

# US Patent & Trademark Office

## Patent Public Search | Text View

United States Patent Application Publication

20250254344

Kind Code

A1

Publication Date

August 07, 2025

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### METHOD AND ELECTRONIC DEVICE FOR SIGNALING GRADUAL DECODING REFRESH PICTURES

#### Abstract

A method for signaling gradual refresh for encoding a set of pictures performed by an electronic device is provided. The method identifies a first picture in the set of pictures as being associated with a gradual refreshed picture, and stores a network abstraction layer (NAL) unit type in a coded stream associated with the first picture. The NAL unit type identifies a presence of the gradual refreshed picture. The method then stores, in the coded stream, an enable flag to identify a use of the gradual refresh for encoding at least a subset of pictures in the set of pictures.

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**Family ID:** 69644236

**Appl. No.:** 19/181735

**Filed:** April 17, 2025

#### Foreign Application Priority Data

JP	2018-160712	Aug. 29, 2018
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#### Related U.S. Application Data

parent US continuation 18532042 20231207 parent-grant-document US 12335496 child US 19181735

parent US continuation 17974459 20221026 parent-grant-document US 11889092 child US 18532042

## Publication Classification

**Int. Cl.:** **H04N19/169** (20140101); **H04N19/107** (20140101); **H04N19/167** (20140101);  
**H04N19/172** (20140101); **H04N19/70** (20140101); **H04N19/82** (20140101)

**U.S. Cl.:**

**CPC** **H04N19/188** (20141101); **H04N19/107** (20141101); **H04N19/172** (20141101);  
**H04N19/70** (20141101); H04N19/167 (20141101); H04N19/82 (20141101)

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## Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION(S) [0001] This application is a continuation application of U.S. patent application Ser. No. 17/974,459, filed on Oct. 26, 2022, which is a continuation application of U.S. patent application Ser. No. 17/271,201, filed on Feb. 24, 2021, which is a national stage application of International Patent Application No. PCT/JP2019/032910, filed on Aug. 22, 2019, which claims the benefit of and priority to Japanese Patent Application Serial No. 2018-160712, filed on Aug. 29, 2018, the contents of all of which are hereby incorporated herein fully by reference in their entirety for all purposes.

### TECHNICAL FIELD

[0002] Embodiments of the present invention relate to a video decoding apparatus and a video coding apparatus.

### BACKGROUND ART

[0003] In order to efficiently transmit or record videos, video coding apparatuses that generate coded data by coding videos and video decoding apparatuses that generate decoded images by decoding the coded data are used.

[0004] Examples of specific video coding schemes include schemes proposed by H.264/Advanced Video Coding (AVC) and H.265/High-Efficiency Video Coding (HEVC).

[0005] In HEVC, a method of splitting pictures called tiles into rectangles has been introduced. The tiles are mainly for splitting screens and performing coding and decoding in parallel, and intra prediction, motion vector prediction, and entropy coding operate independently for each tile.

[0006] In addition, NPL 1 is exemplified as a recent technique for coding and decoding videos.

### CITATION LIST

#### Non Patent Literature

[0007] NPL 1: “Algorithm Description of Joint Exploration Test Model 7,” JVET-G1001, Joint Video Exploration Team (JVET) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, Aug. 19, 2017

[0008] NPL 2: “Improved Cyclic Intra Refresh,” JVET-K0212, Joint Video Exploration Team (JVET) of ITU-T SG 16 WP 3 and ISO/IEC JTC1/SC 29/WG 11, Jul. 10, 2018

### SUMMARY OF INVENTION

#### Technical Problem

[0009] In a tile, intra prediction and a motion vector in the same screen are restricted although inter prediction is not restricted.

[0010] In order to independently decode only a specific partial image region in the same screen, it is not possible to properly perform decoding if inter prediction processing referring to a region

other than the partial image region is included. Thus, there is a method of restricting a direction of a motion vector on a coding side in the related art. However, according to recent schemes, such as HEVC, there is a method using a motion vector coded in the past, such as a merging mode, and there is a problem that it is difficult to explicitly restrict the motion vector and coding efficiency is significantly degraded.

[0011] Thus, the present invention was made in view of the aforementioned problem, and an object thereof is to provide a mechanism that realizes video coding and decoding such that only a specific portion on the same screen can be independently decoded.

#### Solution to Problem

[0012] In a first aspect of the present disclosure, a video decoding apparatus configures a partial image region in a picture that is a target of intra prediction, inter prediction, loop filter processing, or the like, handles a region outside the partial image region in a similar manner to a region outside the picture, and does not apply such limitation to a region other than the partial image region in the picture.

[0013] In a second aspect of the present disclosure, a method for signaling gradual refresh for encoding a set of pictures is provided. The method includes identifying a first picture in the set of pictures as being associated with a gradual refreshed picture; storing a network abstraction layer (NAL) unit type in a coded stream associated with the first picture, the NAL unit type identifying a presence of the gradual refreshed picture; and storing, in the coded stream, an enable flag to identify a use of the gradual refresh for encoding at least a subset of pictures in the set of pictures.

[0014] In a third aspect of the present disclosure, an electronic device for signaling gradual refresh for encoding a set of pictures is provided. The electronic device includes one or more processors, and one or more non-transitory machine-readable medium coupled to the one or more processors and storing one or more machine-executable instructions. The machine-executable instructions, when executed by at least one of the one or more processors, cause the electronic device to: identify a first picture in the set of pictures as being associated with a gradual refreshed picture; store a network abstraction layer (NAL) unit type in a coded stream associated with the first picture, the NAL unit type identifying a presence of the gradual refreshed picture; and store, in the coded stream, an enable flag to identify a use of the gradual refresh for encoding at least a subset of pictures in the set of pictures.

#### Advantageous Effects of Invention

[0015] According to an aspect of the present invention, it is possible to realize partial decoding in a picture by configuring a partial image region, in which prediction processing and loop filter processing are restricted, in the picture.

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## Description

### BRIEF DESCRIPTION OF DRAWINGS

[0016] FIG. 1 is a diagram illustrating a hierarchical structure of data of a coded stream, in accordance with one or more example implementations of this disclosure.

[0017] FIGS. 2A-2F are diagrams respectively illustrating a CTU split example, in accordance with one or more example implementations of this disclosure.

[0018] FIGS. 3A-3B are conceptual diagrams respectively illustrating an example of reference pictures and reference picture lists, in accordance with one or more example implementations of this disclosure.

[0019] FIG. 4 is a schematic diagram illustrating types (mode numbers) of intra prediction modes, in accordance with one or more example implementations of this disclosure.

[0020] FIG. 5 is a diagram illustrating a partial image region and a non-partial image region, in accordance with one or more example implementations of this disclosure.

[0021] FIGS. **6A-6B** are diagrams respectively illustrating a range in which a target block may be referred to, in accordance with one or more example implementations of this disclosure.

[0022] FIG. **7** is a flowchart illustrating a flow of decoding processing performed by a parameter decoder, in accordance with one or more example implementations of this disclosure.

[0023] FIG. **8** is a diagram illustrating an example of a syntax provided as a notification for configuring the partial image region, in accordance with one or more example implementations of this disclosure.

[0024] FIG. **9** is a diagram illustrating an example of the syntax provided as the notification for configuring the partial image region, in accordance with one or more example implementations of this disclosure.

[0025] FIG. **10** is a flowchart illustrating a flow of a partial image region configuring procedure, in accordance with one or more example implementations of this disclosure.

[0026] FIG. **11** is a diagram illustrating a configuration of a partial image region map, in accordance with one or more example implementations of this disclosure.

[0027] FIGS. **12A-12B** are diagrams respectively illustrating the gradual refresh, in accordance with one or more example implementations of this disclosure.

[0028] FIG. **13** is a diagram illustrating a syntax necessary for the gradual refresh, in accordance with one or more example implementations of this disclosure.

[0029] FIG. **14** is a schematic diagram illustrating a configuration of a video decoding apparatus, in accordance with one or more example implementations of this disclosure.

[0030] FIG. **15** is a block diagram illustrating a configuration of a video coding apparatus, in accordance with one or more example implementations of this disclosure.

[0031] FIGS. **16A-16B** are diagrams respectively illustrating configurations of a transmitting apparatus equipped with the video coding apparatus and a receiving apparatus equipped with the video decoding apparatus, in accordance with one or more example implementations of this disclosure.

[0032] FIGS. **17A-17B** are diagrams respectively illustrating configurations of a recording apparatus equipped with the video coding apparatus and a reconstruction apparatus equipped with the video decoding apparatus, in accordance with one or more example implementations of this disclosure.

[0033] FIG. **18** is a schematic diagram illustrating a configuration of an image transmission system, in accordance with one or more example implementations of this disclosure.

## DESCRIPTION OF EMBODIMENTS

### First Embodiment

[0034] Hereinafter, the present embodiment of the present invention will be described with reference to the drawings.

[0035] FIG. **18** is a schematic diagram illustrating a configuration of an image transmission system **1**, in accordance with one or more example implementations of this disclosure.

[0036] The image transmission system **1** is a system in which coded streams obtained by coded target images are transmitted, the transmitted coded streams are decoded, and thus images are 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**.

[0037] An image **T** is input to the video coding apparatus **11**.

[0038] The network **21** transmits a coded stream **Te** generated by the video coding apparatus **11** to the video decoding apparatus **31**. The network **21** may be 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 bidirectional communication network and may be a unidirectional communication network configured to transmit broadcast waves of digital terrestrial broadcasting, satellite broadcasting, or the like. The network **21** may be substituted by a storage medium in which the coded stream **Te** is

recorded, such as a Digital Versatile Disc (DVD) or a Blue-ray Disc (BD).

[0039] The video decoding apparatus **31** decodes each coded stream  $T_e$  transmitted through the network **21** and generates one or multiple decoded images  $T_d$ .

[0040] The video display apparatus **41** displays all or some of the one or more decoded images  $T_d$  generated by the video decoding apparatus **31**. The video display apparatus **41** includes, for example, a display device, such as a liquid crystal display or an organic electro-luminescence (EL) display. Examples of forms of the display include a stationary form, a mobile form, an HMD form, and the like. Images with high image quality are displayed in a case that the video decoding apparatus **31** has a high processing capability, while images that do not require a high processing capability and a high display capability are displayed in a case that the video decoding apparatus **31** has only a low processing capability.

#### Operator

[0041] Operators used in the present specification will be described below.

[0042]  $\gg$  denotes a right bit shift,  $\ll$  denotes a left bit shift,  $\&$  denotes a bitwise AND,  $|$  denotes a bitwise OR,  $|=$  denotes an OR assignment operator, and  $||$  denotes a logical sum.

[0043]  $x? y:z$  is a ternary operator that is  $y$  in a case that  $x$  is true (other than 0) and is  $z$  in a case that  $x$  is false (0).

[0044]  $\text{Clip3}(a, b, c)$  is a function that clips  $c$  in a value equal to or greater than  $a$  and equal to or less than  $b$  and a function that returns  $a$  in a case that  $c < a$ , returns  $b$  in a case that  $c > b$ , and returns  $c$  in other cases (provided that  $a \leq b$ ). [0045]  $\text{abs}(a)$  is a function that returns an absolute value of  $a$ . [0046]  $\text{Int}(a)$  is a function that returns an integer value of  $a$ . [0047]  $\text{floor}(a)$  is a function that returns a maximum integer that is equal to or less than  $a$ . [0048]  $\text{ceil}(a)$  is a function that returns a maximum integer that is equal to greater than  $a$ . [0049]  $a/d$  denotes division of  $a$  by  $d$  (rounded down to the nearest decimal point).

