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IMAGE DECODING APPARATUS AND IMAGE CODING APPARATUS

Abstract

Object
Known derivation, on a per intra prediction modes basis, of a template-based intra mode derivation based on a difference between a template prediction image and a template image has a problem that derivation of the template image and cost calculation require great computational resources.
Solution
Included are an intra prediction image generation unit configured to generate a template prediction image for an intra prediction mode candidate predetermined, a template cost derivation unit configured to derive a cost from the template prediction image and a template image corresponding to an image near a target block, and an intra prediction image generation unit configured to generate an intra prediction image by using a selected intra prediction mode, wherein the number of taps of an interpolation filter for the template prediction image is less than the number of taps of an interpolation filter for intra prediction.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] The present application is a continuation application of U.S. patent application Ser. No. 18/094,833, filed on Jan. 9, 2023, which claims priority from Japanese Patent Application No. 2022-153696 filed on Sep. 27, 2022, the content of which is hereby incorporated by reference into this application.

TECHNICAL FIELD
[0002] Embodiments of the present invention relate to an image decoding apparatus and an image coding apparatus.
BACKGROUND ART
[0003] A video coding apparatus which generates coded data by coding a video, and a video decoding apparatus which generates decoded images by decoding the coded data are used for efficient transmission or recording of videos.
[0004] For example, specific video coding schemes include schemes proposed in H.264/AVC, High-Efficiency Video Coding (HEVC), and Versatile Video Coding (VVC), and the like.
[0005] In such a video coding scheme, images (pictures) constituting a video are managed in a hierarchical structure including slices obtained by splitting an image, coding tree units (CTUs) obtained by splitting a slice, units of coding (which may also be referred to as coding units (CUs)) obtained by splitting a coding tree unit, and transform units (TUs) obtained by splitting a coding unit, and are coded/decoded for each CU.
[0006] In such a video coding scheme, usually, a prediction image is generated based on a local decoded image that is obtained by coding/decoding an input image (a source image), and prediction errors (which may be referred to also as "difference images" or "residual images") obtained by subtracting the prediction image from the input image are coded. Generation methods of prediction images include an inter-picture prediction (inter

prediction) and an intra-picture prediction (intra prediction).

[0007] In addition, the recent technology for video coding and decoding includes NPL 1. NPL 1 discloses a Template-based Intra Mode Derivation (TIMD) prediction in which a decoder generates a prediction image by deriving an intra-direction prediction mode number using pixels in an adjacent region.

CITATION LIST

Non Patent Literature

NPL 1

[0008] K. Cao, N. Hu, V. Seregin, M. Karczewicz, Y. Wang, K. Zhang, L. Zhang, "EE2-related Fusion for template-based intra mode derivation", JVET-W0123

SUMMARY OF INVENTION

Technical Problem

[0009] In template-based intra mode derivation such as in NPL 1, an image of a template reference region near a target block is used to generate a template prediction image from adjacent images (template images) of the target block for intra prediction mode candidates. Then, as an intra prediction mode of the target block, an intra prediction mode candidate is selected for which a cost for the template image and the template prediction image is reduced. However, a problem with the template-based intra mode derivation is the need for derivation of template prediction images for the multiple intra prediction mode candidates and cost calculation for the derivation, leading to the need for very large computational resources.

[0010] An object of the present invention is to reduce the complexity of the template-based intra mode derivation while maintaining the accuracy of the prediction image.

Solution to Problem

[0011] Included are a parameter decoder configured to decode coded data into a template-based intra prediction flag, a reference sample derivation unit configured to derive a reference sample by using an image of a template reference region near a target block, an intra prediction image generation unit configured to generate, by using the reference sample, a template prediction image for an intra prediction mode candidate predetermined, a template cost derivation unit configured to derive a cost from the template prediction image and a template image corresponding to an image near the target block, and an intra prediction mode selection unit configured to select an intra prediction mode for the target block based on the cost, wherein in a case that the prediction flag is a predetermined value, a prediction image of the target block is generated by using the selected intra prediction mode.

[0012] The reference sample derivation unit derives a pixel value of the reference sample by right-shifting a pixel value of the template reference region near the target block according to an image bit depth, and the cost derivation unit derives a pixel value of the template image by right-shifting pixel values of surrounding of the target block according to an image bit depth.

[0013] The intra prediction image generation unit references MTAP reference samples in a case of generating the template prediction image, and references NTAP reference samples in a case of generating the prediction image of the target block, and MTAP is smaller than NTAP.

[0014] Included are a parameter coder configured to code a template-based intra prediction flag from coded data, a reference sample derivation unit configured to derive a reference sample by using an image of a template reference region near a target block, an intra prediction image generation unit configured to generate, by using the reference sample, a template prediction image for an intra prediction mode candidate predetermined, a template cost derivation unit configured to derive a cost from the template prediction image and a template image corresponding to an image near the target block, and an intra prediction mode selection unit configured to select an intra prediction mode for the target block based on the cost, wherein in a case that the prediction flag is a predetermined value, a prediction image of the target block is generated by using the selected intra prediction mode.

[0015] The reference sample derivation unit derives a pixel value of the reference sample by right-shifting a pixel value of the template reference region near the target block according to an image bit depth, and the cost derivation unit derives a pixel value of the template image by right-shifting surrounding pixel values of the target block according to an image bit depth.

[0016] The intra prediction image generation unit references MTAP reference samples in a case of generating the template prediction image, and references NTAP reference samples in a case of generating the prediction image of the target block, and MTAP is smaller than NTAP.

Advantageous Effects of Invention

[0017] According to one aspect of the present invention, complexity of the template-based intra mode derivation can be reduced with the accuracy of the prediction image maintained.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0018] FIG. **1** is a schematic diagram illustrating a configuration of an image transmission system according to the present embodiment.

[0019] FIG. **2** is a diagram illustrating a hierarchical structure of data of a coding stream.

[0020] FIG. **3** is a schematic diagram illustrating types (mode numbers) of an intra prediction mode.

[0021] FIG. **4** is a schematic diagram illustrating a configuration of a video decoding apparatus.

[0022] FIG. **5** is a schematic diagram illustrating a configuration of an intra prediction image generation unit.

[0023] FIG. **6** is a diagram illustrating a relationship between a target block and a template region and a template reference region.

[0024] FIG. **7** is a diagram illustrating details of a TIMD prediction unit.

[0025] FIG. **8** is an example of a syntax related to TIMD prediction.

[0026] FIG. **9** is a diagram illustrating a configuration of a TIMD prediction unit realizing derivation of a template region and a template reference region that limit a bit depth of an image.

[0027] FIG. **10** is a diagram illustrating switching of the number of filter taps in template prediction image generation during an intra prediction mode search for TIMD prediction.

[0028] FIG. **11** is a block diagram illustrating a configuration of a video coding apparatus.

DESCRIPTION OF EMBODIMENTS

First Embodiment

[0029] Hereinafter, an embodiment of the present invention will be described with reference to the drawings.

[0030] FIG. **1** is a schematic diagram illustrating a configuration of an image transmission system **1** according to the present embodiment.

[0031] The image transmission system **1** is a system in which a coding stream obtained by coding a coding target image is transmitted, the transmitted coding stream is decoded, and thus an image is displayed. The image transmission system **1** includes a video coding apparatus (image coding apparatus) **11**, a network **21**, a video decoding apparatus (image decoding apparatus) **31**, and a video display apparatus (image display apparatus) **41**.

[0032] An image T is input to the video coding apparatus **11**.

[0033] The network **21** transmits a coding stream Te generated by the video coding apparatus **11** to the video decoding apparatus **31**. The network **21** is the Internet, a Wide Area Network (WAN), a Local Area Network (LAN), or a combination thereof. The network **21** is not necessarily limited to a

bi-directional communication network, and may be a unidirectional communication network configured to transmit broadcast waves of digital terrestrial television broadcasting, satellite broadcasting of the like. The network **21** may be substituted by a storage medium in which the coding stream Te is recorded, such as a Digital Versatile Disc (DVD: trade name) or a Blu-ray Disc (BD: trade name).

[0034] The video decoding apparatus **31** decodes each of the coding streams Te transmitted from the network **21** and generates one or multiple decoded images Td.

