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Okawa et al.

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(54) IMAGE ENCODING APPARATUS, IMAGE DECODING APPARATUS, IMAGE ENCODING METHOD, IMAGE DECODING METHOD, AND NON-TRANSITORY COMPUTER-READABLE STORAGE MEDIUM

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This patent is subject to a terminal disclaimer.

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CPC *H04N 19/119* (2014.11); *H04N 19/129* (2014.11); *H04N 19/174* (2014.11); *H04N 19/176* (2014.11)

(58) **Field of Classification Search**
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See application file for complete search history.

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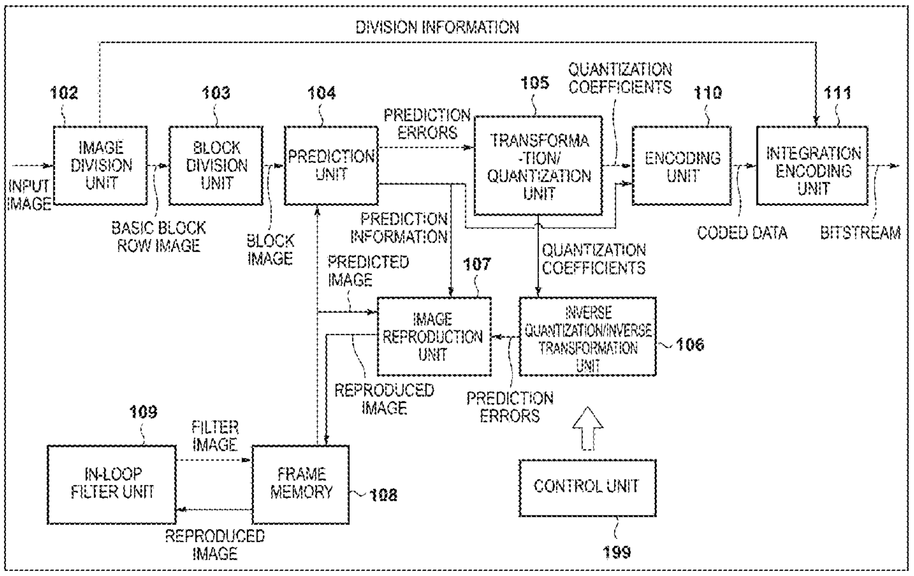
(74) *Attorney, Agent, or Firm* — Canon U.S.A., Inc. IP Division

(57) **ABSTRACT**

An image is divided into rectangular regions each including at least one block row, and the image is divided into rectangular slices or slices to be processed in raster order. In a case where the image is divided into the rectangular slices, based on first information for specifying a rectangular region to be processed first and second information for specifying a rectangular region to be processed last, the rectangular regions in the rectangular slice is specified. Based on the number of blocks in a vertical direction in each of the specified rectangular regions, the number of pieces of information for specifying a start position of coded data of the block row in the rectangular slice is specified. A bitstream in which at least the pieces of information, the first and second information, and the coded data are multiplexed is generated.

17 Claims, 9 Drawing Sheets



Related U.S. Application Data

continuation of application No. PCT/JP2020/021184, filed on May 28, 2020.

(51) **Int. Cl.**

H04N 19/129	(2014.01)
H04N 19/174	(2014.01)
H04N 19/176	(2014.01)