#### Structure of Coded Stream $T_e$

[0050] Prior to detailed description of the video coding apparatus **11** and the video decoding apparatus **31**, according to the present embodiment, a data structure of the coded stream  $T_e$  generated by the video coding apparatus **11** and decoded by the video decoding apparatus **31** will be described.

[0051] FIG. **1** is a diagram illustrating a hierarchy structure of data a coded stream  $T_e$ , in accordance with one or more example implementations of this disclosure. The coded stream  $T_e$  includes a sequence and multiple pictures constituting the sequence in an illustrative example. FIG. **1** is the diagram illustrating a coded video sequence prescribing a sequence SEQ, a coded picture prescribing a picture PICT, a coded slice prescribing a slice S, coded slice data prescribing slice data, a coding tree unit included in the coded slice data, and coding units included in the coding tree unit, respectively.

#### Coding Video Sequence

[0052] In the coded video sequence, a set of data items referred to by the video decoding apparatus **31** to decode the sequence SEQ to be processed is defined. As illustrated in FIG. **1**, the sequence SEQ may include a video parameter set, a sequence parameter set SPS, a picture parameter set PPS, a picture PICT, and supplemental enhancement information SEI.

[0053] In the video parameter set VPS, a set of coding parameters common to multiple videos and a set of coding parameters associated with multiple layers and individual layers included in the video are defined in a video constituted by multiple layers.

[0054] In the sequence parameter set SPS, a set of coding parameters referred to 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 be present. In that case, any of the multiple SPSs is selected from the PPS.

[0055] In the picture parameter set PPS, a set of coding parameters referred to 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 weighted prediction are included. Note that multiple PPSs may be present. In that case, any of the multiple PPSs is selected from each picture in a target sequence.

#### Coding Picture

[0056] In the coded picture, a set of data items referred to by the video decoding apparatus **31** to decode a picture PICT to be processed is defined. As illustrated in FIG. **1**, the picture PICT includes slices 0 to NS-1 (NS is the total number of slices included in the picture PICT).

[0057] Note that in a case that it is not necessary to distinguish each of the slices 0 to NS-1 below, subscripts of reference signs may be omitted. In addition, the same applies to other data with subscripts included in the coded stream *Te* which will be described below.

#### Coding Slice

[0058] In the coded slice, a set of data items referred to by the video decoding apparatus **31** to decode the slice *S* to be processed is defined. As illustrated in FIG. **1**, the slice includes a slice header and slice data.

[0059] The slice header includes a coding parameter group referred to by the video decoding apparatus **31** to determine a method of decoding a target slice. Slice type specification information (`slice_type`) specifying a slice type is one example of a coding parameter included in the slice header.

[0060] Examples of slice types that may be specified by the slice type specification information include (1) I slice using only intra prediction in coding, (2) P slice using a unidirectional prediction or intra prediction in coding, (3) B slice using unidirectional prediction, bidirectional prediction, or intra prediction in coding, and the like. Note that the inter prediction is not limited to uni-prediction and bi-prediction and a prediction image may be generated using more reference pictures.

Hereinafter, slices called P and B slices indicate slices including blocks that may use inter prediction.

[0061] Note that the slice header may include reference (`pic_parameter_set_id`) to the picture parameter set PPS.

#### Coding Slice Data

[0062] In the coded slice data, a set of data items referred to by the video decoding apparatus **31** to decode the slice data to be processed is defined. The slice data includes a CTU as illustrated in FIG. **1**. The CTU is a block with a fixed size (for example, 64×64) constituting a slice and may be called a largest coding unit (LCU).

#### Coding Tree Unit

[0063] In FIG. **1**, a set of data items referred to by the video decoding apparatus **31** to decode the CTU to be processed is defined. FIGS. 2A-2F are diagrams respectively illustrating a CTU split example, in accordance with one or more example implementations of this disclosure. The CTU is split into coding unit CUs that are basic units of coding processing through recursive quad tree split (quad tree (QT) split, binary tree (BT) split) or ternary tree split (ternary tree (TT) split). The BT split and the TT split will collectively be referred to as multi-tree split (multi-tree (MT) split). Nodes with a tree structure obtained by recursive quad tree split will be 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.

[0064] CT includes, as CT information, QT split flag (`cu_split_flag`) indicating whether or not to perform QT split, an MT split mode (`split_mt_mode`) indicating a splitting method for MT split, an MT split direction (`split_mt_dir`) indicating a splitting direction of MT split, and an MT split type (`split_mt_type`) indicating a split type of MT split. `Cu_split_flag`, `split_mt_flag`, `split_mt_dir`, and `split_mt_type` are transmitted for each coding node.

[0065] In a case that `cu_split_flag` is 1, the coding node is split into four coding nodes (FIG. 2B). In a case that `cu_split_flag` is 0, the coding node is not split and has one CU as a node in a case that

split\_mt\_flag is 0 (FIG. 2A). The CU is an end node of the coding node and is not split any more. The CU is a basic unit of coding processing.

[0066] In a case that split\_mt\_flag is 1, the following MT split is performed on the coding node. In a case that the split\_mt\_type is 0, the coding node is horizontally split into two coding nodes in a case that split\_mt\_dir is 1 (FIG. 2D), and the coding node is vertically split into two coding nodes in a case that split\_mt\_dir is 0 (FIG. 2C). Also, in a case that the split\_mt\_type is 1, the coding node is horizontally split into three coding nodes in a case that split\_mt\_dir is 1 (FIG. 2F), and the coding node is vertically split into three coding nodes in a case that split\_mt\_dir is 0 (FIG. 2E).

[0067] Also, in a case that the size of the CTU is 64×64 pixels, the size of the CU may be any of 64×64 pixels, 64×32 pixels, 32×64 pixels, 32×32 pixels, 64×16 pixels, 16×64 pixels, 32×16 pixels, 16×32 pixels, 16×16 pixels, 64×8 pixels, 8×64 pixels, 32×8 pixels, 8×32 pixels, 16×8 pixels, 8×16 pixels, 8×8 pixels, 64×4 pixels, 4×64 pixels, 32×4 pixels, 4×32 pixels, 16×4 pixels, 4×16 pixels, 8×4 pixels, 4×8 pixels, and 4×4 pixels.

#### Coding Unit

[0068] As illustrated in FIG. 1, a set of data items referred to by the video decoding apparatus 31 to decode the coding unit to be processed is defined. Specifically, the CU is constituted of 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.

[0069] The prediction processing may be performed in units of Cus and in units of sub-Cus obtained by further splitting the Cus. In a case that the sizes of the CU and the sub-CU are the same, there is one sub-CU in the CU. In a case that the CU has a larger size than the sub-CU, the CU is split into the 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 horizontally split into two sub-Cus, is vertically split into two sub-Cus, and is thus split into four sub-Cus.

[0070] There are two types of predictions (or two prediction modes): intra prediction and inter prediction. Intra prediction is a prediction in an identical picture, and inter prediction is a prediction processing performed between different pictures (for example, between pictures of different display times, or between pictures of different layer images).

[0071] Although the transform and quantization processing is performed in units of Cus, the quantization transform coefficient may be entropy-coded in units of 4×4 sub-blocks or the like.

#### Prediction Parameters

[0072] The prediction image is derived by prediction parameters that accompany blocks. The prediction parameters include prediction parameters of intra prediction and prediction parameters of inter prediction.

[0073] Hereinafter, the prediction parameters of inter prediction will be described. The inter prediction parameters are constituted by prediction list utilization flags predFlagL0 and predFlagL1, reference picture indexes refIdxL0 and refIdxL1, and motion vectors mvL0 and mvL1. The prediction list utilization flags predFlagL0 and predFlagL1 are flags to indicate whether or not reference picture lists referred to as an L0 list and an L1 list respectively are to be used, and a corresponding reference picture list is used in a case that the value is 1. Note that, in a case that the present specification mentions “a flag indicating whether or not XX,” a flag being other than 0 (for example, 1) assumes a case of XX, and a flag being 0 assumes a case of not XX, and 1 is treated as true and 0 is treated as false in a logical negation, a logical product, and the like (hereinafter, the same is applied). However, other values may be used for true values and false values in real apparatuses and methods.

[0074] For example, syntax elements to derive inter prediction parameters include a merge flag merge\_flag, a merge index merge\_idx, an inter prediction identifier inter\_pred\_idc, a reference picture index refIdxLX, a prediction vector index mvp\_LX\_idx, and a difference vector mvdLX.

#### Reference Picture List

[0075] A reference picture list is a list constituted by reference pictures stored in a reference picture

memory 306. FIGS. 3A-3B are conceptual diagram respectively illustrating an example of reference pictures and reference picture lists, in accordance with one or more example implementations of this disclosure, in a picture structure for low latency. In FIG. 3A, a rectangle indicates a picture, an arrow indicates a reference relationship of a picture, a horizontal axis indicates time, I, P, and B in a rectangle indicate an intra-picture, a uni-prediction picture, and a bi-prediction picture, respectively, and numbers in rectangles indicates a decoding order. As illustrated in the drawing, the decoding order of the pictures is I0, P1/B1, P2/B2, P3/B3, and P4/B4, and the display order is also the same. FIG. 3B illustrates an example of reference picture lists of the picture B3 (target picture). The reference picture lists are lists to represent candidates of a reference picture, and one picture (slice) may have one or more reference picture lists. In the illustrated example, the target picture B3 has two reference picture lists, namely, an L0 list RefPicList0 and an L1 list RefPicList1. For the individual Cus, which of the pictures in the reference picture list RefPicListX (X=0 or 1) is to be actually referred to is designated by a reference picture index refIdxLX. The drawing shows an example in which refIdxL0=2 and refIdxL1=0. In a case that the target picture is P3, the reference picture list is only the L0 list. Note that LX is a description method used in a case of not distinguishing the L0 prediction and the L1 prediction, and in the following description, the parameter for the L0 list and the parameter for the L1 list are distinguished by replacing LX with L0 or L1.

#### Merge Prediction and AMVP Prediction

[0076] Decoding (coding) methods of prediction parameters include a merge prediction (merge) mode and an adaptive motion vector prediction (AMVP) mode, and merge flag merge\_flag is a flag to identify these modes.

[0077] The merge prediction mode is a mode used to derive the prediction list utilization flag predFlagLX (or the inter prediction identifier inter\_pred\_idc), the reference picture index refIdxLX, and the motion vector mvLX from prediction parameters of a nearby block that has already been processed without including these in the coded data. The merge index merge\_idx is an index indicating which prediction parameter among prediction parameter candidates (merge candidates) derived from the block that has already been processed is to be used as a prediction parameter for the target block.

[0078] The AMVP mode is a mode in which the inter prediction identifier inter\_pred\_idc, the reference picture index refIdxLX, and the motion vector mvLX are included in the coded data. Note that the motion vector mvLX is coded as a prediction vector index mvp\_LX\_idx identifying a prediction vector mvpLX and a difference vector mvdLX. The inter prediction identifier inter\_pred\_idc is a value indicating types and number of reference pictures and takes any of the values PRED\_L0, PRED\_L1, and PRED\_B1. PRED\_L0 and PRED\_L1 indicate uni-prediction using one reference picture managed by the L0 list and the L1 list, respectively. PRED\_B1 indicates bi-prediction BiPred using two reference pictures managed by the L0 list and the L1 list.

#### Motion Vector

[0079] The motion vector mvLX indicates a shift amount between blocks in two different pictures. A prediction vector and a difference vector related to the motion vector mvLX are referred to as a prediction vector mvpLX and a difference vector mvdLX, respectively.