[0035] The video display apparatus **41** displays all or part of one or multiple decoded images Td generated by the video decoding apparatus **31**. For example, the video display apparatus **41** includes a display device such as a liquid crystal display and an organic Electro-Luminescence (EL) display. Forms of the display include a stationary type, a mobile type, an HM D type, and the like. In a case that the video decoding apparatus **31** has a high processing capability, an image having high image quality is displayed, and in a case that the apparatus has a lower processing capability, an image which does not require high processing capability and display capability is displayed.

Operator

[0036] Operators used in the present specification will be described below. [0037] >> denote a right bit shift, << denotes a left bit shift, & denotes a bitwise AND, | denotes a bitwise OR, {circumflex over ( )}denotes a bitwise XOR, |=denotes an OR assignment operator, ! denotes a logical negation (NOT), & & denotes a logical product (AND), and ‖ denotes a logical sum (OR). [0038] x? y: z is a ternary operator that takes y in a case that x is true (other than 0) and takes z in a case that x is false (0). [0039] Clip3 (a, b, c) is a function to clip c in a value equal to or greater than a and less than or equal to b, and a function to return a in a case that c is less than a (c<a), return b in a case that c is greater than b (c>b), and return c in other cases (provided that a is less than or equal to b (a ⇐b)). [0040] Clip1Y (c) is an operator that sets, in Clip3 (a, b, c), a=0 and b=(1<<BitDepthY) −1. [0041] BitDepthY is a bit depth of luminance. [0042] abs (a) is a function that returns the absolute value of a. [0043] Int (a) is a function that returns the integer value of a. [0044] Floor (a) is a function that returns the maximum integer equal to or less than a. [0045] Log 2 (a) is a logarithm function that returns a logarithm of a to base **2**. [0046] Ceil (a) is a function that returns the minimum integer equal to or greater than a. [0047] a/d represents division of a by d (round down decimal places). [0048] Min(a) is a function that returns a smaller value of a and b.

Structure of Coding Stream Te

[0049] Prior to the detailed description of the video coding apparatus **11** and the video decoding apparatus **31** according to the present embodiment, a data structure of the coding stream Te generated by the video coding apparatus **11** and decoded by the video decoding apparatus **31** will be described.

[0050] FIG. **2** is a diagram illustrating the hierarchy structure of data in the coding stream Te. The coding stream Te includes a sequence and multiple pictures constituting the sequence illustratively. FIG. **2** depicts a diagram illustrating a coded video sequence defining a sequence SEQ, a coded picture prescribing a picture PICT, a coding slice prescribing a slice S, a coding slice data prescribing slice data, a coding tree unit included in the coding slice data, and a coding unit included in the coding tree unit.

Coded Video Sequence

[0051] In the coded video sequence, a set of data referenced by the video decoding apparatus **31** to decode the sequence SEQ to be processed is defined. As illustrated in the coded video sequence of FIG. **2**, the sequence SEQ includes a Video Parameter Set VPS, a Sequence Parameter Set SPS, a Picture Parameter Set PPS, a picture PICT, and Supplemental Enhancement Information SEI.

[0052] In the video parameter set VPS, in a video including multiple layers, a set of coding parameters common to multiple videos and a set of coding parameters associated with the multiple layers and an individual layer included in the video are defined.

[0053] In the sequence parameter set SPS, a set of coding parameters referenced by the video decoding apparatus **31** to decode a target sequence is defined. For example, a width and a height of a picture are defined. Note that multiple SPSs may exist. In that case, any of the multiple SPSs is selected from the PPS.

[0054] In the picture parameter set PPS, a set of coding parameters referenced by the video decoding apparatus **31** to decode each picture in a target sequence is defined. For example, a reference value (pic_init_qp_minus26) of a quantization step size used for decoding of a picture and a flag (weighted_pred_flag) indicating an application of a weight prediction are included. Note that multiple PPSs may exist. In that case, any of the multiple PPSs is selected from each picture in a target sequence.

Coded Picture

[0055] In the coded picture, a set of data referenced by the video decoding apparatus **31** to decode the picture PICT to be processed is defined. As illustrated in a coded picture in FIG. **2**, the picture PICT includes a slice 0 to a slice NS−1 (NS is the total number of slices included in the picture PICT).

[0056] Note that in a case that it is not necessary to distinguish each of the slice 0 to the slice NS−1 below, subscripts of reference signs may be omitted. The same applies to other data with subscripts included in the coding stream Te which will be described below.

Coding Slice

[0057] In the coding slice, a set of data referenced by the video decoding apparatus **31** to decode the slice S to be processed is defined. As illustrated in a coding slice in FIG. **2**, the slice includes a slice header and slice data.

[0058] The slice header includes a coding parameter group referenced by the video decoding apparatus **31** to determine a decoding method for a target slice. Slice type indication information (slice_type) indicating a slice type is one example of a coding parameter included in the slice header.

[0059] Examples of slice types that can be specified by the slice type specification information include (1) I slice using only an intra prediction in coding, (2) P slice using a unidirectional prediction or an intra prediction in coding, and (3) B slice using a unidirectional prediction, a bidirectional prediction, or an intra prediction in coding, and the like. Note that the inter prediction is not limited to a uni-prediction and a bi-prediction, and the prediction image may be generated by using a larger number of reference pictures. Hereinafter, in a case of being referred to as the P or B slice, a slice that includes a block in which the inter prediction can be used is indicated.

[0060] Note that the slice header may include a reference to the picture parameter set PPS (pic_parameter_set_id).

Coding Slice Data

[0061] In the coding slice data, a set of data referenced by the video decoding apparatus **31** to decode the slice data to be processed is defined. The slice data includes CTUs as illustrated in the coding slice header in FIG. **2**. The CTU is a block of a fixed size (for example, 64×64) constituting a slice, and may also be called a Largest Coding Unit (LCU).

Coding Tree Unit

[0062] In the coding tree unit in FIG. **2**, a set of data is defined that is referenced by the video decoding apparatus **31** to decode the CTU to be processed. The CTU is split into coding unit CUs, each of which is a basic unit of coding processing, by a recursive Quad Tree split (QT split), Binary Tree split (BT split), or Ternary Tree split (TT split). The BT split and the TT split are collectively referred to as a Multi Tree split (MT split). Nodes of a tree structure obtained by recursive quad tree splits are referred to as Coding Nodes. Intermediate nodes of a quad tree, a binary tree, and a ternary tree are coding nodes, and the CTU itself is also defined as the highest coding node.

Coding Unit

[0063] As illustrated in the coding unit in FIG. **2**, a set of data is defined that is referenced by the video decoding apparatus **31** to decode the coding unit to be processed. Specifically, the CU includes a CU header CUH, a prediction parameter, a transform parameter, a quantization transform coefficient, and the like. In the CU header, a prediction mode and the like are defined.

[0064] There are cases that the prediction processing is performed in units of CU or performed in units of sub-CU in which the CU is further split. In a case that the sizes of the CU and the sub-CU are equal to each other, the number of sub-CUs in the CU is one. In a case that the CU is larger in size than the sub-CU, the CU is split into sub-CUs. For example, in a case that the CU has a size of 8×8, and the sub-CU has a size of 4×4, the CU is split

into four sub-CUs which include two horizontal splits and two vertical splits.

[0065] There are two types of predictions (prediction modes), which are intra prediction and inter prediction. The intra prediction refers to a prediction in an identical picture, and the inter prediction refers to prediction processing performed between different pictures (for example, between pictures of different display times, and between pictures of different layer images).

[0066] Transform and quantization processing is performed in units of CU, but the quantization transform coefficient may be subjected to entropy coding in units of subblock such as 4×4.

Prediction Parameter

[0067] A prediction image is derived by prediction parameters accompanying a block. The prediction parameters include prediction parameters for intra prediction and inter prediction.

[0068] The prediction parameters for intra prediction will be described below. The intra prediction parameters include a luminance prediction mode IntraPredModeY and a chrominance prediction mode IntraPredModeC. FIG. **3** is a schematic diagram illustrating types (mode numbers) of an intra prediction mode. As illustrated in FIG. **3**, the intra prediction mode includes, for example, 67 types (0 to 66). For example, there are planar prediction (0), DC prediction (1), and Angular prediction (2 to 66). In addition, linear model (LM) prediction may be used such as Cross Component Linear Model (CCLM) prediction or Multi Mode Linear Model (MMLM) prediction. Furthermore, for chrominance, an LM mode may be added. Template-based Intra Mode Derivation (TIMD) prediction or Decoder Intra Mode Derivation (DIM D) prediction may also be used.