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FIG. 1

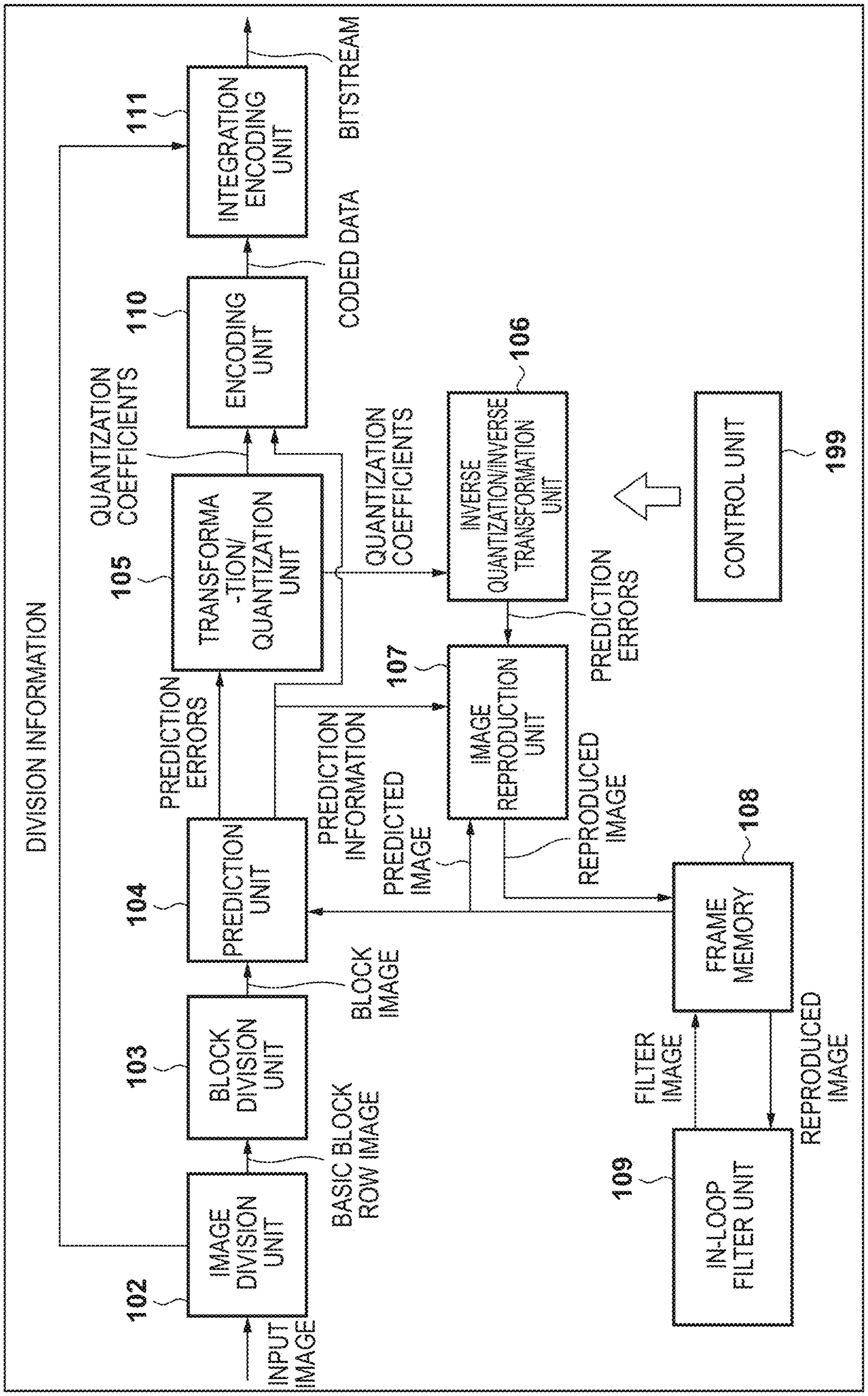

INPUT IMAGE
102
IMAGE DIVISION UNIT
BASIC BLOCK ROW IMAGE
103
BLOCK DIVISION UNIT
BLOCK IMAGE
104
PREDICTION UNIT
PREDICTION ERRORS
PREDICTION INFORMATION
PREDICTED IMAGE
105
TRANSFORMA-TION/QUANTIZATION UNIT
QUANTIZATION COEFFICIENTS
110
ENCODING UNIT
CODED DATA
111
INTEGRATION ENCODING UNIT
BITSTREAM
DIVISION INFORMATION
QUANTIZATION COEFFICIENTS
106
INVERSE QUANTIZATION/INVERSE TRANSFORMATION UNIT
PREDICTION ERRORS
107
IMAGE REPRODUCTION UNIT
REPRODUCED IMAGE
108
FRAME MEMORY
FILTER IMAGE
REPRODUCED IMAGE
109
IN-LOOP FILTER UNIT
CONTROL UNIT
199