[0080] Hereinafter, prediction parameters of the intra prediction will be described. The intra prediction parameters are constituted by a luminance prediction mode IntraPredModeY and a chrominance prediction mode IntraPredModeC. FIG. 4 is a schematic diagram illustrating types (mode numbers) of intra prediction modes, in accordance with one or more example implementations of this disclosure. As illustrated in FIG. 4, there are 67 (0 to 66) types of intra prediction modes, for example. For example, there are Planar prediction (0), DC prediction (1), and Angular prediction (2 to 66). Furthermore, LM modes (67 to 72) may be added for chrominance.

[0081] Syntax elements to derive the intra prediction parameters include, for example, prev\_intra\_luma\_pred\_flag, mpm\_idx, rem\_selected\_mode\_flag, rem\_selected\_mode, and



rem\_non\_selected\_mode.

## MPM

[0082] prev\_intra\_luma\_pred\_flag is a flag indicating whether or not the luminance prediction mode IntraPredModeY of the target block conforms to a most probable mode (MPM). MPM is a prediction mode included in an MPM candidate list mpmCandList[]. The MPM candidate list is a list storing candidates that are estimated to have high likelihoods of application to the target block from the intra prediction mode of an adjacent block and a predetermined intra prediction mode. In a case that prev\_intra\_luma\_pred\_flag is 1, the luminance prediction mode IntraPredModeY of the target block is derived using the MPM candidate list and the index mpm\_idx.

IntraPredModeY=mpmCandList[mpm\_idx]

## REM

[0083] In a case that prev\_intra\_luma\_pred\_flag is 0, an intra prediction mode is selected from modes RemIntraPredMode remaining after excluding intra prediction modes included in the MPM candidate list from all the intra prediction modes. The intra prediction mode which is selectable as RemIntraPredMode is referred to as “non-MPM” or “REM”. The flag rem\_selected\_mode\_flag is a flag designating whether an intra prediction mode is to be selected with reference to rem\_selected\_mode or whether an intra prediction mode is to be selected with reference to rem\_non\_selected\_mode. RemIntraPredMode is derived using rem\_selected\_mode or rem\_non\_selected\_mode.

## Partial Image Region Coding and Decoding Region

[0084] Video coding decoding methods of configuring a partial image region in the same picture, performing coding and decoding processing on the partial image region without using pixels in the other region, and performing coding and decoding processing on the other region using the entire picture will be described.

[0085] FIG. 5 is a diagram illustrating a partial image region A and a non-partial image region B, in accordance with one or more example implementations of this disclosure. According to the video coding apparatus and decoding apparatus in the present invention, regions corresponding to the region A and the region B in the picture are configured. For example, the region A and the region B are configured by a partial image region controller, which will be described later. For the region A, it is possible to perform prediction processing only from the region A, and for the outside of the region, processing similar to that for the outside of the picture or the tile, such as padding, is performed. On the other hand, it is possible to perform prediction processing from the entire picture including the region A for the region B. Here, the “prediction processing” indicates intra prediction, inter prediction, loop filter processing, and the like. As for the region A, the coding processing and the decoding processing are closed in the region A, and it is thus possible to decode only the region A.

[0086] Hereinafter, the region A will be referred to as a partial image region (a first region, a controlled region, a clean region, a refreshed region, a region A). On the other hand, the region other than the partial image region will also be referred to as a non-partial image region (a second region, a non-controlled region, a dirty region, an unrefreshed region, a region B, outside of the limited region).

[0087] For example, a region that is coded and decoded only through the intra prediction and that has already been coded through intra prediction (a newly refreshed region IRA obtained only through intra, which will be described later) is a partial image region. A region that is coded and decoded further referring the partial image region constituted through the intra prediction is also a partial image region. Further, a region that is coded and decoded with reference to the partial image region in the reference picture as in the inter prediction, for example, is also a partial image region. In other words, the partial image region is a region that is coded and decoded referring only to the pixels in the partial image region without referring to the pixels in the non-partial image region.

[0088] Hereinafter, the upper left position of a partial image region is indicated as (xRA\_st, yRA\_st), the lower right position thereof is indicated as (xRA\_en, yRA\_en), and the size thereof is indicated as (wRA, hRA). Also, because the position and the size have the following relationship, one of them may be derived from the other.

$$xRA\_en = xRA\_st + wRA - 1$$

$$yRA\_en = yRA\_st + hRA - 1$$

[0089] Also, the following derivation may also be employed.

$$wRA = xRA\_en - xRA\_st + 1$$

$$hRA = yRA\_en - yRA\_st + 1$$

[0090] Further, the upper left position of a limited reference region at a time j is indicated as (xRA\_st[j], yRA\_st[j]), the lower right position thereof is indicated as (xRA\_en[j], yRA\_en[j]), and the size thereof is indicated as (wRA[j], hRA[j]). Also, the position of the limited reference region of the reference picture Ref may be indicated as (xRA\_st[Ref], yRA\_st[Ref]), the lower right position may be indicated as (xRA\_en[Ref], yRA\_en[Ref]), and the size thereof may be indicated as (wRA[Ref], hRA[Ref]).

#### Determination of Partial Image Region

[0091] For example, in a case that a certain picture is taken at a time i and the position of a certain block is (x, y), whether or not a pixel at the position is inside a partial image region may be determined by the following equation.

$$IsRA(x, y) = (xRA\_st[i] \leq x \ \&\& \ x \leq xRA\_en[i] \ \&\& \ yRA\_st[i] \leq y \ \&\& \ y \leq yRA\_en[i])$$

Alternatively, the following determination equation may be used.

$$IsRA(x, y) = (xRA\_st[i] \leq x \ \&\& \ x < xRA\_st[i] + wRA[i] \ \&\& \ yRA\_st[i] \leq y \ \&\& \ y < yRA\_st[i] + hRA[i])$$

$$IsRA(xRef, yRef) = (xRA\_st[Ref] \leq xRef \ \&\& \ xRef \leq xRA\_en[Ref] \ \&\& \ yRA\_st[Ref] \leq yRef \ \&\& \ yRef \leq yRA\_en[Ref])$$

For example, in a case that the target picture is taken at the time i, the upper left coordinates of the target block Pb are (xPb, yPb), and the width and the height are bW and bH, the intra prediction unit, the motion compensation unit, and the loop filter of the video decoding apparatus and the video coding apparatus derive IsRA (Pb) by the following determination equation if the target block Pb is inside the partial image region.

$$IsRA(Pb) = (xRA\_st[i] \leq xPb \ \&\& \ xPb \leq xRA\_en[i] \ \&\& \ yRA\_st[i] \leq yPb \ \&\& \ yPb \leq yRA\_en[i])$$

Alternatively, the following determination equation may be used.

$$IsRA(Pb) = (xRA\_st[i] \leq xPb \ \&\& \ xPb < xRA\_st[i] + wRA[i] \ \&\& \ yRA\_st[i] \leq yPb \ \&\& \ yPb < yRA\_st[i] + hRA[i])$$

#### Basic Operations for Reference Region of Partial Image Region

[0092] The video coding apparatus and the video decoding apparatus according to the present specification perform the following operations.

[0093] FIGS. 6A-6B are diagrams respectively illustrating a range in which a target block may be referred to, in accordance with one or more example implementations of this disclosure. The range in which the partial image region having the target block may be referred to through the intra prediction, the inter prediction, and the loop filter is shown according to the present disclosure. The region surrounded by the thick line in the picture in FIG. 6A is a region that is included in the

partial image region and that has already been coded and decoded. The region that is included in the partial image region in the same picture (target image i) as that of the target block and that has already been coded and decoded is a range in which the target block may be referred to through the intra prediction, the inter prediction, and the loop filter. Similarly, the partial image region in the reference picture (reference image j) is a range in which the target block may be referred to through the inter prediction and the loop filter. FIG. 6B illustrates a range in which the target block included in the non-partial image region may be referred to. The region surrounded by the thick line in the picture in FIG. 6B is a region that has already been coded and decoded in the target picture. The region that has already been coded or decoded in the target picture (target image i) is a range in which the target block may be referred to through the intra prediction and the inter prediction. Similarly, all the regions in the reference picture (reference image j) are in the range in which reference may be made through the inter prediction. Note that, in a case that parallel processing and reference restriction of tiles, slices, wavefronts, and the like are used, other restrictions may be added in addition to the aforementioned restrictions. [0094] For the target block included in the partial image region, intra prediction referring only to pixels in the partial image region in the target picture or inter prediction referring to the limited reference region of the reference picture is performed. [0095] For the target block included in the partial image region, the coding parameter of the target block is derived with reference to the coding parameter (for example, the intra prediction direction, the motion vector, or the reference picture index) of the partial image region in the target picture or with reference to the coding parameter of the limited reference region of the reference picture. [0096] For the target block included in the partial image region, loop filter processing is performed referring only to the pixels in the partial image region in the target picture.

#### Determination and Availability of Partial Image Region

[0097] In MPM derivation of the intra prediction, merge candidate derivation of the inter prediction and the like, the prediction parameters (the intra prediction mode, the motion vector) of the target block may be derived using prediction parameters of the adjacent region. In such a case, the following processes may be performed. In a case that in a case that the target block in the intra prediction and the inter prediction is the partial image region ( $\text{IsRA}(x_{\text{Pb}}, y_{\text{Pb}})$  is true) and the reference position ( $x_{\text{NbX}}, y_{\text{NbX}}$ ) of the adjacent block of the target block is the non-partial image region ( $\text{IsRA}(x_{\text{NbX}}, y_{\text{NbX}})$  is false), the value of the adjacent block is not used to derive the prediction parameters. In other words, in a case that the target block is the partial image region ( $\text{IsRA}(x_{\text{Pb}}, y_{\text{Pb}})$  is true) and the reference position ( $x_{\text{NbX}}, y_{\text{NbX}}$ ) of the adjacent block of the target block is the partial image region ( $\text{IsRA}(x_{\text{NbX}}, y_{\text{NbX}})$  is true), the position ( $x_{\text{NbX}}, y_{\text{NbX}}$ ) is used to derive the prediction parameters.

[0098] Note that the derivation of prediction candidates has been described above, the determination of the partial image region may be used generally for determining a region outside the screen similarly to the determination of units (the slice boundary, the tile boundary) for the region outside the screen or parallel processing. In this case, in a case that the target block is the partial image region ( $\text{IsRA}(x_{\text{Pb}}, y_{\text{Pb}})$  is true) and the reference position ( $x_{\text{NbX}}, y_{\text{NbX}}$ ) of the target block is the partial image region ( $\text{IsRA}(x_{\text{NbX}}, y_{\text{NbX}})$  is true), it is determined that the reference position ( $x_{\text{NbX}}, y_{\text{NbX}}$ ) cannot be referred to ( $\text{availableNbX}=0$ ). In other words, in a case that the target block is within the screen, the target block and the reference position are not in the same different parallel processing unit, and the target block is present in the non-partial image region, or the reference position ( $x_{\text{NbX}}, y_{\text{NbX}}$ ) of the target block is the partial image region ( $\text{IsRA}(x_{\text{NbX}}, y_{\text{NbX}})$  is true), it is determined that the reference position ( $x_{\text{NbX}}, y_{\text{NbX}}$ ) may be referred to ( $\text{availableNbX}=1$ ). In the intra prediction and the inter prediction, in a case that the reference position ( $x_{\text{NbX}}, y_{\text{NbX}}$ ) may be referred to ( $\text{availableNbX}=1$ ), the prediction parameters at the reference position are used to derive the prediction parameters of the target block.