Configuration of Video Decoding Apparatus

[0069] The configuration of the video decoding apparatus **31** (FIG. **4**) according to the present embodiment will be described.

[0070] The video decoding apparatus **31** includes an entropy decoder **301**, a parameter decoder (a prediction image decoding apparatus) **302**, a loop filter **305**, a reference picture memory **306**, a prediction parameter memory **307**, a prediction image generation unit (prediction image generation apparatus) **308**, an inverse quantization and inverse transform processing unit **311**, an addition unit **312**, and a prediction parameter derivation unit **320**. Note that a configuration in which the loop filter **305** is not included in the video decoding apparatus **31** may be used in accordance with the video coding apparatus **11** described later.

[0071] The parameter decoder **302** includes a header decoder **3020**, a CT information decoder **3021**, and a CU decoder **3022** (prediction mode decoder), and the CU decoder **3022** further includes a TU decoder **3024**. These may be collectively referred to as a decoding module. The header decoder **3020** decodes, from coded data, parameter set information such as the VPS, the SPS, the PPS, and an APS, and a slice header (slice information). The CT information decoder **3021** decodes a CT from coded data. The CU decoder **3022** decodes a CU from coded data. In a case that a TU includes a prediction error, the TU decoder **3024** decodes QP update information (quantization correction value) and quantization prediction error (residual_coding) from coded data.

[0072] In the mode other than the skip mode (skip_mode==0), the TU decoder **3024** decodes QP update information and quantization prediction error from coded data. M ore specifically, the TU decoder **3024** decodes, in a case of skip_mode==0, a flag cu_cbp indicating whether a quantization prediction error is included in the target block, and decodes the quantization prediction error in a case that cu_cbp is 1. In a case that cu_cbp is not present in the coded data, the TU decoder **3024** derives cu_cbp as 0.

[0073] The prediction image generation unit **308** includes an inter prediction image generation unit **309** and an intra prediction image generation unit **310**.

[0074] The prediction parameter derivation unit **320** includes an inter prediction parameter derivation unit **303** and an intra prediction parameter derivation unit **304**.

[0075] An example in which a CTU and a CU are used as units of processing is described below, but the processing is not limited to this example, and processing in units of sub-CU may be performed. Alternatively, the CTU and the CU may be replaced with a block, the sub-CU may be replaced with by a subblock, and processing may be performed in units of blocks or subblocks.

[0076] The entropy decoder **301** performs entropy decoding on the coding stream Te input from the outside and separates and decodes individual codes (syntax elements). The entropy coding includes a scheme (Context Adaptive Binary Arithmetic Coding; CABAC) in which syntax elements are subjected to variable-length coding by using a context (probability model) that is adaptively selected according to a type of the syntax elements and a surrounding condition, and a scheme in which syntax elements are subjected to variable-length coding by using a predetermined table or a predetermined calculation expression. The entropy decoder **301** initializes all CABAC states at the beginning of a segment (tile, CTU row, or slice). The entropy decoder **301** transforms the syntax element into a binary string (Bin String) and decodes each bit of the Bin String. In a case that the context is used, a context index ctxInc is derived for each bit of the syntax element, the bit is decoded using the context, and the CABAC state of the context used is updated. Bits that do not use the context are decoded at an equal probability (EP, bypass), and the ctxInc derivation and CABAC state are omitted.

[0077] The entropy decoder **301** outputs the decoded codes to the parameter decoder **302**. Which code is to be decoded is controlled based on an indication of the parameter decoder **302**.

Configuration of Intra Prediction Parameter Derivation Unit **304**

[0078] The intra prediction parameter derivation unit **304** decodes an intra prediction parameter, for example, an intra prediction mode IntraPredMode, with reference to the prediction parameters stored in the prediction parameter memory **307**, based on a code input from the entropy decoder **301**. The intra prediction parameter derivation unit **304** outputs the decoded intra prediction parameter to the prediction image generation unit **308**, and stores the decoded intra prediction parameter in the prediction parameter memory **307**. The intra prediction parameter derivation unit **304** may derive different intra prediction modes between luminance and chrominance.

[0079] The intra prediction parameter derivation unit **304** decodes the syntax elements related to intra prediction as illustrated in FIG. **8**.

[0080] The loop filter **305** is a filter provided in the coding loop, and is a filter that removes block distortion and ringing distortion and improves image quality. The loop filter **305** applies a filter such as a deblocking filter, a Sample Adaptive Offset (SAO), and an Adaptive Loop Filter (ALF) on a decoded image of a CU generated by the addition unit **312**.

[0081] The reference picture memory **306** stores a decoded image of the CU generated by the addition unit **312** in a predetermined position for each target picture and target CU.

[0082] The prediction parameter memory **307** stores a prediction parameter in a position predetermined for each CTU or CU to be decoded. Specifically, the prediction parameter memory **307** stores a parameter decoded by the parameter decoder **302**, the prediction mode predMode separated by the entropy decoder **301**, and the like.

[0083] To the prediction image generation unit **308**, the prediction mode predMode, the prediction parameter, and the like are input. In addition, the prediction image generation unit **308** reads a reference picture from the reference picture memory **306**. The prediction image generation unit **308** generates a prediction image of a block or a subblock by using the prediction parameter and the read reference picture (reference picture block) in the prediction mode indicated by the prediction mode predMode. Here, the reference picture block refers to a set of pixels (referred to as a block because they are normally rectangular) on a reference picture and is a region that is referenced for generating a prediction image.

Intra Prediction Image Generation Unit **310**

[0084] In a case that prediction mode predMode indicates an intra prediction mode, the intra prediction image generation unit **310** performs intra prediction by using an intra prediction parameter input from the intra prediction parameter derivation unit **304** and a reference picture read out from the reference picture memory **306**.

[0085] Specifically, the intra prediction image generation unit **310** reads, from the reference picture memory **306**, adjacent blocks located on the

target picture within a prescribed range from the target block. The prescribed range corresponds to a left, an upper left, a lower left, an upper, and an upper right adjacent blocks of the target block, and the referenced area varies depending on the intra prediction mode.

[0086] The intra prediction image generation unit **310** references decoded pixel values read out and the prediction mode indicated by IntraPredMode to generate a prediction image of the target block. The intra prediction image generation unit **310** outputs the generated prediction image of the block to the addition unit **312**.

[0087] The generation of the prediction image based on the intra prediction mode will be described below. In the Planar prediction, DC prediction, and Angular prediction, decoded peripheral regions adjacent to (proximate to) the prediction target block are set as a reference region R. Then, the pixels on the reference region R are extrapolated in a particular direction to generate the prediction image. For example, the reference region R may be configured as an L-shaped region including a left and an upper regions (or further an upper left, an upper right, and a lower left regions) of the prediction target block.

Details of Prediction Image Generation Unit

[0088] Now, the details of the configuration of the intra prediction image generation unit **310** will be described with reference to FIG. **5**. The intra prediction image generation unit **310** includes a reference sample filter unit **3103** (second reference image configuration unit), a prediction unit **3104**, and a prediction image correction unit **3105** (prediction image correction unit, filter switching unit, weighting factor change unit).

[0089] Based on each reference pixel (reference image) on the reference region R, a filtered reference image generated by application of a reference sample filter (first filter), and the intra prediction mode, the prediction unit **3104** generates a prediction image of a prediction target block (temporary prediction image, uncorrected prediction image) and outputs the prediction image to the prediction image correction unit **3105**. The prediction image correction unit **3105** modifies the temporary prediction image in accordance with the intra prediction mode, generates a prediction image (corrected prediction image), and outputs the prediction image.

[0090] Units of the intra prediction image generation unit **310** will be described below.

Reference Sample Filter Unit **3103**

[0091] The reference sample filter unit **3103** derives a reference sample s[x][y] at each position (x, y) on the reference region R with reference to the reference image. The reference sample filter unit **3103** applies the reference sample filter (first filter) to the reference sample s[x][y] in accordance with the intra prediction mode to update the reference sample s[x][y] at each position (x, y) on the reference region R (derive a filtered reference image s[x][y]). Specifically, the low pass filter is applied to the position (x, y) and the reference images surrounding the position to derive the filtered reference image. Note that the low pass filter is not necessarily applied to all of the intra prediction modes, and the low pass filter may be applied to some of the intra prediction modes. Note that the filter to be applied to the reference image on the reference region R in the reference sample filter unit **3103** is referred to as the "reference sample filter (first filter)", whereas a filter for correcting the temporary prediction image in the prediction image correction unit **3105** described below is referred to as a "position dependent filter (second filter)".