FIG. 2

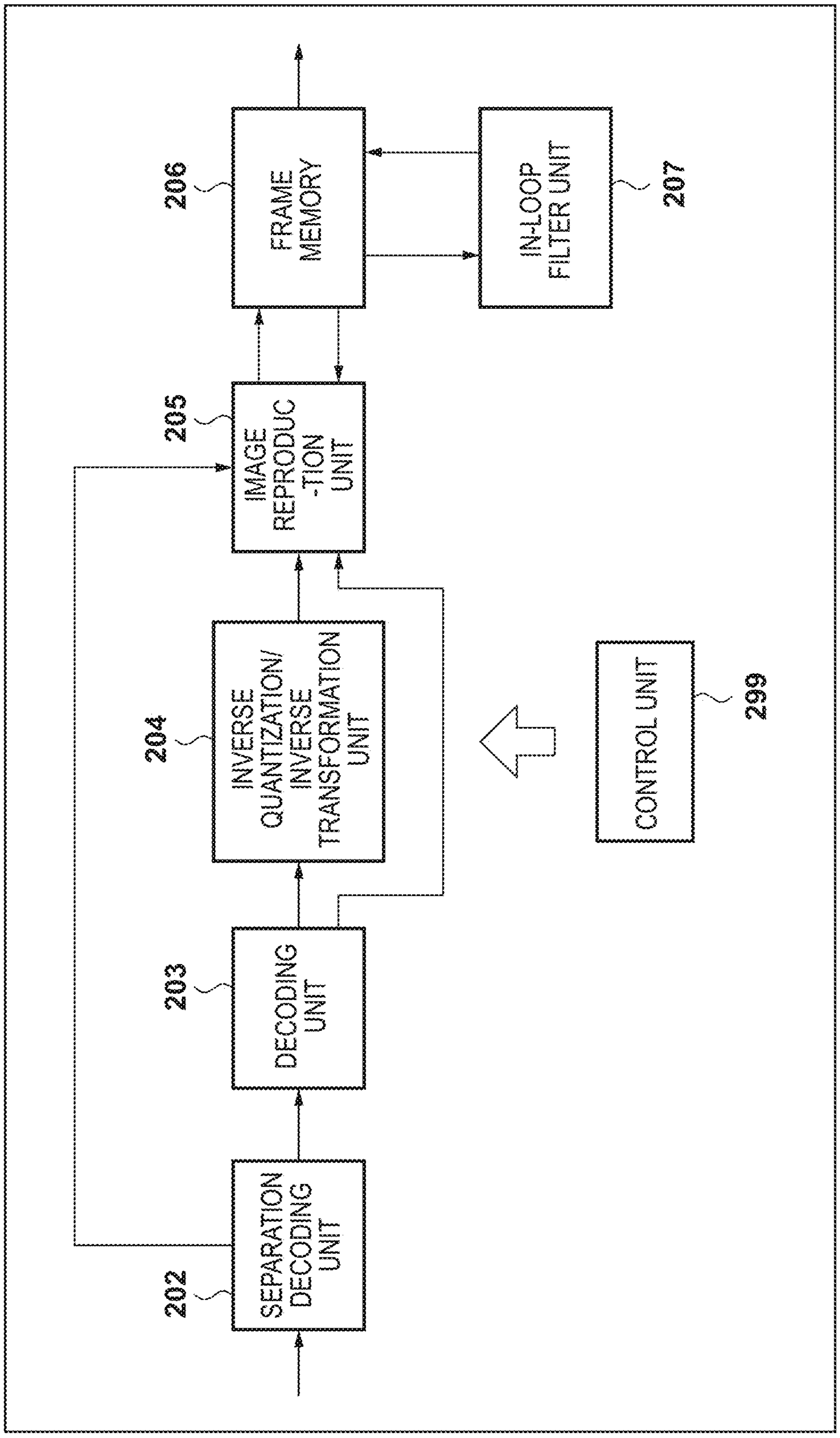

202
SEPARATION DECODING UNIT
203
DECODING UNIT
204
INVERSE QUANTIZATION/ INVERSE TRANSFORMATION UNIT
205
IMAGE REPRODUC -TION UNIT
206
FRAME MEMORY
207
IN-LOOP FILTER UNIT
299
CONTROL UNIT