#### Determination of Limited Reference Region and Clipping of Limited Reference Region

[0099] Also, in a case that the reference picture is taken at the time j and the upper left position of

the reference image is (xRef, yRef), the motion compensation unit derives the case that the reference pixels are present within the limited reference region using the following determination equation.

$$\text{IsRA}(\text{xRef}, \text{yRef}) = (\text{xRA\_st}[j] \leq \text{xRef} \ \&\& \ \text{xRef} \leq \text{xRA\_en}[j] \ \&\& \ \text{yRA\_st}[j] \leq \text{yRef} \ \&\& \ \text{yRef} \leq \text{yRA\_en}[j])$$

Alternatively, the following determination equation may be used.

$$\text{IsRA}(\text{xRef}, \text{yRef}) = (\text{xRA\_st}[j] \leq \text{xRef} \ \&\& \ \text{xRef} < \text{xRA\_st}[j] + \text{wRA}[j] \ \&\& \ \text{yRA\_st}[j] \leq \text{yRef} \ \&\& \ \text{yRef} < \text{yRA\_st}[j] + \text{hRA}[j])$$

Also, the motion compensation unit may clip the reference pixels at positions in the partial image region using the following equations.

$$\text{Xref} = \text{Clip3}(\text{xRA\_st}[j], \text{xRA\_en}[j], \text{xRef})$$
$$\text{Yref} = \text{Clip3}(\text{yRA\_st}[j], \text{yRA\_en}[j], \text{yRef})$$

Alternatively, the following derivation equations may be used.

$$\text{xRef} = \text{Clip3}(\text{xRA\_st}[j], \text{xRA\_st}[j] + \text{wRA}[j] - 1, \text{xRef})$$
$$\text{yRef} = \text{Clip3}(\text{yRA\_st}[j], \text{yRA\_st}[j] + \text{hRA}[j] - 1, \text{yRef})$$

Note that the position of the partial image region is transmitted from the video coding apparatus to the video decoding apparatus using gradual refresh information, which will be described later. Note that instead of deriving the position and the size of the partial image region in accordance with the time (for example, the POC), a reference picture Ref in a reference memory may be configured after the target picture is decoded or at a time when decoding of the target picture is started. In this case, it is possible to derive the position and the size of the partial image region through designation of the reference picture Ref.

#### SDR Picture

[0100] The entire instantaneous decoder refresh (IDR) picture in the AVC or the HEVC is an intra CTU, may be randomly accessed, and realizes a random-access of coded data as a picture that may be independently decoded. In the present embodiment, the picture in which the partial image region has entirely been intra-coded may be identified with nal\_unit\_type of a network abstraction layer (NAL) as a sequentially decoder refresh (SDR) picture.

[0101] As for the SDR picture, it is possible to independently decode a partial screen region in the picture and to randomly access the partial screen region. Because the entire IDR picture in the related art corresponds to intra while a part of the SDR picture corresponds to intra, the coding amount varies less.

#### Parameter Decoder 302

[0102] The parameter decoder 302 configures a partial image region as follows, for example, in an SDR picture. [0103] A partial image region is configured as a rectangle defined by the coordinates of the upper left CTU and the numbers of CTUs corresponding to the width and the height. [0104] A partial image region is configured as a rectangle defined by the position of the upper left pixel and the numbers of pixels corresponding to the width and the height. [0105] Multiple partial image regions are configured in a single picture. [0106] Multiple partial image regions are configured such that the partial image regions are superimposed on each other.

[0107] “The multiple partial image region are superimposed on each other” means that multiple partial image regions included in one picture may include a CTU at the same position, for example.

[0108] In addition, partial image regions of multiple pictures in a group of pictures (GOP) may be superimposed on each other. Here, “the partial image regions are superimposed on each other”

corresponds to the situation that the partial image region configured in the SDR picture and the partial image region configured in the next picture of the SDR picture include CTUs at the same position. The number of pictures including the partial image regions superimposed on each other is not particularly limited, and the pictures are multiple pictures continuing from the SDR picture in the GOP.

#### Flow of Processing Performed by Parameter Decoder **302** (SDR Picture)

[0109] FIG. 7 is a flowchart illustrating a flow of decoding processing performed by the parameter decoder **302**, in accordance with one or more example implementations of this disclosure.

##### Step S1

[0110] Decoding is started, and the processing proceeds to Step S2.

##### Step S2

[0111] The parameter decoder **302** determines whether or not the target picture is an SDR picture with `nal_unit_type` of NAL. The processing proceeds to S3 in a case that the target picture is an SDR picture, and the processing proceeds to S4 in a case that the target picture is not an SDR picture.

##### Step S3

[0112] The partial image region included in the target picture is configured as a region to be decoded through intra prediction, and the processing proceeds to S4.

##### Step S4

[0113] The parameter decoder **302** decodes the target picture.

[0114] The video decoding apparatus **31** may decode a video of only the partial image region of the pictures continuing from the SDR picture by configuring the partial image region in this manner.

#### Example 1 of Region Information

[0115] A syntax for configuring partial image regions may be included in a picture parameter set. FIG. 8 is a diagram illustrating an example of a syntax provided as a notification for configuring partial image regions, in accordance with one or more example implementations of this disclosure. `Partial_region_mode` is information for specifying whether or not to define partial image regions in pictures. In a case that `partial_region_mode` included in the picture parameter set is 1, the entropy decoder **301** included in the video decoding apparatus **31** determines that it is necessary to configure the partial image regions and decodes `num_of_ptial_region_minus1`.

[0116] `num_of_ptial_region_minus1` indicates “the number of partial image regions-1” in the picture. `Position_ctu_address[i]` indicates the address of the upper left CTU in the i-th partial image region of multiple partial image regions in the pictures. `Region_ctu_width_minus1[i]` indicates, in regard to the i-th partial image region from among multiple partial image regions in the pictures, “the number of CTUs in the partial image region in the horizontal direction-1”. `Region-ctu_height_minus1[i]` indicates, in regard to the i-th partial image region from among multiple partial image regions in the pictures, the number of CTUs in the partial image region in the vertical direction-1”.

[0117] The entropy decoder **301** adds one to i until i becomes equal to the value of `num_of_ptial_region_minus1` and decodes `position_ctu_adress[i]`, `region_ctu_width_minus1[i]`, and `region_ctu_height_minus1[i]`.

[0118] Then, the partial image region controller **320** included in the video decoding apparatus **31** configures, in a target picture, a partial image region at the position and with the size specified by

[0119] `position_ctu_adress[i]` [0120] `region_ctu_width_minus1[i]` [0121]

`region_ctu_height_minus1[i]`

for each i.

[0122] Note that [0123] `num_of_ptial_region_minus1` [0124] `position_ctu_adress[i]` [0125] `region_ctu_width_minus1[i]` [0126] `region_ctu_height_minus1[i]`

are examples of region information for specifying the partial image regions.

#### Example 2 of Region Information

[0127] A syntax for configuring partial image regions may be included in a slice header. FIG. 9 is a diagram illustrating an example of a syntax provided as a notification for configuring the partial image regions, in accordance with one or more example implementations of this disclosure.

First\_slice\_segment\_in\_pic\_flag is a flag indicating whether or not a corresponding slice is the first slice in a decoding order. In a case that first\_slice\_segment\_in\_pic\_flag is 1, this indicates that the corresponding slice is the first slice. Also, in a case that first\_slice\_segment\_in\_pic\_flag is 0, this indicates that the corresponding slice is not the first slice. In a case that first\_slice\_segment\_in\_pic\_flag is 1, partial\_region\_mode is configured, and the entropy decoder **301** included in the video decoding apparatus **31** decodes num\_of\_patial\_region\_minus1.

[0128] num\_of\_patial\_region\_minus1 indicates “the number of partial image regions-1” in a slice. Position\_ctu\_adress[i] indicates the address of the upper left CTU in the i-th partial image region from among multiple partial image regions that are present in the slice.

Region\_ctu\_width\_minus1[i] indicates, in regard to the i-th partial image region from among multiple partial image regions in the slice, “the number of CTUs in the partial image region in the horizontal direction-1”. Region\_ctu\_height\_minus1[i] indicates, in regard to the i-th partial image region from among the multiple partial image regions in the slice, “the number of CTUs in the partial image region in the vertical direction-1.”

[0129] The entropy decoder **301** adds one to i until i becomes equal to the value of num\_of\_patial\_region\_minus1 and decodes position\_ctu\_adress[i], region\_ctu\_width\_minus1[i], and region\_ctu\_height\_minus1[i].

[0130] Then, the partial image region controller **320** included in the video decoding apparatus **31** configures, in a target slice, a partial image region at a position with a size specified by [0131] position\_ctu\_adress[i] [0132] region\_ctu\_width\_minus1[i] [0133] region\_ctu\_height\_minus1[i] for each i.

[0134] Note that [0135] num\_of\_patial\_region\_minus1 [0136] position\_ctu\_adress[i] [0137] region\_ctu\_width\_minus1[i] [0138] region\_ctu\_height\_minus1[i] are examples of region information for specifying the partial image regions.

[0139] Note that although one CTU is regarded as a minimum unit in the above example, one or multiple CTU columns or one or multiple CTU rows and multiple CTUs may be configured as minimum units.

#### Example of Procedure for Configuring Partial Image Region

[0140] FIG. 10 is a flowchart illustrating a flow of a partial image region configuring procedure, in accordance with one or more example implementations of this disclosure. The partial image region configuring procedure may be performed by the video decoding apparatus **31** in a case that partial image regions are defined in a picture parameter set.

##### Step S1

[0141] The decoding processing is started, and processing proceeds to Step S2.

##### Step S2

[0142] The entropy decoder **301** moves on to Step S3 in a case of partial\_region\_mode (in a case that partial\_region\_mode is 1) and moves on to Step S4 in a case of not partial\_region\_mode (in a case that partial\_region\_mode is 0).

##### Step S3

[0143] In a case of partial\_region mode, the entropy decoder **301** decodes each syntax included in region information, and the partial image region controller **320** defines partial image regions designated by each syntax and ends the processing. Specific processing of configuring the partial image regions is as described above.

##### Step S4

[0144] In a case of not partial\_region\_mode, the video decoding apparatus **31** deletes the partial image regions and ends the processing.

#### Partial Image Region Map

[0145] The parameter decoder **302** may be configured to configure a partial image region map (partial\_region\_map) as information representing the position of the partial image region for each picture.

[0146] FIG. **11** is a diagram illustrating a configuration of a partial image region map, in accordance with one or more example implementations of this disclosure. The example of the syntax may be provided as a notification to configure partial image regions. Partial\_region\_map is a syntax representing whether or not a corresponding region is a partial screen region for each CTU inside a picture. The entropy decoder **301** included in the video decoding apparatus **31** determines that the corresponding region is a partial image region in a case that partial\_region\_map is 1 and determines that the corresponding region is a non-partial image region in a case that partial\_region\_map is 0. Partial\_region\_mode is information for specifying whether or not to define partial image regions in pictures.

[0147] PicHeightInCtbsY indicates the number of CTUs in a picture in the vertical direction, and PicWidthInCtbsY indicates the number of CTUs in the picture in the horizontal direction.

[0148] One is added to i until i becomes equal to num\_of\_patial\_region\_minus1+1, and  $y = \text{position\_ctu\_adress}[i] / \text{PicWidthInCtbsY}$  and  $x = \text{position\_ctu\_adress}[i] \% \text{PicWidthInCtbsY}$  are calculated.

[0149] One is added to j until j becomes equal to region\_ctu\_width\_minus1[i], one is added to k until k becomes equal to rgion\_ctu\_height\_minus1[i], and corresponding partial\_region\_map[h+j][w+k] is configured to be one.