Configuration of Prediction Unit **3104**

[0092] Based on the intra prediction mode, the reference image, and the filtered reference pixel value, the prediction unit **3104** generates a temporary prediction image (temporary prediction pixel value, uncorrected prediction image) of the prediction target block, and outputs the temporary prediction image to the prediction image correction unit **3105**. The prediction unit **3104** includes a Planar prediction unit **31041**, a DC prediction unit **31042**, an Angular prediction unit **31043**, an LM prediction unit **31044**, a Matrix-based Intra Precision (MIP) unit **31045**, and a Template-based Intra Mode Derivation (TIMD) prediction unit **31047**. The prediction unit **3104** selects a specific prediction unit in accordance with the intra prediction mode, and receives input of the reference image and the filtered reference image. The relationship between the intra prediction mode and the corresponding prediction unit is as follows. [0093] Planar prediction . . . Planar Prediction unit **31041** [0094] DC Prediction . . . DC prediction unit **31042** [0095] Angular prediction . . . Angular prediction unit **31043** [0096] LM prediction . . . LM prediction unit **31044** [0097] Matrix intra prediction . . . MIP unit **31045** [0098] TIMD prediction . . . TIMD prediction unit **31047**

Planar Prediction

[0099] The Planar prediction unit **31041** linearly adds reference samples s[x][y] together in accordance with the distance between a prediction target pixel position and a reference pixel position to generate a temporary prediction image predSamples[x][y], and outputs the temporary prediction image predSamples[x][y] to the prediction image correction unit **3105**. Note that s[ ][ ] may also be referred to as p[ ][ ].

DC Prediction

[0100] The DC prediction unit **31042** derives a DC prediction value corresponding to the average value of the reference samples s[x][y], and outputs a temporary prediction image q[x][y] including the DC prediction value as a pixel value.

Angular Prediction

[0101] The Angular prediction unit **31043** derives a prediction image predSamples[ ][ ](=temporary prediction image q[ ][ ]) by using the reference samples s[x][y] in the prediction direction (reference direction) indicated by the intra prediction mode, and outputs the temporary prediction image to the prediction image correction unit **3105**.

In a Case of IntraPredMode>=DIR

[00001] $\text{ref}[x] = s[\text{-1 - refIdx} + x][\text{-1 - refIdx}](x = 0 \ .\text{Math}.\ bW + \text{refIdx} + 1)$

[0102] Furthermore, the following is performed on x=0 . . . bW−1, y=0 . . . bH−1. [0103] iIdx=(((y+1+refIdx)*intraPredAngle)>>5)+refIdx [0104] iFact=((y+1+refIdx)*intraPredAngle) & 31

[00002] $\text{predSamples}[x][y] = \text{Clip1}(((\quad (fT[i] * \text{ref}[x + iIdx + i])) + 32)\quad 6)$

Otherwise (IntraPredMode<DIR)

[00003] $\text{ref}[x] = s[\text{-1 - refIDx}][\text{-1 - refIdx} + x](x = 0 \ .\text{Math}.\ bH + \text{refIdx} + 1)$

[0105] Furthermore, the following is performed on x=0 . . . bW−1, y=0 . . . bH−1.

[00004] $\text{iIdx} = (((x + 1 + \text{refIdx}) * \text{intraPredAngle})\quad 5) + \text{refIdx}$

[0106] iFact=((x+1+refIdx)*intraPredAngle) & 31

[00005] $\text{predSamples}[x][y] = \text{Clip1}(((\quad (fT[i] * \text{ref}[y + iIdx + i])) + 32)\quad 6)$

[0107] DIR and refIdx represent prescribed constants. For example, DIR=34, 66, or the like. refIdx=0, 1, 2, or the like. For normal angular prediction, the value of refIdx may be set by decoding the syntax of coded data. fT represents an interpolation filter coefficient for an intra prediction image. In a case of prediction image generation for TIMD prediction described below, refIdx=0 may be fixed. In a case of derivation of a template prediction image, refIdx=2 or 4 may be used.

LM Prediction

[0108] The LM prediction unit **31044** predicts a chrominance pixel value based on a luminance pixel value. Specifically, in this scheme, based on a decoded luminance image, a linear model is used to generate a prediction image of a chrominance image (Cb, Cr). One of the LM predictions is Cross-Component Linear Model (CCLM) prediction. The CCLM prediction is a prediction scheme that uses, for one block, a linear model for predicting chrominance from luminance.

Matrix Intra Prediction

[0109] The MIP unit **31045** generates a temporary prediction image q[x][y] by a product-sum operation of a weighting matrix and a reference sample s[x][y] derived from an adjacent region, and outputs the temporary prediction image q[x][y] to the prediction image correction unit **3105**.

TIMD Prediction

[0110] The TIMD prediction is a prediction scheme that generates a prediction image by using an intra prediction mode that is not explicitly signaled

(also referred to as template-based intra mode). The intra prediction parameter derivation unit **304** first generates a template prediction image of a template image corresponding to an adjacent region of a target block from which an intra prediction mode candidate is to be derived. Then, an image of a reference region (template reference region) near the target block is used to generate a template prediction image for multiple intra prediction mode candidates. Then, as the TIMD intra prediction mode of the target block, the intra prediction mode candidate is selected that is used for derivation of a template prediction image with the minimum cost (e.g., difference absolute value sum) of the template image and the template prediction image. The TIMD prediction unit **31047** generates a prediction image (temporary prediction image) by using this TIMD intra prediction mode. Details will be described below.

Configuration of Prediction Image Correction Unit **3105**

[0111] The prediction image correction unit **3105** modifies the temporary prediction image output from the prediction unit **3104** in accordance with the intra prediction mode. Specifically, the prediction image correction unit **3105** derives, for each pixel of the temporary prediction image, a position dependent weighting factor depending on the positions of the reference region R and the target prediction pixel. Then, the reference sample s[ ][ ] and the temporary prediction image q[x][y] are added together with weighting (weighted average) to derive a prediction image (corrected prediction image) Pred[ ][ ] corresponding to a modified temporary prediction image. Note that in some intra prediction modes, the temporary prediction image q[x][y] may be set as a prediction image without being corrected by the prediction image correction unit **3105**.

First Example

[0112] FIG. **8** illustrates an example syntax of coded data related to TIMD. The parameter decoder **302** decodes, from the coded data, a template-based intra prediction flag timd_flag indicating whether the TIMD is used for each block. If timd_flag is equal to 1, the parameter decoder **302** does not need to decode the coded data into some syntax elements related to the intra prediction mode. If timd_flag is equal to 0, intra_luma_mpm_flag is decoded. intra_luma_mpm_flag is a flag indicating whether to derive an intra prediction mode from a prediction candidate list candModeList (Most Probable Mode (MPM) list). If intra_luma_mpm_flag is equal to 1, intra_luma_not_planar_flag and intra_luma_mpm_idx are decoded. If intra_luma_mpm_flag is equal to 0, intra_luma_mpm_reminder is decoded. intra_not_planar_flag is a flag indicating whether to perform planar prediction. intra_luma_mpm_idx is an index that indicates, as a prediction candidate, one of the intra prediction modes stored in the MPM list candModeList[ ]. intra_luma_mpm_reminder is an index that selects a prediction candidate from intra prediction modes other than those in the MPM list.

