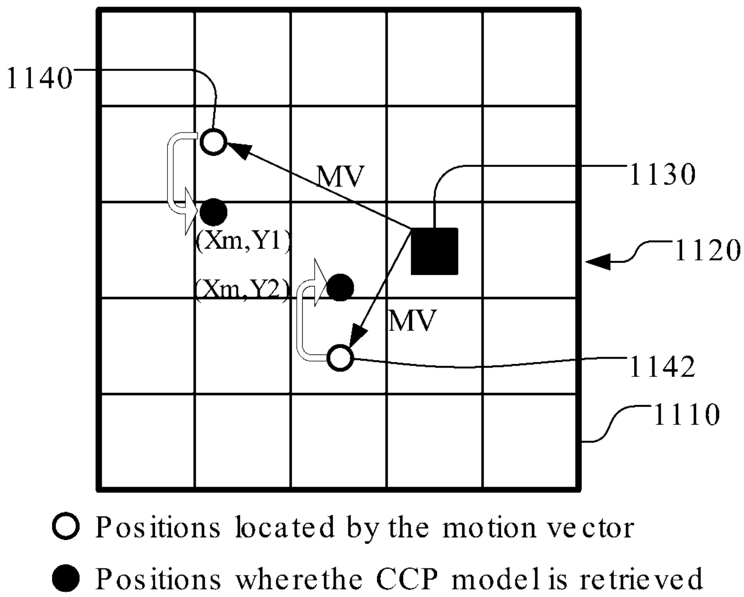
1140
MV
1130
(Xm,Y1)
1120
(Xm,Y2)
MV
1142
1110
Positions located by the motion vector
Positions wherethe CCP model is retrieved