FIG. 3

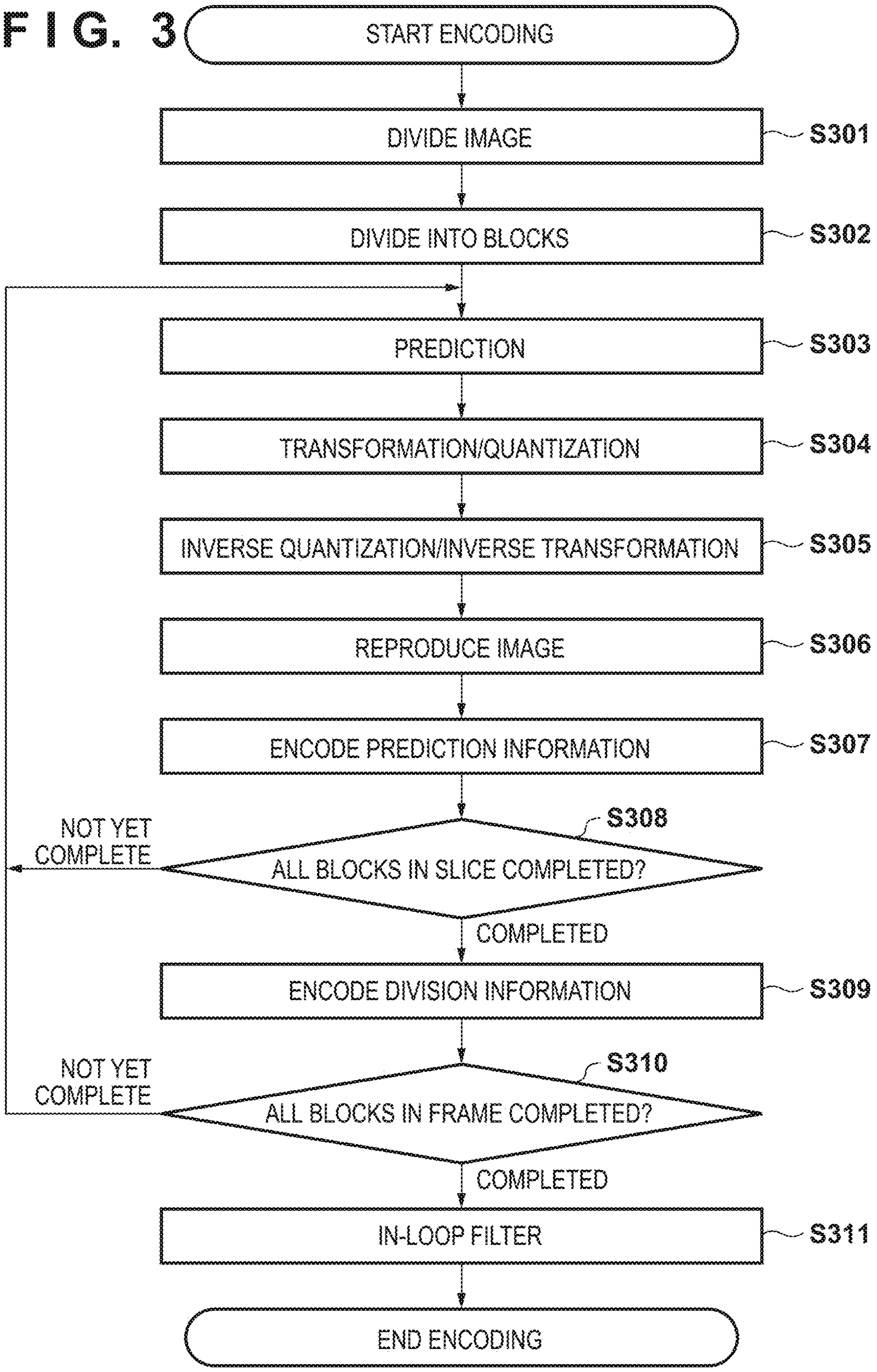

START ENCODING
DIVIDE IMAGE
S301
DIVIDE INTO BLOCKS
S302
PREDICTION
S303
TRANSFORMATION/QUANTIZATION
S304
INVERSE QUANTIZATION/INVERSE TRANSFORMATION
S305
REPRODUCE IMAGE
S306
ENCODE PREDICTION INFORMATION
S307
S308
NOT YET COMPLETE
ALL BLOCKS IN SLICE COMPLETED?
COMPLETED
ENCODE DIVISION INFORMATION
S309
S310
NOT YET COMPLETE
ALL BLOCKS IN FRAME COMPLETED?
COMPLETED
IN-LOOP FILTER
S311
END ENCODING