[0113] For example, the target block is assumed to have upper left coordinates (xC, yC), a block width bW, and a block height bH. With the intraPredMode of a block A adjacent to the target block on the left being used as intraPredModeA and with the intraPredMode of a block B adjacent to the target block above being used as intraPredModeB, prediction mode candidates for the target block may be derived as follows. Block A (hereinafter referred to as A) is a block including coordinates (xC−1, yC+bH−1). Block B (hereinafter referred to as B) is a block including coordinates (xC+bW−1, yC−1). [0114] candModePredModeA=(A is not available ‖ A is other than MODE_INTRA)? INTRA_PLANAR: intraPredModeA [0115] candModePredModeB=(B is not available ‖ B is other than MODE_INTRA ‖ B is positioned above an upper CTU boundary of the target block)? INTRA_PLANAR: intraPredModeB

[0116] Note that whether B is positioned above the CTU boundary can be determined depending on whether yC−1<((yC>>CtbLog 2SizeY) <<CtbLog 2SizeY) is true or false. Here, CtbLog 2SizeY=Log 2 (CTU size). A syntax element sps_log 2_ctu_size_minus5 in the coded data may be decoded for derivation in accordance with CtbLog 2SizeY=sps_log 2_ctu_size_minus5+5. candModeList may be derived as follows. [0117] candModeList[0]=candIntraPredModeA [0118] candModeList[1]=candIntraPredModeB [0119] minAB=Min(candIntraPredModeA, candIntraPredModeB) [0120] candModeList[2]=2+((minAB+61) % 64) [0121] candModeList[3]=2+((minAB−1) % 64) [0122] candModeList[4]=2+((minAB+60) % 64)

[0123] If timd_flag is equal to 1, the TIMD prediction unit **31047** generates a template prediction image for the intra prediction mode candidate using an image of the template reference region near the target block, and selects a preferable intra prediction mode for a prediction image of the template image of the target block.

[0124] FIG. **6** illustrates a template region RT and a template reference region (template reference sample region) RTRS referenced in the TIMD prediction. The template region is a region in the template image. The template reference region is a region referenced when a template prediction image is generated that corresponds to a prediction image of the template image.

[0125] FIG. **7** illustrates a configuration of the TIMD prediction unit **31047** in the present embodiment. The TIMD prediction unit **31047** includes a reference sample derivation unit **4701**, a template derivation unit **4702**, an intra prediction image derivation unit **4703**, an intra prediction mode candidate derivation unit **4711**, a template prediction image generation unit **4712**, a template cost derivation unit **4713**, and an intra prediction mode selection unit **4714**. Note that the intra prediction mode candidate derivation unit **4711**, the template prediction image generation unit **4712**, the template cost derivation unit **4713** may be collectively referred to as a template intra prediction mode derivation apparatus **4710**.

[0126] The intra prediction mode candidate derivation unit **4711** derives a list timdModeList[ ] of intra prediction mode candidates from intra prediction modes of adjacent blocks of the target block. For example, the MPM list candModeList[ ] may be used as timdModeList.

timdModeList[i]=candModeList[i] (i=0 . . . the number of elements in candModeList−1)

[0127] The template derivation unit **4702** derives a template image tempSamples of the target block. As illustrated in FIG. **6**, the template image tempSamples may be derived from an L-shaped template region RT of one-pixel width adjacent to the target block.

tempSamples[$x+i$][$y+j$]=recSamples[$xC+i$][$yC+j$](i=−1 . . . bW−1,j=−1),(i=−1,j=−1 . . . bH−1)

[0128] The region on recSamples used for deriving tempSamples is referred to as the template region RT, and is expressed as a set of coordinates (i, j). In other words, RT={{i=−1 . . . bW−1, j=−1}, {i=−1, j=−1 . . . bH−1}}. Instead of using tempSamples, an array of decoded images recSamples corresponding to the template region may be used as a template image (in this case, the region in which tempSamples is positioned is referred to as a template region).

[0129] Alternatively, the template region may be an L-shaped region of two-pixel width adjacent to the target block.

tempSamples[$x+i$][$y+$]=recSamples[$xC+i$][$yC+j$](i=−2 . . . bW−1,j=−2 . . . 1),(i=−2 . . . 1,j=−2 . . . bH−1)

[0130] The reference sample derivation unit **4701** derives a reference sample refUnit from the template reference region RTRS. Note that the reference sample filter unit **3103** may perform the operation of the reference sample derivation unit **4701**.
[00006]refUnit[x][y] = recSamples[xNbCmp + x][yNbComp + y]

[0131] Here, xNbCmp=xC and yNbCmp=yC, and x and y range as follows: x=−1−refIdxW and y=−1−refIdxH . . . refH−1, and x=−1−refIdxW . . . refW−1 and y=−1−refIdxH. Here, refIdxW and refIdxH are distances of the template reference region from the target block boundary. refIdxW=refIdxH=2 or 4 may be set or refIdxW and refIdxH may vary depending on the block size.

refIdxW=refIdxH=(bW>=8)& &(bH>=8)?4:2
Here, refW=bW*2 and refH=bH*2.

[0132] Furthermore, the reference sample refUnit[x][y] may be filtered to derive a reference sample p[x][y].

[0133] The template prediction image generation unit **4712** generates a prediction image (template prediction image) of the intra prediction mode IntraPredMode from the template reference region. The prediction unit **3104** may perform prediction image generation instead of the template

prediction image generation unit **4712**. For example, the Planar prediction unit **31041**, the DC prediction unit **31042**, and the Angular prediction unit **31043** may perform both generation of a template prediction image and generation of a prediction image of the target block.

[0134] Specifically, for each of the intra modes intraPredMode included in timdModeList[i] (tIntraPredMode=timdModeList[i]), the Planar prediction unit **31041**, the DC prediction unit **31042**, and the Angular prediction unit **31043** generate a one-dimensional reference pixel array ref[ ] from the reference sample refUnit[x][y] or the filtered reference sample p[x][y]. Then, tIntraPredMode and ref[ ] are transmitted to the intra prediction image derivation unit **4703**. The intra prediction image derivation unit **4703** generates a template prediction image tpredSamples[ ][ ] corresponding to tIntraPredMode, and outputs the template prediction image tpredSamples[ ][ ] to the template prediction image generation unit **4712**.

[0135] The template prediction image generation unit **4712** generates ref[ ], for example, as indicated in (Formula TIMD-ANGULAR-REF) below. In the formula, tpredSamples[ ][ ] is generated from p[ ]. However, instead of p[ ][ ], refUnit[ ][ ] may be used.

Formula TIMD-ANGULAR-REF

In a Case of tIntraPredMode>=DIR

$[00007] \mathrm{ref}[x] = p[-1 - \mathrm{refIdx} + x][-1 - \mathrm{refIdx}], (x = 0 \,.\mathrm{Math.}\, bW + \mathrm{refIdx} + 1)$

Otherwise (tIntraPredMode<DIR)

$[00008] \mathrm{ref}[x] = p[-1 - \mathrm{refIDx}][-1 - \mathrm{refIdx} + x], (x = 0 \,.\mathrm{Math.}\, bH + \mathrm{refIdx} + 1)$

DIR is a prescribed constant, For example, DIR=34, 66, or the like. Here, refIdx is a distance from the target block. For the template region, refIdx=0 (or 1), and for the template reference region used for prediction of the template region, refIdx>0 (e.g., refIdx=2, 4, or the like) is used. refIdx may be changed depending on the block size.

$\mathrm{refIdx}=(bW>=8)\&\&(bH>=8)4:2$

[0136] The template prediction image generation unit **4712** (intra prediction image derivation unit **4703**) generates a template prediction image tpredSamples[ ][ ] corresponding to tIntraPredMode, for example, as indicated in (Formula TIMD-ANGULAR-PRED) below.

Formula TIMD-ANGULAR-PRED

In a case of tIntraPredMode>=DIR

[00009]

$\mathrm{iIdx} = (((y + 1 + \mathrm{refIdx}) * \mathrm{intraPredAngle}) \quad 5) + \mathrm{refIdx} \quad \mathrm{iFact} = ((y + 1 + \mathrm{refIdx}) * \mathrm{intraPredAngle})\&31 \quad \mathrm{tpredSamples}[x][y] = \mathrm{Clip1}((\quad (\mathrm{filt}[i] * \mathrm{ref}[x + \mathrm{iIdx} + i]$

Otherwise (tIntraPredMode<DIR)

[00010]

$\mathrm{iIdx} = (((x + 1 + \mathrm{refIdx}) * \mathrm{intraPredAngle}) \quad 5) + \mathrm{refIdx} \quad \mathrm{iFact} = ((x + 1 + \mathrm{refIdx})\mathrm{intraPredAngle})\&31 \quad \mathrm{tpredSamples}[x][y] = \mathrm{Clip1}((\quad (\mathrm{filt}[i] * \mathrm{ref}[y + \mathrm{iIdx} + i]) \cdot$

x=−1 . . . bW−1, y=−1 and x=−1, y=−1 . . . bH−1.