[0150] The partial image region controller **320** of the parameter decoder **302** may be configured to configure partial image regions with reference to thus generated partial\_region\_map.

[0151] Information regarding partial\_region\_map representing the position of the partial image region saved for each picture is managed by a decoder picture buffer (DPB) in a decoded picture memory. Further, information regarding partial\_region\_map is stored in the reference picture list in the reference picture memory **306** to be used for inter prediction performed by the prediction image generation unit **308**.

[0152] Here, in regard to the order of decoding and coding of the CTUs, the video decoding apparatus **31** decodes the CTUs in a raster scanning order in units of pictures or tiles without distinguishing the CTUs in the partial image region and the non-partial image region, and the video coding apparatus **11** codes the CTUs in a raster scanning order without distinguishing the CTUs in the partial image region and the CTUs in the non-partial image region.

[0153] Also, the entropy coder **104** is configured to perform entropy coding without distinguishing the partial image region and the non-partial image region, and the entropy decoder **301** is configured to perform entropy decoding independently for the partial image region and for the non-partial image region. More specifically, the entropy coder **104** and the entropy decoder **301** are configured to update context in a continuous manner between the partial image region and the non-partial image region.

[0154] Because the concepts of the partial image region and the non-partial image region described in the present embodiment are concepts that are independent from the decoding and coding orders, the orders of decoding and coding the CTUs may be mutually independent between the partial image region and the non-partial image region.

[0155] In one example, the video decoding apparatus **31** may be configured to mutually independently decode the CTUs in the partial image region and the CTUs in the non-partial image region in a raster scanning order, and the video coding apparatus **11** may be configured to mutually independently code the CTUs in the partial image region and the CTUs in the non-partial image region in a raster scanning order.

[0156] Also, the entropy coder **104** may be configured to perform entropy coding independently for the partial image region and the non-partial image region, and the entropy decoder **301** may be configured to perform entropy decoding independently for the partial image region and for the non-

partial image region. More specifically, the entropy coder **104** and the entropy decoder **301** may be configured to update context independently for the partial image region and the non-partial image region.

### Decoding of Partial Image Region

[0157] In the above-mentioned configurations, an initial configuration of a partial image region is performed with an SDR picture. The video coding apparatus **11** codes a video signal in which partial image regions that is temporally continuous are configured to create a bit stream. If the video decoding apparatus **31** finds an SDR picture from `nal_unit_type` of NAL in the bit stream, the video decoding apparatus **31** first performs intra coding and loop filter processing on the partial image region in the SDR picture without referring to the non-partial region. It is thus possible to properly decode the partial image region. Because for the partial image region of a picture decoded later, the non-partial image region is not referred to in a case of the inter coding and the non-partial image region of the picture is not referred to in a case of the intra coding and the loop filter processing, it is possible to secure that the partial image region may be properly decoded.

### Second Embodiment

#### Gradual Refresh

[0158] An embodiment in which the methods of coding and decoding a partial image region according to the present invention are applied to intra refresh will be described. In general, intra refresh is a method of configuring a region to be intra-coded at a part of a picture and temporally moving the region in the picture such that the entire picture may be intra-coded in a specific period of time. An object is to intra-code an entire picture without increasing the coding amount of the specific picture, realize random-access, and realize recovery from an error in a case that there has been an error in a bit stream by spitting the picture in a specific period of time and performing intra coding thereon. In the present embodiment, coding and decoding of a partial screen region, using an SDR picture, and a gradual refresh function equivalent to intra refresh are realized.

[0159] FIGS. **12A-12B** are diagrams respectively illustrating the gradual refresh, in accordance with one or more example implementations of this disclosure. FIG. **12A** is a diagram for explaining an overview of gradual refresh, in accordance with one or more example implementations of this disclosures. In the gradual refresh according to the present embodiment, the parameter coder **111** configures a partial image region A at a part of a picture first, and the gradual refresh is started from an SDR picture in which the partial image region has been intra-coded and is ended at a time when the partial screen region A temporally includes a previous partial image region, the region is caused to increase, and the partial screen region A reaches the entire picture.

[0160] If the video decoding apparatus **31** sets the SDR picture as an access point, starts decoding from the bit stream, and performs decoding until the region A reaches the entire picture, then the entire picture may be properly decoded.

[0161] A method of configuring a partial image region may be specified in a PPS or a slice header by using the method described in the first embodiment, or in a case that `seq_refresh_enable_flag`, which will be described later, is 1, the partial image region may be caused to implicitly increase for each CTU column, each CTU row, or each CTU in a coding order of the picture after the partial image region is configured in the SDR picture.

[0162] A non-reference picture refers to other pictures but is not referred to by other pictures. In a non-reference picture, the partial image region may not be configured by the gradual refresh.

[0163] FIG. **12B** is a diagram for explaining an overview of other gradual refresh, in accordance with one or more example implementations of this disclosure. In the gradual refresh according to the present embodiment, the parameter coder **111** first configures a partial image region A at a part of a picture and causes the partial screen region A to temporally include previous partial image regions and increases in size starting from the SDR picture in which the partial image region has been intra-coded. At this time, the partial image region caused to increase in size is intra-coded. Then, at a time when the partial screen region A reaches the entire picture, the gradual refresh ends.



Since it is difficult to correctly perform inter prediction, which is prediction in a time direction, for the partial image region caused to increase in size, the partial image region may be coded with reference to the coding parameters.

[0164] If the video decoding apparatus **31** sets the SDR picture as an access point, starts decoding from the bit stream, and performs decoding until the region A reaches the entire picture, then the entire picture may be properly decoded.

[0165] FIG. **13** is a diagram illustrating syntax necessary for the gradual refresh, in accordance with one or more example implementations of this disclosure. The example of a syntax may be provided as a notification to realize the gradual refresh. The syntax (gradual refresh information) may be provided as a notification using a sequence parameter set (SPS). Seq\_refresh\_enable\_flag is a flag indicating whether or not to use the gradual refresh for pictures after the SDR picture. The parameter decoder **302** decodes the gradual refresh information, and the video decoding apparatus **31** performs decoding using the gradual refresh in a case that seq\_refresh\_enable\_flag flag is 1 and does not use the gradual refresh in a case that seq\_refresh\_enable\_flag is 0. The parameter decoder **302** decodes seq\_refresh\_period in a case that seq\_refresh\_enable\_flag is 1. seq\_refresh\_period indicates the number of pictures until the entire picture may be properly decoded from the SDR picture that is a random-access point. Note that the number of non-reference pictures may not be counted at this time.

#### Configuration of Video Decoding Apparatus

[0166] FIG. **14** is a schematic diagram illustrating a configuration of a video decoding apparatus **3**, in accordance with one or more example implementations of this disclosure.

[0167] The video decoding apparatus **31** is configured to include 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 unit **311**, and an addition unit **312**. Note that a configuration in which the loop filter **305** is not included in the video decoding apparatus **31** may be combined with the video coding apparatus **11**, which will be described later.

[0168] The parameter decoder **302** includes a partial image region controller **320**, the partial image region controller **320** includes a header decoder **3020**, a CT information decoder **3021**, and a CU decoder **3022** (prediction mode decoder), which are not illustrated in the drawing, and the CU decoder **3022** further includes a TU decoder **3024**. The header decoder **3020** decodes parameter set information, such as VPS, SPS, and PPS, from coded data. The header decoder **3020** decodes a slice header (slice information) from the coded data. 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.

[0169] In addition, the parameter decoder **302** is configured to include an inter prediction parameter decoder **303** and an intra prediction parameter decoder **304**, which are not illustrated in the drawing. The prediction image generation unit **308** includes an inter prediction image generation unit **309** and an intra prediction image generation unit **310**.

[0170] Although an example in which a CTU and a CU are used as units of processing will be described below, the present invention is not limited thereto, and processing may be performed in units of sub-CUs. Alternatively, a CTU, a CU, and a TU may be read as a block instead, and a sub-CU may be read as a sub-block instead, to understand the processing as processing in units of blocks or sub-blocks.

[0171] The entropy decoder **301** performs entropy decoding on the coded stream Te input from the outside and separates and decodes individual codes (syntax elements). For entropy coding, there are a scheme in which variable length coding is performed on the syntax elements using context (probability model) adaptively selected in accordance with types of syntax elements and a

surrounding condition and a scheme in which variable length coding is performed on the syntax elements using a predefined table or a calculation equation. Representative examples of the former case include context adaptive binary arithmetic coding (CABAC). The separated codes include prediction information to generate a prediction image, a prediction error to generate a difference image, and the like.

[0172] The entropy decoder **301** outputs a part of the separated codes to the parameter decoder **302**. A part of the separated codes includes, for example, a prediction mode `predMode`, a merge flag `merge_flag`, a merge index `merge_idx`, an inter prediction identifier `inter_pred_idc`, a reference picture index `refIdxLX`, a prediction vector index `mvp_LX_idx`, and a difference vector `mvdLX`. Which code is to be decoded is controlled based on an indication of the parameter decoder **302**. The entropy decoder **301** outputs quantization transform coefficients to the inverse quantization and inverse transform unit **311**.

[0173] The loop filter **305** is a filter that is provided in a coding loop and removes block distortion and ringing distortion to improve image quality. The loop filter **305** applies a filter, such as a deblocking filter **3051**, a sample adaptive offset (SAO), and an adaptive loop filter (ALF), on a decoded image of a CU generated by the addition unit **312**.

[0174] The reference picture memory **306** stores a decoded image of the CU generated by the addition unit **312** at a predefined position for each target picture and target CU.

[0175] The prediction parameter memory **307** stores prediction parameters at predefined position for each CTU or each CU to be decoded. Specifically, the prediction parameter memory **307** stores the parameters decoded by the parameter decoder **302**, the prediction mode `predMode` separated by the entropy decoder **301**, and the like.

[0176] The prediction mode `predMode`, the prediction parameters, and the like are input to the prediction image generation unit **308**. 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 sub-block using the prediction parameters and the read reference picture (reference picture block) in the prediction mode (intra prediction, inter prediction) indicated by the prediction mode `predMode`. Here, the reference picture block is a set (this is called a block since the shape thereof is typically a rectangle) of pixels in the reference picture and is a region to be referred to for generating a prediction image.

#### Inter Prediction Image Generation Unit **309**

[0177] Here, in a case that the prediction mode `predMode` indicates the inter prediction mode, the inter prediction image generation unit **309** generates a prediction image of a block or a sub-block through inter prediction using inter prediction parameters input from the inter prediction parameter decoder **303** and a reference picture.

#### Motion Compensation

[0178] A motion compensation unit **3091** (interpolated image generation unit) generates an interpolated image (motion compensation image) by reading a block located at a position shifted by the amount of a motion vector `mvLX` starting from a position of a target block in a reference picture `RefLX` designated by a reference picture index `refIdxLX` from the reference picture memory **306** based on the inter prediction parameters (a prediction list utilization flag `predFlagLX`, the reference picture index `refIdxLX`, and the motion vector `mvLX`) input from the inter prediction parameter decoder **303**. Here, in a case that precision of the motion vector `mvLX` is not integer precision, the motion compensation image is generated by applying a filter to generate pixels at decimal positions, which is called motion compensation filter.