FIG. 4

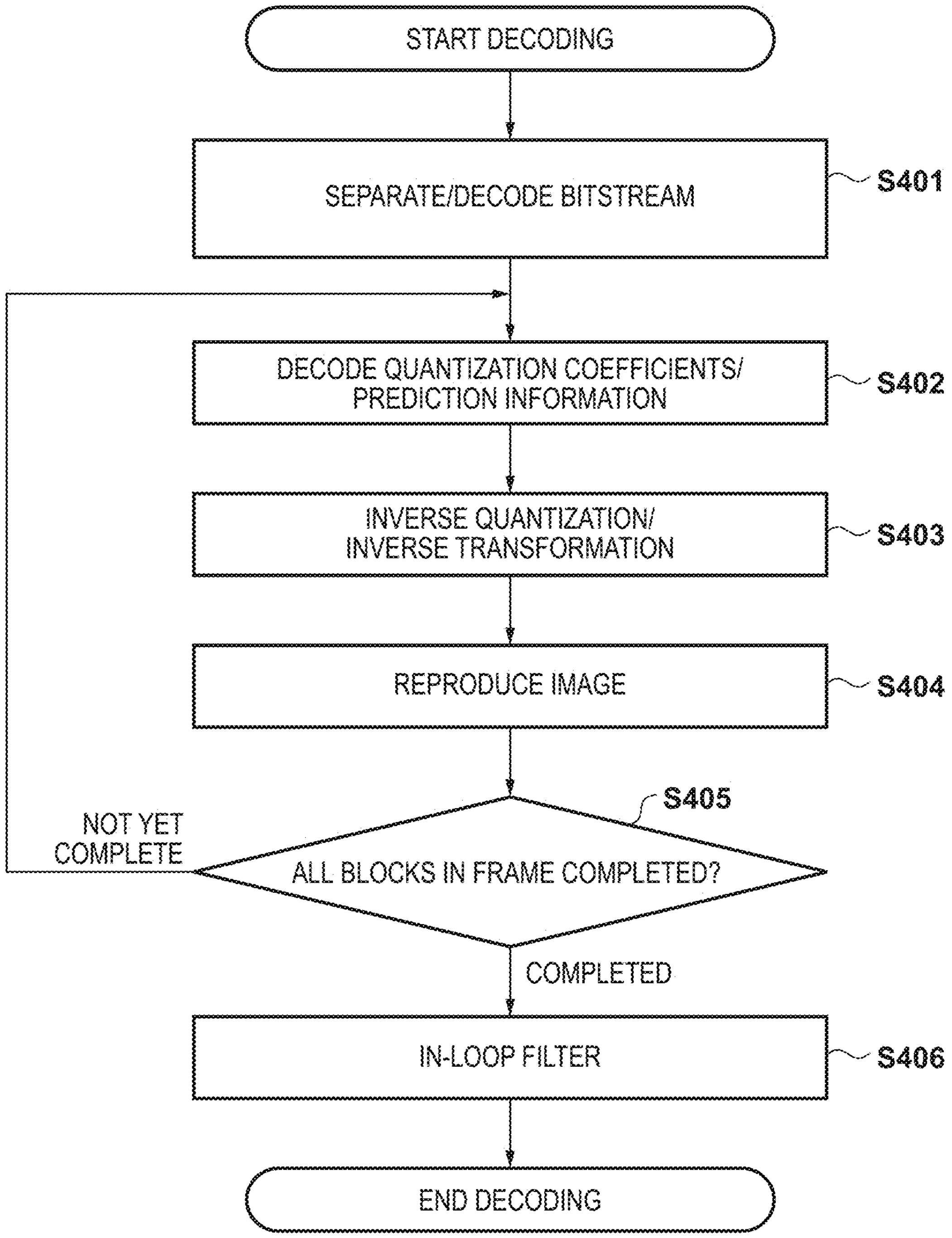