[0137] Here, Σ is the sum with i=0. MTAP−1, and fT represents an interpolation filter coefficient for the template prediction image. The number of taps MTAP of the interpolation filter used to derive the template prediction image is, for example, 4. [0138] intraPredAngle is an angular parameter for each intra prediction mode. [0139] filt may be derived from iFast as follows: filtG[phase][j] is a coefficient for the interpolation filter used to generate a template prediction image.

filt[j]=filtG[iFact][*j*]

[0140] The template cost derivation unit **4713** derives the cost tempCost of an intra prediction mode candidate from the difference between the template prediction image tpredSamples of each intra prediction mode candidate and the template image tempSamples of the target block. The cost may be the Sum of Absolute Difference (SAD).

$[00011] \mathrm{tempCost} = \Sigma \mathrm{abs}(\mathrm{tpredSamples}[i][j] - \mathrm{tempSamples}[i][j])$

(i, j) is, for example, (i=−1 . . . bW−1, j=−1), (i=−1, j=−1 . . . bH−1)) Alternatively, the cost may be the Sum of Absolute Transformed Difference (SATD).

[0141] The intra prediction mode selection unit **4714** derives the intra prediction mode corresponding to the minimum value of tempCost as the TIMD intra prediction mode IntraPredMode.

[0142] The intra prediction image derivation unit **4703** derives the intra prediction image predSamples[ ][ ] corresponding to IntraPredMode derived above. Note that the derivation may be performed by the prediction unit **3104**.

TABLE-US-00001 Formula INTRA−ANGULAR−PRED In a case of IntraPredMode >= DIR   ref[x] = p[−1 − refIdx + x][−1 − refIdx], (x = 0..bW + refIdx + 1) Otherwise (IntraPredMode < DIR)   ref[x] = p[−1 − refIDx][−1 − refIdx + x], (x = 0..bH + refIdx + 1)   if (intraPredMode >= DIR) {   iIdx = (((y + 1) * intraPredAngle) >> 5)   iFact = ((y + 1) * intraPredAngle) & 31   predSamples[x][y] = Clip1((Σ(fT[i] * ref[x + iIdx + i]) + 32 >> 6)   } else {/* intraPredMode < DIR*/   iIdx = (((x + 1) * intraPredAngle) >> 5)   iFact = ((x + 1) * intraPredAngle) & 31   predSamples[x][y] = Clip1((Σ(fT[i] * ref[y + iIdx + i]) + 32 >> 6)   }

[0143] Here, Σ is the sum with i=0 . . . NTAP−1. and fT represents an interpolation filter coefficient for the intra prediction image. The number of taps NTAP of the interpolation filter used for deriving the intra prediction image is 6, for example.

[0144] fT may also be derived from iFast as follows: fG[phase][j] is the coefficient of interpolation filter for generating the intra prediction image.

fT[j]=fG[iFact][*j*]

[0145] The intra prediction image derivation unit **4703** may select a filter coefficient from fG and fC in accordance with a difference minDistVerHor and a prescribed threshold THRES as follows. minDistVerHor is a difference between the horizontal direction or the vertical direction and IntraPredMode.

fT[j]=minDistVerHor>THRES:*fG*[iFact][*j*]:*fC*[iFact][*j*]

fC[phase][ ] may be a filter that successfully preserves high frequencies components for which the coefficients include negative values, and fG may be a filter with a high low-pass effect for preventing the coefficients from including negative values. An example of fC is cubic convolution, and an example of fG is a gauss function, but the present invention is not limited thereto. In other words, fC and fG may satisfy min (fC[phase][j])<min (fG[phase][j]). Furthermore, min (fC[phase][j])>min (fG[phase][j]) may be satisfied. At the position of phase=0, the coefficients of fC may be 0 except for one coefficient, and the coefficients of fG may be two or more coefficients having values other than 0. For example, the following may be employed.

*fC[ ][*0]={0,0,64,0,0,0}*fG[ ][*0]={0,16,32,16,0,0}

Block Size-Specific Template Reference Region

[0146] In another configuration, the distances refIdxW and refIdxH from the target block with respect to the template reference region RTRS of the reference sample derivation unit **4701** and ref of the template prediction image generation unit **4712** may be varied depending on the horizontal direction or the vertical direction.

refIdxW=(*bW*>=8)?4:2

refIdxH=(*bW*>=8)& &(*bH*>=8)4:2

Formula TIMD-ANGULAR-PRED

In a Case of tIntraPredMode>=DIR

[00012]ref[x] = p[-1 - refIdxW + x][-1 - refIdxH], $(x = 0$ .Math. bW + refIdxW + 1)

Otherwise (tIntraPredMode<DIR)

[00013]ref[x] = p[-1 - refIdxW][-1 - refIdxH + x], $(x = 0$ .Math. bH + refIdxH + 1)

Template Prediction Image Generation Unit **4712**

In a Case of tIntraPredMode>=DIR

[00014]

iIdx = $(((y + 1 + refIdxH) * intraPredAngle)$ 5) + refIdxHiFact = $((y + 1 + refIdxH) * intraPredAngle)$&31tpredSamples[$x$][$y$] = Clip1(((filt[$i$] * ref[$x$ + iId

Otherwise (tIntraPredMode<DIR)

[00015]

iIdx = $(((x + 1 + refIdxW) * intraPredAngle)$ 5) + refIdxWiFact = $((x + 1 + refIdxW) * intraPredAngle)$&31tpredSamples[$x$][$y$] = Clip1(((filt[$i$] * ref[$y$ + i

$x=-1 \ldots bW-1, y=-1$ and $x=-1, y=-1 \ldots bH-1$.

[0147] According to the configuration described above, the region referenced in the template prediction image is varied according to the size of the target block. This improves the accuracy of the template prediction image to improve the accuracy of the TIMD intra prediction image.

Summary of Example of Change in Number of Taps

[0148] FIG. **10** is a diagram illustrating switching of the number of filter taps during an intra prediction mode search for TIMD prediction and during intra prediction image generation. The intra prediction image derivation unit **4703** includes an MTAPS filter **47031**, an NTAPS filter **47033**, and a memory **47032**.

[0149] In a case that the template prediction image generation unit **4712** derives the template prediction image, the MTAPS filter **47031** of the intra prediction image derivation unit **4703** references tIntraPredMode and the reference sample p[ ][ ] stored in the memory **47032**, and derives the template prediction image tpredSamples[ ][ ] according to (Formula TIMD-ANGULAR-PRED). tIntraPredMode is an intra prediction mode candidate input from the template prediction image generation unit **4712**.

[0150] In a case that the TIMD prediction unit **31047** derives an intra prediction image, the NTAPS filter **47033** of the intra prediction image derivation unit **4703** references IntraPredMode selected by the intra prediction mode selection unit **4714** and the reference sample p[ ][ ] stored in the memory **47032**, and generates an intra prediction image predSamples[ ][ ] according to (Formula INTRA-ANGULAR-PRED). Then, predSamples[ ][ ] is output as an intra prediction image of the target block.

[0151] As described above, in a case of generating the template prediction image, the template prediction image generation unit **4712** (the prediction unit **3104** and the intra prediction image derivation unit **4703**) generates the prediction image by using the sum of products of ref[i] with i=0 . . . . MTAP−1 and the filter coefficient filt. That is, MTAP reference samples p (refUnit) are referenced. In a case of generating a prediction image of the target block, the TIMD prediction unit **31047** (the prediction unit **3104** and the intra prediction image derivation unit **4703**) generates the prediction image by using the sum of products of ref[i] with i=0 . . . . NTAP−1 and the filter coefficient fT. That is, NTAP reference samples p (refUnit) are referenced. The present embodiment includes switching between a filter used to generate a template prediction image and a filter used to generate a prediction image of the target block. Then, the number of taps MTAP may be set smaller for the filter used to generate a template prediction image than the number of taps NTAPS for the filter used to generate a prediction image of the target block. For example, any of the following may be set: {MTAP=2, NTAP=4}, {MTAP=2, NTAP=6}, {MTAP=4, NTAP=6}, {MTAP=2, NTAP=8}, and {MTAP=4, NTAP=8}.

[0152] Depending on tIntraPredMode, the template prediction image generation unit **4712** uses a fixed filter coefficient filt [ ][ ] without switching the filter. Then, in prediction image generation for the target block performed by the TIMD prediction unit **31047**, the filter is switched between fG[ ][ ] and fC[ ][ ] depending on IntraPredMode. This is effective in reducing the processing amount of generating the template prediction image by using the fixed filter.