Fig. 11

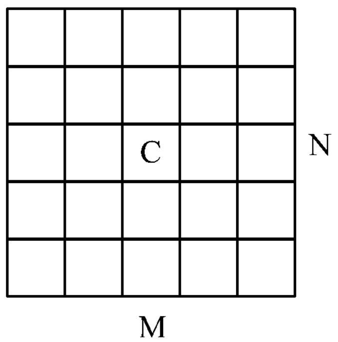

Fig. 12A

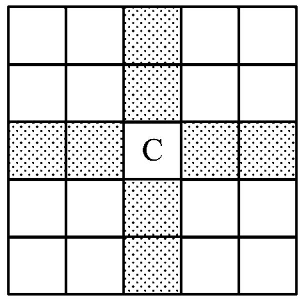

Fig. 12B

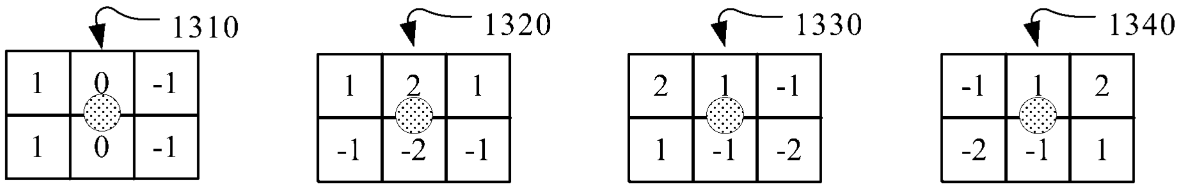

Fig. 13

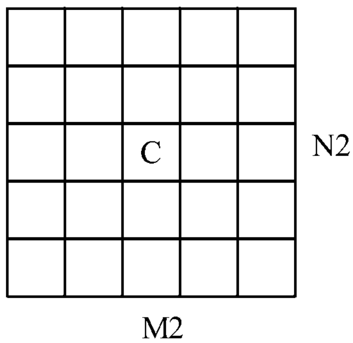

Fig. 14A

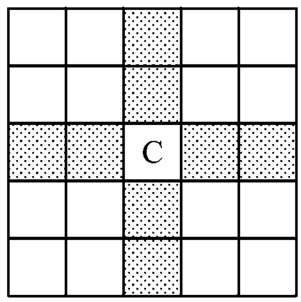

Fig. 14B

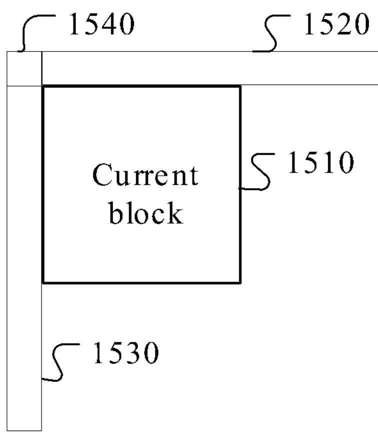

Fig. 15

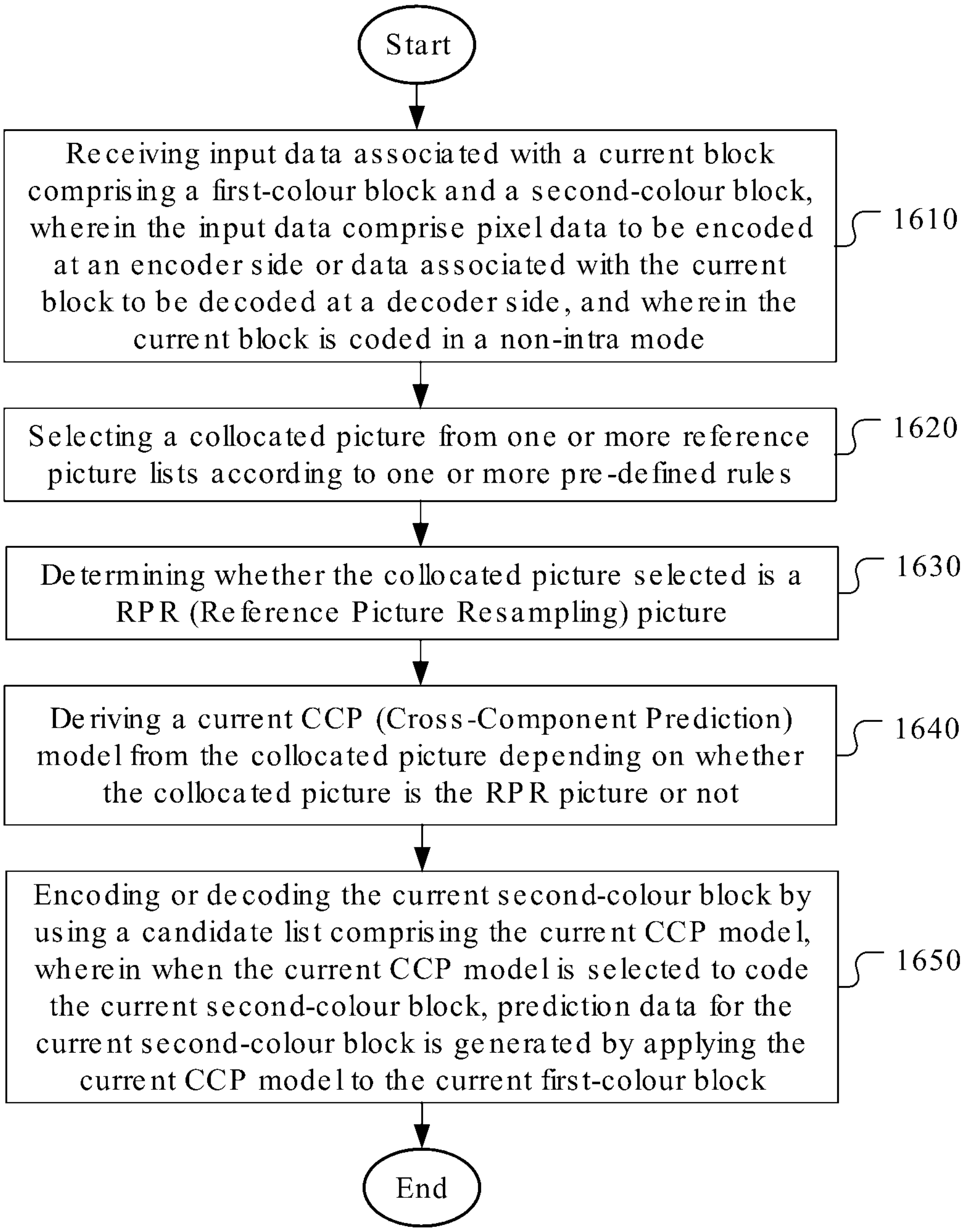
Start
Receiving input data associated with a current block comprising a first-colour block and a second-colour block, wherein the input data comprise pixel data to be encoded at an encoder side or data associated with the current block to be decoded at a decoder side, and wherein the current block is coded in a non-intra mode
1610
Selecting a collocated picture from one or more reference picture lists according to one or more pre-defined rules
1620
Determining whether the collocated picture selected is a RPR (Reference Picture Resampling) picture
1630
Deriving a current CCP (Cross-Component Prediction) model from the collocated picture depending on whether the collocated picture is the RPR picture or not
1640
Encoding or decoding the current second-colour block by using a candidate list comprising the current CCP model, wherein when the current CCP model is selected to code the current second-colour block, prediction data for the current second-colour block is generated by applying the current CCP model to the current first-colour block
1650
End