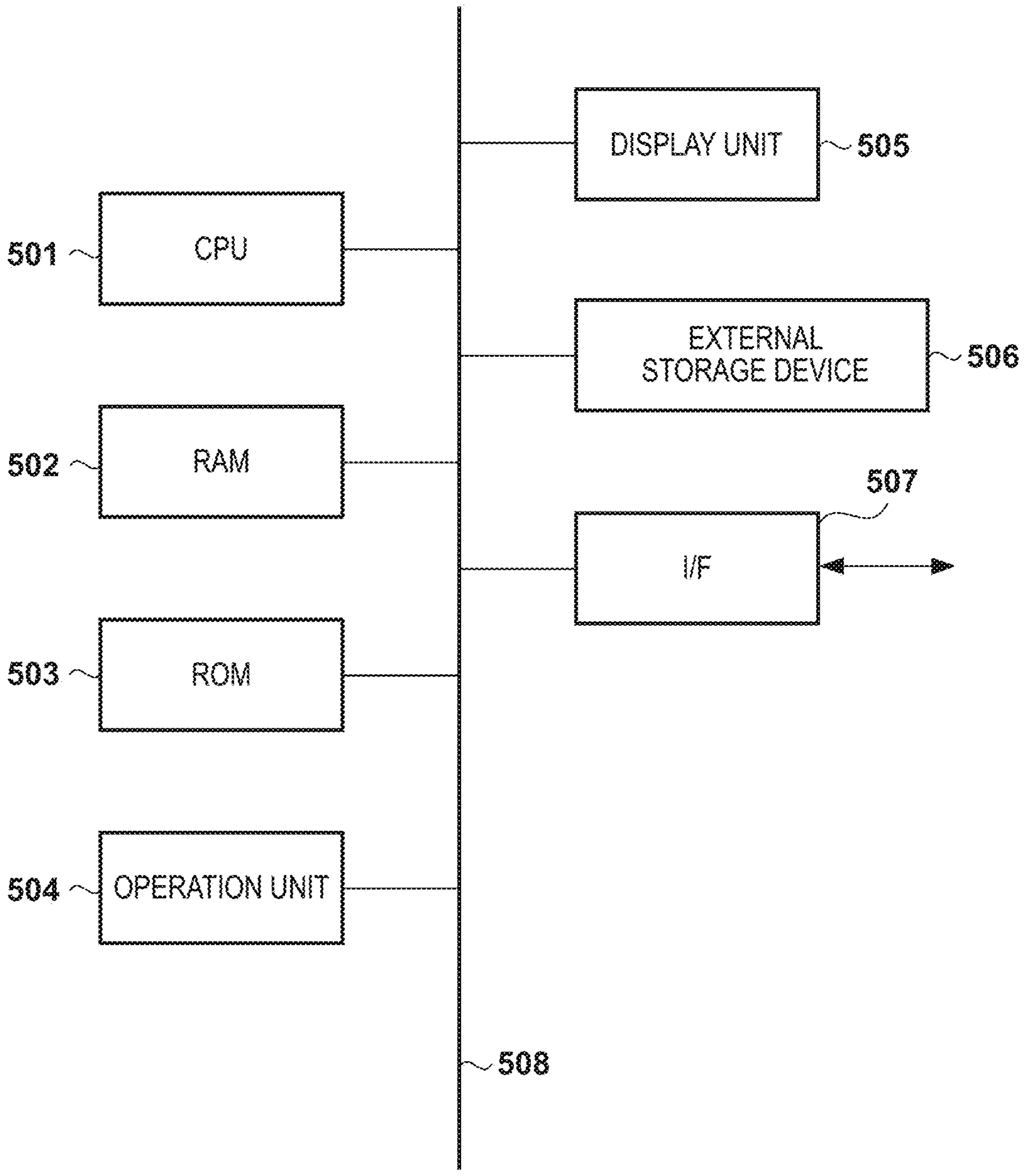