[0153] In the TIMD prediction in which the template prediction image (intra prediction image) is repeatedly derived by using multiple intra prediction candidates for the target block, the configuration described above is effective in reducing the amount of processing for deriving the prediction image of the template image.

Summary of Configuration for TIMD Prediction

[0154] A decoder includes a parameter decoder **302** configured to decode a template-based intra prediction flag indicating whether to generate a prediction image, by deriving an intra prediction mode number from coded data using a pixel of an adjacent region, the reference sample derivation unit **4701** configured to derive a reference sample by using an image of a template reference region near a target block, the template prediction image generation unit **4712** configured to generate a template prediction image for a prescribed intra prediction mode candidate by using the reference sample, the template cost derivation unit **4713** configured to derive a cost from the template prediction image and a template image corresponding to an image near the target block, and the intra prediction mode selection unit **4714** configured to select an intra prediction mode (TIMD intra prediction mode) for the target block based on the cost, and in a case that the template-based intra mode derivation flag has a prescribed value, a prediction image of the target block is generated by using the TIMD intra prediction mode.

Another Configuration Example 1

[0155] FIG. **9** illustrates a configuration of a TIMD prediction unit **31047** that implements template-based intra mode derivation by limiting the bit depth in the derivation of the template region and the template reference sample region. The TIMD prediction unit **31047** in this configuration example includes a bit shift derivation unit **4704** in addition to the above-described configuration.

[0156] The bit shift derivation unit **4704** derives a shift value bitShift according to the bit depth bitDepth of the image. For example, in a case that bitDepth exceeds a prescribed bit depth TIMD_DEPTH, bitShift is set to 1 or larger, and otherwise bitShift is set to 0.

[00016]bitShift = max(bitDepth - TIMD_DEPTH, 0)

Here, TIMD_DEPTH is a prescribed value, for example, 10.

[0157] A template derivation unit **4702***a* may derive the template image of the target block according to the bit depth bitDepth of the image. For example, in a case that bitDepth exceeds a prescribed bit depth TIMD_DEPTH, the template image tempSamples may be derived from the image recSamples of the template region using right shift with bitShift described above.

[00017]tempSamples[$x + i$][$y + j$] = (recSamples[xC - 1 + i][yC - 1 + j] + bitOffset)   bitShift$(i = 0$ .Math. bW, $j = 0)$, $(i = 0, j = 0$ .Math. bH)

bitOffset=(bitShift>0)?1<<(bitShift−1):0

Note that bitOffset=(1<<bitShift)>>1 may be used and results in the same value.

[0158] In a case that the bit depth of the image exceeds the prescribed bit depth TIMD_DEPTH, the reference sample derivation unit **4701***a* may derive the reference sample refUnit from the image recSamples of the template reference region by using right shift with bitShift described above.

refUnit[x][y]=(recSamples[xNbCmp+x][yNbCmp+y]+bitOffset)>>bitShift

[0159] Here, xNbCmp=xC and yNbCmp=yC, and x and y range as follows: x=−1−refIdxW and y=−1−refIdxH . . . refH−1, and x=−1−refIdxW . . . refW−1 and y=−1−refIdxH.

[0160] Note for (Formula TIMD-ANGULAR-REF), a shift operation may be performed by the template image derivation unit (intra prediction

image unit **4703**) instead of the reference sample derivation unit **4701***a* as follows.

In a Case of tIntraPredMode (IntraPredMode)>=DIR

[00018]ref[x] = p[-1 - refIdx + x][-1 - refIdx] + bitOffet)   bitShift, (x = 0 .Math. bW + refIdx + 1)

Otherwise (tIntraPredMode<DIR)

[00019]ref[x] = p[-1 - refIdx + x][-1 - refIdx + x] + bitOffet)   bitShift, (x = 0 .Math. bH + refIdx + 1)

[0161] As described above, p (or refUnit) is used to generate the template prediction image tpredSamples. In a case that the TIMD prediction is used, the derivation of the template prediction image tpredSamples is facilitated by pre-limiting the bit depth (and corresponding range) of p (or refUnit). For the range of tempSamples, the bit depth (and the corresponding range) is also limited by the same bit shift amount bitShift, the derivation of tempCost is also simplified in a prescribed range.

[0162] As described above, the reference sample derivation unit **4701** derives the reference sample by performing a right shift with respect to the image of the template reference region near the target block according to the bit depth of the image. The cost derivation unit may derive the template image by right-shifting the pixel value with respect to the image near the target block according to the bit depth of the image. Thus, even an image having a bit depth larger than a prescribed bit depth can be processed at a fixed bit depth, thus effectively reducing the amount of processing.

[0163] The addition unit **312** adds the prediction image of the block input from the prediction image generation unit **308** and the prediction error input from the inverse quantization and inverse transform processing unit **311** for each pixel, and generates a decoded image of the block. The addition unit **312** stores the decoded image of the block in the reference picture memory **306**, and also outputs it to the loop filter **305**.

Configuration of Video Coding Apparatus

[0164] Next, a configuration of the video coding apparatus **11** according to the present embodiment will be described. FIG. **11** is a block diagram illustrating a configuration of the video coding apparatus **11** according to the present embodiment. The video coding apparatus **11** includes a prediction image generation unit **101**, a subtraction unit **102**, a transform and quantization unit **103**, an inverse quantization and inverse transform processing unit **105**, an addition unit **106**, a loop filter **107**, a prediction parameter memory (a prediction parameter storage unit, a frame memory) **108**, a reference picture memory (a reference image storage unit, a frame memory) **109**, a coding parameter determination unit **110**, a parameter coder **111**, a prediction parameter derivation unit **120**, and an entropy coder **104**.

[0165] The prediction image generation unit **101** generates a prediction image for each CU that is a region obtained by splitting each picture of an image T. The prediction image generation unit **101** includes an intra prediction image generation unit **310**. The operation of the prediction image generation unit **101** is the same as that of the prediction image generation unit **308** already described, and description thereof will be omitted.

[0166] The subtraction unit **102** subtracts a pixel value of the prediction image of a block input from the prediction image generation unit **101** from a pixel value of the image T to generate a prediction error. The subtraction unit **102** outputs the prediction error to the transform and quantization unit **103**.

[0167] The transform and quantization unit **103** performs a frequency transform on the prediction error input from the subtraction unit **102** to calculate a transform coefficient, and derives a quantization transform coefficient by quantization. The transform and quantization unit **103** outputs the quantization transform coefficient to the parameter coder **111** and the inverse quantization and inverse transform processing unit **105**.

[0168] The inverse quantization and inverse transform processing unit **105** is the same as the inverse quantization and inverse transform processing unit **311** (FIG. **4**) in the video decoding apparatus **31**, and descriptions thereof are omitted. The calculated prediction error is output to the addition unit **106**.

[0169] The parameter coder **111** includes a header coder **1110**, a CT information coder **1111**, and a CU coder **1112** (prediction mode coder). The CU coder **1112** further includes a TU coder **1114**. General operation of each module will be described below.

[0170] The header coder **1110** performs coding processing of parameters such as header information, split information, prediction information, and quantization transform coefficients.

[0171] The CT information coder **1111** codes the QT and MT (BT, TT) split information and the like.

[0172] The CU coder **1112** codes the CU information, the prediction information, the split information, and the like.

[0173] In a case that a prediction error is included in the TU, the TU coder **1114** codes the QP update information and the quantization prediction error.

[0174] The CT information coder **1111** and the CU coder **1112** supply, to the parameter coder **111**, syntax elements such as the inter prediction parameter, the intra prediction parameter, and the quantization transform coefficient.

[0175] The parameter coder **111** inputs the quantization transform coefficient and the coding parameters to the entropy coder **104**. The entropy coder **104** entropy-codes the quantization transform coefficient and the coding parameters to generate a coding stream Te and outputs the coding stream Te.

[0176] The prediction parameter derivation unit **120** is a component including the inter prediction parameter coder **112** and the intra prediction parameter coder **113**, and derives an inter prediction parameter and an intra prediction parameter from the parameters input from the coding parameter determination unit **110**. The inter prediction parameter and intra prediction parameter derived are output to the parameter coder **111**.

Configuration of Intra Prediction Parameter Coder **113**

[0177] The intra prediction parameter coder **113** codes IntraPredMode input from the coding parameter determination unit **110**. The intra prediction parameter coder **113** includes a partly identical configuration to a configuration in which the intra prediction parameter derivation unit **304** derives the intra prediction parameters.