Fig. 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/116726

A. CLASSIFICATION OF SUBJECT MATTER

H04N 19/176(2014.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT,ENTXT,ENTXTC,DWPI,JEVT:chroma,color,colour,CCP,CCRM,CCLM,MMLM,CCCM,Cross-Component Prediction, Cross-Component Residual Model, Cross-Component Linear Model, Cross Component Prediction, Cross Component Residual Model, Cross Component Linear Model, Multiple Model CCLM, Convolutional Cross-Component Model,Convolutional Cross Component Model,ARC,RPR, Reference Picture Resampling,collocated picture,reference picture list, candidate, encod+,decod+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 115176478 A (BEIJING BYTEDANCE NETWORK TECHNOLOGY CO., LTD. et al.) 11 October 2022 (2022-10-11) claim 1	1-18
A	CN 114223203 A (PANASONIC INTELLECTUAL PROPERTY CORPORATION OF AMERICA) 22 March 2022 (2022-03-22) the whole document	1-18
A	CN 115086671 A (LEMON INC.) 20 September 2022 (2022-09-20) the whole document	1-18
A	US 2022109868 A1 (BEIJING BYTEDANCE NETWORK TECHNOLOGY CO., LTD. et al.) 07 April 2022 (2022-04-07) the whole document	1-18

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 November 2024	**05 December 2024**

Name and mailing address of the ISA/CN	Authorized officer
CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	**LI,Jing** Telephone No. **(+86) 010-53961705**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2022180261 A1 (FRAUNHOFER-GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG E.V.) 01 September 2022 (2022-09-01) the whole document	1-18
A	CHEN,P. et al. "AHG8: Integrated Specification Text for Reference Picture Resampling" *Joint Video Experts Team (JVET) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11 15th Meeting: Gothenburg, SE, 3–12 July 2019,JVET-O1164-v1,* 12 July 2019 (2019-07-12), the whole document	1-18

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2024/116726

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	115176478	A	11 October 2022	WO	2021160176	A1	19 August 2021
				WO	2021160165	A1	19 August 2021
				WO	2021160175	A1	19 August 2021
				US	2024107006	A1	28 March 2024
				KR	20220131257	A	27 September 2022
				KR	20220138050	A	12 October 2022
				WO	2021160174	A1	19 August 2021
				US	2023009491	A1	12 January 2023
				WO	2021160172	A1	19 August 2021
				US	2022394304	A1	08 December 2022
				EP	4088463	A1	16 November 2022
				WO	2021160171	A1	19 August 2021
				JP	2023513343	A	30 March 2023
				US	2022394243	A1	08 December 2022
				US	2022400284	A1	15 December 2022
				BR	112022016125	A2	04 October 2022
				JP	2023513707	A	03 April 2023
				MX	2022009669	A	09 September 2022
				WO	2021160168	A1	19 August 2021
				JP	2023513709	A	03 April 2023
				KR	20220138051	A	12 October 2022
				KR	20220134561	A	05 October 2022
				WO	2021160167	A1	19 August 2021
				EP	4088462	A1	16 November 2022
				US	2022400256	A1	15 December 2022
				EP	4088473	A1	16 November 2022
				EP	4088453	A1	16 November 2022
				EP	4307669	A2	17 January 2024
				US	2022394244	A1	08 December 2022
				JP	2023513344	A	30 March 2023
				IN	202247045853	A	19 August 2022
CN	114223203	A	22 March 2022	JPWO	2021039871	A1	04 March 2021
				US	2024275949	A1	15 August 2024
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