[0179] First, the motion compensation unit **3091** derives the integer position (`xInt`, `yInt`) corresponding to the intra-prediction-block coordinates (`x`, `y`) and a phase (`xFrac`, `yFrac`) by the following equations.

$$xInt = xPb + (mvLX[0] >> (\log_2(MVBIT))) + x$$

$xFrac = mvLX[0] \& (MVBIT - 1)$

$yInt = yPb + (mvLX[1] \gg (\log_2(MVBIT))) + y$

$yFrac = mvLX[1] \& (MVBIT - 1)$

Here, (xPb, yPb) denotes the upper left coordinates of the block with a size of wPb\*hPb, where  $x=0, \dots, wPb-1$ ,  $y=0, \dots, hPb-1$ , and MVBIT denotes precision (1/MVBIT pixel precision) of the motion vector mvLX.

[0180] The motion compensation unit **3091** derives a temporary image temp[][] through horizontal interpolation processing on the reference picture refImg using an interpolation filter.  $\Sigma$  satisfies  $k=0$  below. The sum related to  $k$  in NTAP-1, or shift1 is a normalization parameter to adjust a range of a value, where  $offset1 = 1 \ll (\text{shift1} - 1)$ .

$temp[x][y] = (>mcFilter[xFrac][k] * refImg[xInt + k - NTAP/2 + 1][yInt] + offset1) \gg \text{shift1}$

Next, the motion compensation unit **3091** derives the interpolated image Pred[][] through vertical interpolation processing performed on the temporary image temp[],  $\Sigma$  satisfies  $k=0$  below. The sum related to  $k$  in NTAP-1, or shift2 is a normalization parameter to adjust a range of a value, where  $offset2 = 1 \ll (\text{shift2} - 1)$ .

$Pred[x][y] = (EmcFilter[yFrac][k] * temp[x][y + k - NTAP/2 + 1] + offset2) \gg \text{shift2}$

Note that in a case of bi-prediction, Pred[][] described above is derived for each of the L0 list and the L1 list (which will be referred to as interpolated images PredL0[][] and PredL1[][]) and the interpolated image Pred[][] is generated from the interpolated image PredL0[][] and the interpolated image PredL1[][],

Weight Prediction

[0181] A weight prediction unit **3094** generates a prediction image of a block by multiplying the motion compensation image PredLX by a weight coefficient. In a case that one of the prediction list utilization flags (predFlagL0 or predFlagL1) is 1 (uni-prediction) and weight prediction is not to be used, processing of the following equation to cause the motion compensation image PredLX (LX is L0 or L1) to conform to the pixel bit number bitDepth is performed.

$Pred[x][y] = \text{Clip3}(0, (1 \ll \text{bitDepth}) - 1, (PredLX[x][y] + offset1) \gg \text{shift1})$

Here,  $\text{shift1} = 14 - \text{bitDepth}$ , and  $offset1 = 1 \ll (\text{shift1} - 1)$ .

[0182] Also, in a case that both the reference list utilization flags (predFlagL0 and predFlagL1) are 1 (bi-prediction BiPred) and weight prediction is not to be used, processing of the following equation to average the motion interpolated images PredL0 and predL1 for conformity to the pixel bit number is performed.

$Pred[x][y] = \text{Clip3}(0, (1 \ll \text{bitDepth}) - 1, (PredL0[x][y] + PredL1[x][y] + offset2) \gg \text{shift2})$

Here,  $\text{shift2} = 15 - \text{bitDepth}$ , and  $offset2 = 1 \ll (\text{shift2} - 1)$ .

[0183] Further, in a case that uni-prediction and weight prediction are performed, the weight prediction unit 3094 derives a weight prediction coefficient w0 and an offset o0 from coded data and performs processing of the following equation.

$Pred[x][y] = \text{Clip3}(0, (1 \ll \text{bitDepth}) - 1, ((PredLX[x][y] * w0 + 2 \{ \text{circumflex over ( )} \} (\log_2 WD - 1)) \gg \log_2 WD) + o0)$

Here, log2WD is a variable indicating a predetermined amount of shift.

[0184] Further, in a case that bi-prediction BiPred and weight prediction are performed, the weight prediction unit 3094 derives weight prediction coefficients w0, w1, o0, and o1 from coded data and

performs processing of the following equation.

$$\text{Pred}[x][y] = \text{Clip3}(0, (1 \ll (\text{bitDepth} - 1)), (\text{PredL0}[x][y] * w_0 + \text{PredL1}[x][y] * w_1 + ((o_0 + o_1 + 1) \ll (\log_2 \text{WD}))) \gg (\log_2 \text{WD} + 1))$$

The inter prediction image generation unit **309** outputs the generated prediction image of the block to the addition unit **312**.

#### Intra Prediction Image Generation Unit **310**

[0185] In a case that the prediction mode `predMode` indicates the intra prediction mode, the intra prediction image generation unit **310** performs intra prediction using intra prediction parameters input from the intra prediction parameter decoder **304** and reference pixels read from the reference picture memory **306**.

[0186] Specifically, the intra prediction image generation unit **310** reads, from the reference picture memory **306**, adjacent blocks within a predefined range from a target block in a target picture. The predefined range includes adjacent blocks on the left, upper left, upper, and upper right sides of the target block, and a region to be referred to differs depending on the intra prediction mode.

[0187] The intra prediction image generation unit **310** generates a prediction image of the target block with reference to a read decoded pixel value and a prediction mode indicated by the intra prediction mode `IntraPredMode`. The intra prediction image generation unit **310** outputs the generated prediction image to the addition unit **312**.

[0188] The inverse quantization and inverse transform unit **311** performs inverse quantization on a quantization transform coefficient input from the entropy decoder **301** to obtain a transform coefficient. The quantization transform coefficient is a coefficient obtained by performing frequency transform, such as a discrete cosine transform (DCT), a discrete sine transform (DST), or a Karyhnen Loeve transform (KLT), on a prediction error to quantize the error in coding processing. The inverse quantization and inverse transform unit **311** performs inverse frequency transform, such as an inverse DCT, an inverse DST, or an inverse KLT, on the obtained transform coefficient to calculate a prediction error. The inverse quantization and inverse transform unit **311** outputs the prediction error to the addition unit **312**.

[0189] 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 unit **311** for each pixel to generate a decoded image of the block. The addition unit **312** stores the decoded image of the block in the reference picture memory **306** and outputs the decoded image to the loop filter **305**.

#### Configuration of Video Coding Apparatus

[0190] Next, a configuration of the video coding apparatus **11** according to the present embodiment will be described. FIG. **15** is a block diagram illustrating a configuration of a video coding apparatus **11**, in accordance with one or more example implementations of this disclosure. The video coding apparatus **11** is configured to include a prediction image generation unit **101**, a subtraction unit **102**, a transform and quantization unit **103**, an inverse quantization and inverse transform 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**, and an entropy coder **104**.

[0191] 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** performs the same operations as those of the prediction image generation unit **308** which has already been described, and description thereof will be omitted.

[0192] The subtraction unit **102** generates a prediction error by subtracting, from a pixel value of the image T, a pixel value of the prediction image of the block input from the prediction image generation unit **101**. The subtraction unit **102** outputs the prediction error to the transform and

quantization unit **103**.

[0193] The transform and quantization unit **103** calculates a transform coefficient through frequency transform performed on the prediction error input from the subtraction unit **102** and derives a quantization transform coefficient through quantization. The transform and quantization unit **103** outputs the quantization transform coefficient to the entropy coder **104** and the inverse quantization and inverse transform unit **105**.

[0194] The inverse quantization and inverse transform unit **105** is the same as the inverse quantization and inverse transform unit **311** (shown in FIG. **14**) in the video decoding apparatus **31**, and description thereof will be omitted. The calculated prediction error is output to the addition unit **106**.

[0195] The parameter coder **111** is configured with a partial image region controller **120**, and an inter prediction parameter coder **112** and an intra prediction parameter coder **113**, which are not illustrated in the drawing.

[0196] The partial image region controller **120** includes a header coder **1110**, a CT information coder **1111**, a CU coder **1112** (prediction mode coder), and an inter prediction parameter coder **112** and an intra prediction parameter coder **113**, which are not illustrated in the drawing. The CU coder **1112** further includes a TU coder **1114**.

[0197] Hereinafter, overview operations of each module will be described. The parameter coder **111** performs processing of coding header information, split information, prediction information, and parameters, such as quantization transform coefficient.

[0198] The CT information coder **1111** codes QT and MT (BT, TT) split information and the like from coded data.

[0199] The CU coder **1112** codes CU information, prediction information, a TU splitting flag `split_transform_flag`, a CU residual flags `cbf_cb`, `cbf_cr`, and `cbf_luma`, and the like.

[0200] The TU coder **1114** codes QP update information (quantization correction value) and a quantization prediction error (`residual_coding`) in a case that a TU includes a prediction error.

[0201] The entropy coder **104** transforms the syntax elements supplied from a supply source into binary data, generates coded data by an entropy coding scheme, such as CABAC, and outputs the coded data. The supply source of the syntax elements is the CT information coder **1111** and the CU coder **1112**. The syntax elements include inter prediction parameters (a prediction mode `predMode`, a merge flag `merge_flag`, a merge index `merge_idx`, an inter prediction identifier `inter_pred_idc`, a reference picture index `refIdxLX`, a prediction vector index `mvp_LX_idx`, a difference vector `mvdLX`), intra prediction parameters (`prev_intra_luma_pred_flag`, `mpm_idx`, `rem_selected_mode_flag`, `rem_selected_mode`, `rem_non_selected_mode`), a quantization transform coefficient, and the like.

[0202] The entropy coder **104** entropy-codes the split information, the prediction parameters, the quantization transform coefficient, and the like to generate a coded stream `Te` and outputs the coded stream `Te`.

Configuration of Inter Prediction Parameter Coder

[0203] The inter prediction parameter coder **112** derives inter prediction parameters based on prediction parameters input from the coding parameter determination unit **110**. The inter prediction parameter coder **112** partially includes the same configuration as the configuration with which the inter prediction parameter decoder **303** derives inter prediction parameters.

Configuration of Intra Prediction Parameter Coder **113**

[0204] The intra prediction parameter coder **113** derives a format for coding (for example, `mpm_idx`, `rem_intra_luma_pred_mode`, and the like) from the intra prediction mode `IntraPredMode` input from the coding parameter determination unit **110**. The intra prediction parameter coder **113** partially includes the same configuration as the configuration with which the intra prediction parameter decoder **304** derives intra prediction parameters.

[0205] The addition unit **106** adds a pixel value of a prediction image of a block input from the

prediction image generation unit **101** and a prediction error input from the inverse quantization and inverse transform unit **105** for each pixel to generate a decoded image. The addition unit **106** stores the generated decoded image in the reference picture memory **109**.

[0206] The loop filter **107** applies a deblocking filter, SAO, or ALF to the decoded image generated by the addition unit **106**. Note that the loop filter **107** may not necessarily include the aforementioned three types of filters and may be configured only with a deblocking filter, for example.

[0207] The prediction parameter memory **108** stores the prediction parameters generated by the coding parameter determination unit **110** at a predefined position for each target picture and each CU.

[0208] The reference picture memory **109** stores the decoded image generated by the loop filter **107** at a predefined position for each target picture and each CU.

[0209] The coding parameter determination unit **110** selects one set from among multiple sets of coding parameters. The coding parameters are the aforementioned QT, BT, or TT split information, the prediction parameters, or parameters to be coded that are generated in relation to these. The prediction image generation unit **101** generates a prediction image using these coding parameters.