[0178] The addition unit **106** adds together, for each pixel, a pixel value for the prediction block input from the prediction image generation unit **101** and a prediction error input from the inverse quantization and inverse transform processing unit **105**, generating a decoded image. The addition unit **106** stores the generated decoded image in the reference picture memory **109**.

[0179] The loop filter **107** applies a deblocking filter, an SAO, and an ALF to the decoded image generated by the addition unit **106**. Note that the loop filter **107** need not necessarily include the above-described three types of filters, and may have a configuration of only the deblocking filter, for example.

[0180] The prediction parameter memory **108** stores the prediction parameters generated by the coding parameter determination unit **110** for each target picture and CU at a predetermined position.

[0181] The reference picture memory **109** stores the decoded image generated by the loop filter **107** for each target picture and CU at a predetermined position.

[0182] The coding parameter determination unit **110** selects one set among multiple sets of coding parameters. The coding parameters include QT, BT, or TT split information described above, a prediction parameter, or a parameter to be coded which is generated related thereto. The prediction image generation unit **101** generates the prediction image by using these coding parameters.

[0183] The coding parameter determination unit **110** calculates, for each of the multiple sets, an RD cost value indicating the magnitude of an amount of information and a coding error. The coding parameter determination unit **110** selects a set of coding parameters of which cost value calculated is a minimum value. In this manner, the entropy coder **104** outputs a set of selected coding parameters as the coding stream Te. The coding parameter determination unit **110** stores the determined coding parameters in the prediction parameter memory **108**.

[0184] Note that a computer may be used to implement some of the video coding apparatus **11** and the video decoding apparatus **31** in the above-described embodiments, for example, the entropy decoder **301**, the parameter decoder **302**, the loop filter **305**, the prediction image generation unit **308**, the inverse quantization and inverse transform processing unit **311**, the addition unit **312**, the prediction parameter derivation unit **320**, the prediction image generation unit **101**, the subtraction unit **102**, the transform and quantization unit **103**, the entropy coder **104**, the inverse

quantization and inverse transform processing unit **105**, the loop filter **107**, the coding parameter determination unit **110**, a parameter coder **111**, and the prediction parameter derivation unit **120**. In that case, this configuration may be realized by recording a program for realizing such control functions on a computer-readable recording medium and causing a computer system to read the program recorded on the recording medium for execution. Note that the "computer system" mentioned here refers to a computer system built into either the video coding apparatus **11** or the video decoding apparatus **31** and is assumed to include an OS and hardware components such as a peripheral apparatus. A "computer-readable recording medium" refers to a portable medium such as a flexible disk, a magneto-optical disk, a ROM, and a CD-ROM, and a storage device such as a hard disk built into the computer system. Moreover, the "computer-readable recording medium" may include a medium that dynamically retains the program for a short period of time, such as a communication wire that is used to transmit the program over a network such as the Internet or over a communication line such as a telephone line, and a medium that retains the program for a certain period of time, such as a volatile memory within the computer system which functions as a server or a client in a case that the program is transmitted via the communication wire. Furthermore, the aforementioned program may be configured to implement part of the functions described above, and also may be configured to be capable of implementing the functions described above in combination with a program already recorded in the computer system.

[0185] A part or all of the video coding apparatus **11** and the video decoding apparatus **31** in the embodiment described above may be realized as an integrated circuit such as a Large Scale Integration (LSI). Each function block of the video coding apparatus **11** and the video decoding apparatus **31** may be individually realized as processors, or part or all may be integrated into processors. The circuit integration technique is not limited to LSI but may be realized as dedicated circuits or a multi-purpose processor. Furthermore, in a case that advances in semiconductor technology lead to the advent of a circuit integration technology that replaces an LSI, an integrated circuit based on the circuit integration technology may be used.

[0186] The embodiment of the present invention has been described in detail above referring to the drawings, but the specific configuration is not limited to the above embodiment and various amendments can be made to a design that fall within the scope that does not depart from the gist of the present invention.

INDUSTRIAL APPLICABILITY

[0187] The embodiment of the present invention can be preferably applied to a video decoding apparatus that decodes coded data in which image data is coded, and a video coding apparatus that generates coded data in which image data is coded. The embodiment of the present invention can be preferably applied to a data structure of coded data generated by the video coding apparatus and referred to by the video decoding apparatus.

REFERENCE SIGNS LIST

[0188] **31** Image decoding apparatus [0189] **301** Entropy decoder [0190] **302** Parameter decoder [0191] **303** Inter prediction parameter derivation unit [0192] **304** Intra prediction parameter derivation unit [0193] **308** Prediction image generation unit [0194] **309** Inter prediction image generation unit [0195] **310** Intra prediction image generation unit [0196] **31047** TIMD prediction unit [0197] **4701** Reference sample derivation unit [0198] **4702** Template derivation unit [0199] **4703** Intra prediction image derivation unit [0200] **47031** MTAPS filter [0201] **47032** Memory [0202] **47033** NTAPS filter [0203] **4704** Bit shift derivation unit [0204] **4711** Intra prediction mode candidate derivation unit [0205] **4712** Template prediction image generation unit [0206] **4713** Template cost derivation unit [0207] **4714** Intra prediction mode selection unit [0208] **311** Inverse quantization and inverse transform processing unit [0209] **312** Addition unit [0210] **320** Prediction parameter derivation unit [0211] **11** Image coding apparatus [0212] **101** Prediction image generation unit [0213] **102** Subtraction unit [0214] **103** Transform and quantization unit [0215] **104** Entropy coder [0216] **105** Inverse quantization and inverse transform processing unit [0217] **107** Loop filter [0218] **110** Coding parameter determination unit [0219] **111** Parameter coder [0220] **112** Inter prediction parameter coder [0221] **113** Intra prediction parameter coder [0222] **1110** Header coder [0223] **1111** CT information coder [0224] **1112** CU coder (prediction mode coder) [0225] **1114** TU coder [0226] **120** Prediction parameter derivation unit

Claims

1. An image decoding apparatus comprising: a parameter decoder configured to decode a template-based intra prediction flag from coded data; a reference sample derivation unit configured to derive a reference sample by using an image of a template reference region near a target block; a template derivation unit configured to derive a template image by using pixels adjacent to the target block; an intra prediction image derivation unit configured to derive a template prediction image by using the template reference region; an intra prediction image generation unit configured to generate, by using the reference sample, the template prediction image for one of predetermined intra prediction mode candidates; a template cost derivation unit configured to derive a cost from the template prediction image and the template image; and an intra prediction mode selection unit configured to select a template-based intra mode for the target block, from the predetermined intra prediction mode candidates, based on the cost, wherein in a case that the template-based intra prediction flag has a predetermined value, the intra prediction image generation unit generates a prediction image of the target block by using the template-based intra mode, wherein the intra prediction image generation unit references MTAP reference samples in a case of generating the template prediction image for the one of the predetermined intra prediction mode candidates, and references NTAP reference samples in a case of generating the prediction image of the target block by using template-based intra mode selected from the predetermined intra prediction mode candidates, and MTAP is smaller than NTAP.

2. The image decoding apparatus according to claim 1, wherein the template reference region is varied according to a size of the target block.

3. An image coding apparatus comprising: a reference sample derivation unit configured to derive a reference sample by using an image of a template reference region near a target block; a template derivation unit configured to derive a template image by using pixels adjacent to the target block; an intra prediction image derivation unit configured to derive a template prediction image by using the template reference region; an intra prediction image generation unit configured to generate, by using the reference sample, the template prediction image for one of predetermined intra prediction mode candidates; a template cost derivation unit configured to derive a cost from the template prediction image and the template image; an intra prediction mode selection unit configured to select a template-based intra mode for the target block, from the predetermined intra prediction mode candidates, based on the cost; and a parameter coder configured to code a template-based intra prediction flag from the template-based intra mode, wherein in a case that the template-based intra prediction flag has a predetermined value, the intra prediction image generation unit generates a prediction image of the target block by using the template-based intra mode, wherein the intra prediction image generation unit references MTAP reference samples in a case of generating the template prediction image for the one of the predetermined intra prediction mode candidates, and references NTAP reference samples in a case of generating the prediction image of the target block by using template-based intra mode selected from the predetermined intra prediction mode candidates, and MTAP is smaller than NTAP.

4. The image coding apparatus according to claim 3, wherein the template reference region is varied according to a size of the target block.