[0210] The coding parameter determination unit **110** calculates an RD cost value indicating how large the amount of information is and indicating a coding error for each of the multiple sets. The RD cost value is a sum of the amount of coding and a value obtained by multiplying a square error by a coefficient  $\lambda$ , for example. The amount of coding is the amount of information of the coded stream  $T_e$  obtained by entropy-coding the quantization error and the coding parameters. The square error is a square sum of the prediction error calculated by the subtraction unit **102**. The coefficient  $\lambda$  is a preset real number that is greater zero. The coding parameter determination unit **110** selects a set of coding parameters with which the calculated cost value is minimum. The entropy coder **104** thus outputs the selected set of coding parameters as the coded stream  $T_e$ . The coding parameter determination unit **110** stores the determined coding parameters in the prediction parameter memory **108**.

[0211] Note that a part of the video coding apparatus **11** and the video decoding apparatus **31** in the aforementioned embodiment, 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 unit **311**, the addition unit **312**, 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 unit **105**, the loop filter **107**, the coding parameter determination unit **110**, and the parameter coder **111** may be realized by a computer. 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 and perform the program recorded on the recording medium. Note that the “computer system” mentioned here refers to a computer system built in 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. Furthermore, the “computer-readable recording medium” refers to a portable medium, such as a flexible disk, a magneto-optical disk, a ROM, or a CD-ROM, or a storage device, such as a hard disk built in the computer system. Moreover, the “computer-readable recording medium” may include a medium that dynamically retains a program for a short period of time, such as a communication line, in a case that the program is transmitted over a network, such as the Internet, or over a communication line, such as a telephone line, and may also include a medium that retains the program for a specific period of time, such as a volatile memory included in a computer system functioning as a server or a client in such a case. Furthermore, the aforementioned program may be one for realizing some of the aforementioned functions, and also may be one capable of realizing the aforementioned functions in combination with a program that has already been recorded in a computer system.

[0212] A video decoding apparatus according to an aspect of the present invention includes: a

picture splitting unit configured to split a picture into a partial image region and a non-partial image region including any one of a CTU, a CTU column, and a CTU row as a minimum unit; and a prediction image generation unit configured to generate a prediction image, in which the prediction image generation unit uses, on a block included in the partial image region, intra prediction and loop filter processing referring only to decoded pixels in the partial image region in the picture or inter prediction referring to the partial image region of the reference picture of the picture, and uses, on a block in the non-partial image region, intra prediction and loop filter processing referring to decoded pixels in the picture or inter prediction referring to the reference picture of the picture, and the video decoding apparatus decodes the picture and then configures the partial image region of the picture as a partial image region of the reference picture.

[0213] A video decoding apparatus according to an aspect of the present invention includes: a picture splitting unit configured to split a picture into a partial image region and a non-partial image region including any one of a CTU, a CTU column, and a CTU row as a minimum unit; and a prediction image generation unit configured to generate a prediction image, in which the prediction image generation unit refers to information indicating whether or not the picture is randomly accessible, and the video decoding apparatus decodes the picture using, on a block included in the partial image region, intra prediction and loop filter processing referring only to decoded pixels in the partial image region in the picture in a case that the picture is randomly accessible, using, on the block included in the partial image region, the intra prediction and the loop filter processing referring only to the decoded pixels in the partial image region in the picture or the inter prediction referring to the partial image region of a reference picture of the picture in a case that the picture is not randomly accessible, and on a block included in the non-partial image region, using the intra prediction and the loop filter processing referring to the decoded pixels in the picture or the inter prediction referring to the reference picture of the picture regardless of whether or not the picture is randomly accessible, thereby configuring the partial image region of the picture as a partial image region of the reference picture.

[0214] In the video decoding apparatus according to an aspect of the present invention, the picture splitting unit splits the picture into the partial image region and the non-partial image region with reference to region information decoded from coded data.

[0215] In the video decoding apparatus according to an aspect of the present invention, the region information includes information indicating a position and a size of the partial image region.

[0216] In the video decoding apparatus according to an aspect of the present invention, refresh information is decoded, the refresh information indicating the number of pictures from the picture including information that is randomly accessible to a picture of which entirety becomes a partial image region.

[0217] A video coding apparatus according to an aspect of the present invention includes: a picture splitting unit configured to split a picture into a partial image region and a non-partial image region including any one of a CTU, a CTU column, and a CTU row as a minimum unit; and a prediction image generation unit configured to generate a prediction image, in which the prediction image generation unit configures, after the picture is coded, the partial image region of the picture as a partial image region of a reference picture using, on a block included in the partial image region, intra prediction and loop filter processing referring only to decoded pixels in the partial image region in the picture or inter prediction referring to a limited reference region of the reference picture of the picture, and using, on a block included in the non-partial image region, intra prediction and loop filter processing referring to decoded pixels in the picture or inter prediction referring to the reference picture of the picture.

[0218] A part or all of the video coding apparatus **11** and the video decoding apparatus **31** in the aforementioned embodiments may be realized as an integrated circuit, such as a large-scale integration (LSI). Functional blocks of the video coding apparatus **11** and the video decoding apparatus **31** may be individually realized as processors, or a part or all of the functional blocks

may be integrated into processors. The circuit integration technique is not limited to the LSI, and the integrated circuits may be realized as dedicated circuits or a general-purpose processor. In a case that with advances in semiconductor technology, a circuit integration technology with which an LSI is replaced appears, an integrated circuit based on the technology may be used.

[0219] Although the embodiments of the present invention have been described in detail with reference to the drawings, the specific configuration is not limited to the above embodiments, and various amendments may be made to a design without departing from the gist thereof.

#### Application Examples

[0220] The aforementioned video coding apparatus **11** and the video decoding apparatus **31** may be mounted on and used with various apparatuses performing transmission, reception, recording, and regeneration of videos. Note that the video may be a natural video imaged by a camera or the like or may be an artificial video (including CG and GUI) generated by computer or the like.

[0221] First, the fact that it is possible to use the aforementioned video coding apparatus **11** and the video decoding apparatus **31** to transmit and receive videos will be described with reference to FIGS. **16A-16B**. FIGS. **16A-16B** are diagrams respectively illustrating configurations of a transmitting apparatus equipped with the video coding apparatus and a receiving apparatus equipped with the video decoding apparatus, in accordance with one or more example implementations of this disclosure.

[0222] FIG. **16A** is a block diagram illustrating a configuration of a transmitting apparatus PROD\_A equipped with the video coding apparatus **11**. As illustrated in FIG. **16A**, the transmitting apparatus PROD\_A includes a coder PROD\_A1 which obtains coded data by coding a video, a modulator PROD\_A2 which obtains a modulation signal by modulating carrier waves with the coded data obtained by the coder PROD\_A1, and a transmitter PROD\_A3 which transmits the modulation signals obtained by the modulator PROD\_A2. The aforementioned video coding apparatus **11** is used as the coder PROD\_A1.

[0223] The transmitting apparatus PROD\_A may further include a camera PROD\_A4 that images a video, a recording medium PROD\_A5 that records the video, an input terminal PROD\_A6 for inputting the video from the outside, and an image processing unit A7 which generates or processes the image, as supply sources of the video input to the coder PROD\_A1. Although an example configuration in which the transmitting apparatus PROD\_A includes all of the components is illustrated in FIG. **16A**, some of the components may be omitted.

[0224] Note that the recording medium PROD\_A5 may record videos which have not been coded or may record videos which have been coded in a coding scheme for recording that is different from a coding scheme for transmission. In the latter case, a decoder (not illustrated) to decode coded data read from the recording medium PROD\_A5 in accordance with the coding scheme for recording may be interposed between the recording medium PROD\_A5 and the coder PROD\_A1.

[0225] FIG. **16B** is a block diagram illustrating a configuration of a receiving apparatus PROD\_B equipped with the video decoding apparatus **31**. As illustrated in FIG. **16B**, the receiving apparatus PROD\_B includes a receiver PROD\_B1 that receives a modulation signal, a demodulator PROD\_B2 that obtains coded data by demodulating the modulation signal received by the receiver PROD\_B1, and a decoder PROD\_B3 that obtains a video by decoding the coded data obtained by the demodulator PROD\_B2. The aforementioned video decoding apparatus **31** is used as the decoder PROD\_B3.

[0226] The receiving apparatus PROD\_B may further include a display PROD\_B4 that displays a video, a recording medium PROD\_B5 for recording the video, and an output terminal PROD\_B6 for outputting the video to the outside, as supply destinations of the video output by the decoder PROD\_B3. Although an example configuration in which the receiving apparatus PROD\_B includes all of the components is illustrated in FIG. **16B**, some of the components may be omitted.

[0227] Note that the recording medium PROD\_B5 may record videos which have not been coded, or may record videos which have been coded in a coding scheme for recording that is different



from a coding scheme for transmission. In the latter case, a coder (not illustrated) that codes videos acquired from the decoder PROD\_B3 in accordance with the coding scheme for recording may be interposed between the decoder PROD\_B3 and the recording medium PROD\_B5.

[0228] Note that a transmission medium for transmitting modulation signals may be a wireless medium or may be a wired medium. In addition, a transmission mode in which the modulation signals are transmitted may be a broadcast (here, which indicates a transmission mode in which a transmission destination is not specified in advance) or may be a communication (here, which indicates a transmission mode in which a transmission destination is specified in advance). That is, the transmission of the modulation signals may be realized by any of a wireless broadcast, a wired broadcast, a wireless communication, and a wired communication.

[0229] For example, a broadcasting station (such as a broadcasting equipment)/receiving station (such as a television receiver) for digital terrestrial broadcasting is an example of the transmitting apparatus PROD\_A/receiving apparatus PROD\_B for transmitting and/or receiving the modulation signals in the wireless broadcast. In addition, a broadcasting station (such as a broadcasting equipment)/receiving station (such as a television receiver) for cable television broadcasting is an example of the transmitting apparatus PROD\_A/receiving apparatus PROD\_B for transmitting and/or receiving the modulation signals in the wired broadcast.

[0230] In addition, a server (such as a workstation)/client (such as a television receiver, a personal computer, or a smartphone) for Video On Demand (VOD) services, video hosting services and the like using the Internet is an example of the transmitting apparatus PROD\_A/receiving apparatus PROD\_B for transmitting and/or receiving the modulation signals in communication (usually, any of a wireless medium or a wired medium is used as a transmission medium in LAN, and the wired medium is used as a transmission medium in WAN). Here, the personal computer includes a desktop PC, a laptop PC, and a tablet PC. In addition, a smartphones also include a multi-functional mobile telephone terminal.

[0231] A client of a video hosting service has a function of coding a video imaged with a camera and uploading the video to a server, in addition to a function of decoding coded data downloaded from a server and displaying on a display. Thus, the client of the video hosting service functions both as the transmitting apparatus PROD\_A and as the receiving apparatus PROD B.

[0232] Next, the fact that it is possible to use the aforementioned video coding apparatus **11** and the video decoding apparatus **31** to record and reconstruct a video will be described with reference to FIGS. **17A-17B**. FIGS. **17A-17B** are diagrams respectively illustrating configurations of a recording apparatus equipped with the video coding apparatus and a reconstruction apparatus equipped with the video decoding apparatus, in accordance with one or more example implementations of this disclosure.

[0233] FIG. **17A** is a block diagram illustrating a configuration of a recording apparatus PROD\_C equipped with the aforementioned video coding apparatus **11**. As illustrated in the drawing, the recording apparatus PROD\_C includes a coder PROD\_C1 that obtains coded data by coding a video and a writer PROD\_C2 that writes the coded data obtained by the coder PROD\_C1 in a recording medium PROD\_M. The aforementioned video coding apparatus **11** is used as the coder PROD\_C1.

[0234] Note that the recording medium PROD\_M may be (1) a type of recording medium built in the recording apparatus PROD\_C, such as a hard disk drive (HDD) or a solid state drive (SSD), may be (2) a type of recording medium connected to the recording apparatus PROD\_C, such as an SD memory card or a universal serial bus (USB) flash memory, or may be (3) a type of recording medium loaded in a drive apparatus (not illustrated) built in the recording apparatus PROD\_C, such as Digital Versatile Disc (DVD: trade name) or a Blue-ray Disc (BD: trade name).

[0235] In addition, the recording apparatus PROD\_C may further include a camera PROD\_C3 that images a video, an input terminal PROD\_C4 for inputting the video from the outside, a receiver PROD\_C5 for receiving the video, and an image processing unit PROD\_C6 that generates or

processes images, as supply sources of the video input to the coder PROD\_C1. Although an example configuration in which the recording apparatus PROD\_C includes all of the components is illustrated in the drawing, some of the components may be omitted.

[0236] Note that the receiver PROD\_C5 may receive a video which has not been coded or may receive coded data which has been coded in a coding scheme for transmission that is different from the coding scheme for recording. In the latter case, a decoder for transmission (not illustrated) that decodes coded data which has been coded in the coding scheme for transmission may be interposed between the receiver PROD\_C5 and the coder PROD\_C1.

[0237] Examples of such a recording apparatus PROD\_C include a DVD recorder, a BD recorder, a hard disk drive (HDD) recorder, and the like (in this case, the input terminal PROD\_C4 or the receiver PROD\_C5 serves as a main supply source of videos). In addition, a camcorder (in this case, the camera PROD\_C3 serves as a main supply source of videos), a personal computer (in this case, the receiver PROD\_C5 or the image processing unit C6 serves as a main supply source of videos), a smartphone (in this case, the camera PROD\_C3 or the receiver PROD\_C5 serves as a main supply source of videos), or the like is an example of such a recording apparatus PROD\_C as well.

[0238] FIG. 17B is block illustrating a configuration of a reconstruction apparatus PROD\_D equipped with the aforementioned video decoding apparatus 31. As illustrated in the drawing, the reconstruction apparatus PROD\_D includes a reader PROD\_D1 which reads coded data written in the recording medium PROD\_M and a decoder PROD\_D2 which obtains a video by decoding the coded data read by the reader PROD\_D1. The aforementioned video decoding apparatus 31 is used as the decoder PROD\_D2.

[0239] Note that the recording medium PROD\_M may be (1) a type of recording medium built in the reconstruction apparatus PROD\_D, such as an HDD or an SSD, may be (2) a type of recording medium connected to the reconstruction apparatus PROD\_D, such as an SD memory card or a USB flash memory, or may be (3) a type of recording medium loaded in a drive apparatus (not illustrated) built in the reconstruction apparatus PROD\_D, such as a DVD or a BD.

[0240] In addition, the reconstruction apparatus PROD\_D may further include a display PROD\_D3 that displays a video, an output terminal PROD\_D4 for outputting the video to the outside, and a transmitter PROD\_D5 that transmits the video, as supply destinations of the video output by the decoder PROD\_D2. Although an example configuration in which the reconstruction apparatus PROD\_D includes all of the components is illustrated in the drawing, some of the components may be omitted.

[0241] Note that the transmitter PROD\_D5 may transmit a video which has not been coded or may transmit coded data which has been coded in a coding scheme for transmission that is different from a coding scheme for recording. In the latter case, a coder (not illustrated) that codes a video in the coding scheme for transmission may be interposed between the decoder PROD\_D2 and the transmitter PROD\_D5.

[0242] Examples of such a reconstruction apparatus PROD\_D include, for example, a DVD player, a BD player, an HDD player, and the like (in this case, the output terminal PROD\_D4 to which a television receiver or the like is connected serves as a main supply destination of videos). In addition, a television receiver (in this case, the display PROD\_D3 serves as a main supply destination of videos), a digital signage (this is also referred to as an electronic signboard, an electronic bulletin board, or the like, and the display PROD\_D3 or the transmitter PROD\_D5 serves as a main supply destination of videos), a desktop PC (in this case, the output terminal PROD\_D4 or the transmitter PROD\_D5 serves as a main supply destination of videos), a laptop or tablet PC (in this case, the display PROD\_D3 or the transmitter PROD\_D5 serves as a main supply destination of videos), a smartphone (in this case, the display PROD\_D3 or the transmitter PROD\_D5 serves as a main supply destination of videos), or the like is an example of the reconstruction apparatus PROD\_D.

Realization by Hardware and Realization by Software

[0243] Each block of the aforementioned video decoding apparatus **31** and the video coding apparatus **11** may be realized as hardware using a logical circuit formed on an integrated circuit (IC chip) or may be realized as software using a central processing unit (CPU).

[0244] In the latter case, each apparatus includes a CPU performing a command of a program to implement each function, a read-only memory (ROM) storing the program, a random-access memory (RAM) in which the program is deployed, and a storage apparatus (recording medium), such as a memory storing the program and various kinds of data, and the like. In addition, an object of the embodiments of the present invention may also be achieved by supplying, to each of the apparatuses, a recording medium that records, in a computer-readable form, program codes of a control program (executable program, intermediate code program, source program) of each of the apparatuses that is software for realizing the aforementioned functions and by reading and executing, by the computer (or a CPU or an MPU), the program codes recorded in the recording medium.

[0245] As the recording medium, for example, tapes including a magnetic tape, a cassette tape, and the like, discs including a magnetic disk, such as a floppy (trade name) disk/a hard disk and an optical disc, such as a compact disc read-only memory (CD-ROM)/a magneto-optical disc (MO disc)/a mini disc (Md)/a Digital Versatile Disc (DVD; trade name)/a CD recordable (CD-R)/a Blu-ray (trade name) disc (trade name), cards, such as an IC card (including a memory card)/an optical card, semiconductor memories, such as a mask ROM/an erasable programmable read-only memory (EPROM)/an Electrically Erasable and Programmable Read-Only Memory (EEPROM: trade name)/a flash ROM, logical circuits, such as a programmable logic device (PLD) and a field-programmable gate array (FPGA), or the like may be used.

[0246] In addition, each of the apparatuses may be configured to be connectable to a communication network, and the program codes may be supplied through the communication network. The communication network may be any communication network as long as it is possible to transmit the program codes and is not particularly limited. For example, the Internet, an intranet, an extranet, a local area network (LAN), an integrated services digital network (ISDN), a value-added network (VAN), a community antenna television/cable television (CATV) communication network, a virtual private network, a telephone network, a mobile communication network, a satellite communication network, and the like are available. In addition, a transmission medium constituting this communication network may be any transmission medium as long as it is possible to transmit the program codes and is not limited to one with a specific configuration or of a specific type. For example, a wired transmission medium, such as Institute of Electrical and Electronic Engineers (IEEE) 1394, a USB, a power-line carrier, a cable TV line, a telephone line, an asymmetric digital subscriber line (ADSL), and a wireless transmission medium, such as infrared-ray of infrared data association (IrDA) or a remote control, Blue Tooth (trade name), IEEE 802.11 wireless communication, high data rate (HDR), near-field communication (NFC), Digital Living Network Alliance (DLNA: trade name), a cellular telephone network, a satellite channel, a terrestrial digital broadcast network are available. Note that the embodiments of the present invention may be also realized in the form of computer data signals embedded in carrier waves such that the transmission of the program codes is embodied in electronic transmission.

[0247] The embodiments of the present invention are not limited to the aforementioned embodiments, and various modifications are possible within the scope of the claims. In other words, embodiments obtained by combining technical means modified appropriately within the scope defined by claims are included in the technical scope of the present invention as well.

#### INDUSTRIAL APPLICABILITY

[0248] The embodiments of the present invention may be suitably applied to a video decoding apparatus that decodes coded data obtained by coding image data and a video coding apparatus that generates coded data obtained by coding image data. It is possible to suitably apply the

embodiments of the present invention to a data structure of a coded data generated by a video coding apparatus and referred to by the video decoding apparatus.

## CROSS-REFERENCE OF RELATED APPLICATIONS

[0249] This application claims the benefit of priority to JP 2018-160712 filed on Aug. 29, 2018, which is incorporated herein by reference in its entirety.

## REFERENCE SIGNS LIST

[0250] **31** Image decoding apparatus [0251] **301** Entropy decoder [0252] **302** Parameter decoder [0253] **3020** Header decoder [0254] **303** Inter prediction parameter decoder [0255] **304** Intra prediction parameter decoder [0256] **308** Prediction image generation unit [0257] **309** Inter prediction image generation unit [0258] **310** intra prediction image generation unit [0259] **311** Inverse quantization and inverse transform unit [0260] **312** Addition unit [0261] **320** Partial image region controller [0262] **11** Image coding apparatus [0263] **101** Prediction image generation unit [0264] **102** Subtraction unit [0265] **103** Transform and quantization unit [0266] **104** Entropy coder [0267] **105** Inverse quantization and inverse transform unit [0268] **107** Loop filter [0269] **110** Coding parameter determination unit [0270] **111** Parameter coder [0271] **112** Inter prediction parameter coder [0272] **113** Intra prediction parameter coder [0273] **120** Partial image region controller [0274] **1110** Header coder [0275] **1111** CT information coder [0276] **1112** CU coder (prediction mode coder) [0277] **1114** TU coder

## Claims

1. A video decoding apparatus that decodes a Network Abstraction Layer (NAL) UNIT, the video decoding apparatus comprising: a parameter decoder configured to decode refresh validity information which is included in a sequence parameter set and indicates whether to use a gradual refresh picture, wherein the parameter decoder: identifies whether a first specific picture is the gradual refresh picture by using a type of the NAL UNIT associated with a slice, and identifies an enabled flag to determine a usage of gradual refresh for decoding at least a subset of pictures in a set of pictures, the subset of pictures including the gradual refresh picture.
2. The video decoding apparatus according to claim 1, wherein the parameter decoder further decodes a syntax element associated with a number of pictures included in the subset, and the number of pictures is determined based on a position of the gradual refresh picture in the subset to a position of a second specific picture in the subset, an entirety of the second specific picture being properly decodable.
3. The video decoding apparatus according to claim 1, further comprising: a picture splitting unit configured to split a target picture into a partial image region and a non-partial image region; and a prediction image generation unit configured to generate a prediction image associated with the target picture, wherein the prediction image generation unit configures the partial image region of the target picture as a partial image region of a reference picture by: using, on a block in the partial image region of the target picture, intra prediction and loop filter processing, referring only to decoded pixels in the partial image region of the target picture, or inter prediction, referring to the partial image region of the reference picture of the target picture, and using, on a block in the non-partial image region of the target picture, intra prediction and loop filter processing, referring to decoded pixels in the target picture, or inter prediction, referring to the reference picture of the target picture.
4. The video decoding apparatus according to claim 3, wherein: the picture splitting unit splits the target picture by using region information decoded from coded data, and the region information includes information indicating a position and a size of the partial image region of the target picture.
5. A video coding apparatus that encodes a Network Abstraction Layer (NAL) UNIT, the video coding apparatus comprising: a parameter coder configured to code refresh validity information

which is included in a sequence parameter set and indicates whether to use a gradual refresh picture, wherein the parameter coder: identifies whether a first specific picture is the gradual refresh picture by using a type of the NAL UNIT associated with a slice, and identifies an enabled flag to determine a usage of gradual refresh for decoding at least a subset of pictures in a set of pictures, the subset of pictures including the gradual refresh picture.

**6.** The video coding apparatus as claimed in claim 5, wherein the parameter coder further codes a syntax element associated with a number of pictures included in the subset, and the number of pictures is determined based on a position of the gradual refresh picture in the subset to a position of a second specific picture in the subset, an entirety of the second specific picture being properly decodable.

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