START DECODING
SEPARATE/DECODE BITSTREAM
S401
DECODE QUANTIZATION COEFFICIENTS/ PREDICTION INFORMATION
S402
INVERSE QUANTIZATION/ INVERSE TRANSFORMATION
S403
REPRODUCE IMAGE
S404
S405
ALL BLOCKS IN FRAME COMPLETED?
NOT YET COMPLETE
COMPLETED
IN-LOOP FILTER
S406
END DECODING

FIG. 5


DISPLAY UNIT
505
501
CPU
EXTERNAL STORAGE DEVICE
506
502
RAM
507
I/F
503
ROM
504
OPERATION UNIT
508

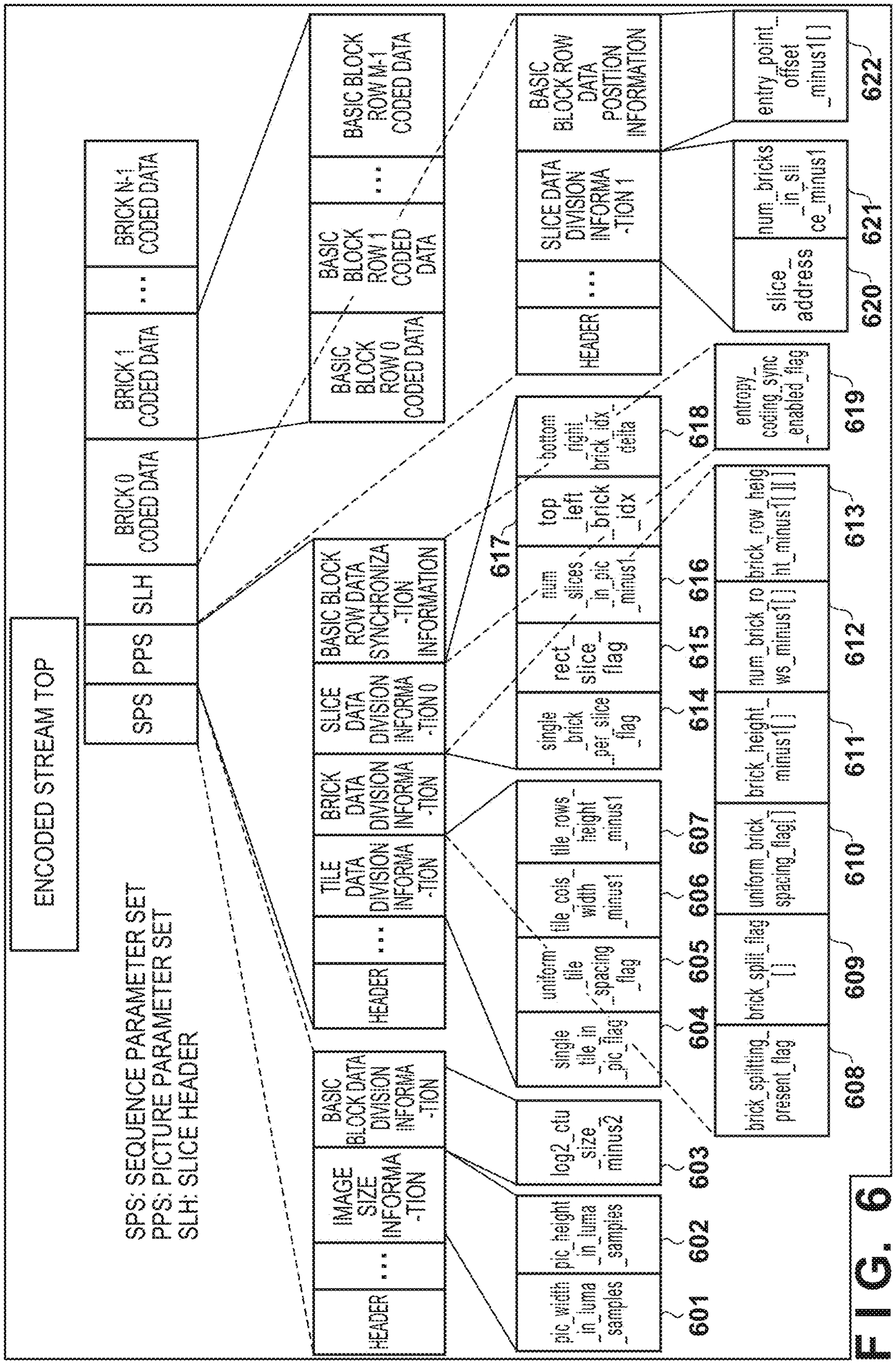

ENCODED STREAM TOP
SPS: SEQUENCE PARAMETER SET
PPS: PICTURE PARAMETER SET
SLH: SLICE HEADER
SPS
PPS
SLH
BRICK 0 CODED DATA
BRICK 1 CODED DATA
...
BRICK N-1 CODED DATA
BASIC BLOCK ROW 0 CODED DATA
BASIC BLOCK ROW 1 CODED DATA
...
BASIC BLOCK ROW M-1 CODED DATA
HEADER
...
IMAGE SIZE INFORMA-TION
BASIC BLOCK DATA DIVISION INFORMA-TION
HEADER
...
TILE DATA DIVISION INFORMA-TION
BRICK DATA DIVISION INFORMA-TION
SLICE DATA DIVISION INFORMA-TION 0
BASIC BLOCK ROW DATA SYNCHRONIZA-TION INFORMATION
HEADER
...
SLICE DATA DIVISION INFORMA-TION 1
BASIC BLOCK ROW DATA POSITION INFORMATION
pic_width_in_luma_samples
601
pic_height_in_luma_samples
602
log2_ctu_size_minus2
603
single_tile_in_pic_flag
604
uniform_tile_spacing_flag
605
tile_cols_width_minus1
606
tile_rows_height_minus1
607
brick_splitting_present_flag
608
brick_split_flag[ ]
609
uniform_brick_spacing_flag[ ]
610
brick_height_minus1[ ]
611
num_brick_rows_minus1[ ]
612
brick_row_height_minus1[ ][ ]
613
single_brick_per_slice_flag
614
rect_slice_flag
615
num_slices_in_pic_minus1
616
top_left_brick_idx
617
bottom_right_brick_idx_delta
618
entropy_coding_sync_enabled_flag
619
slice_address
620
num_bricks_in_slice_minus1
621
entry_point_offset_minus1[ ]
622

FIG. 6

FIG. 7

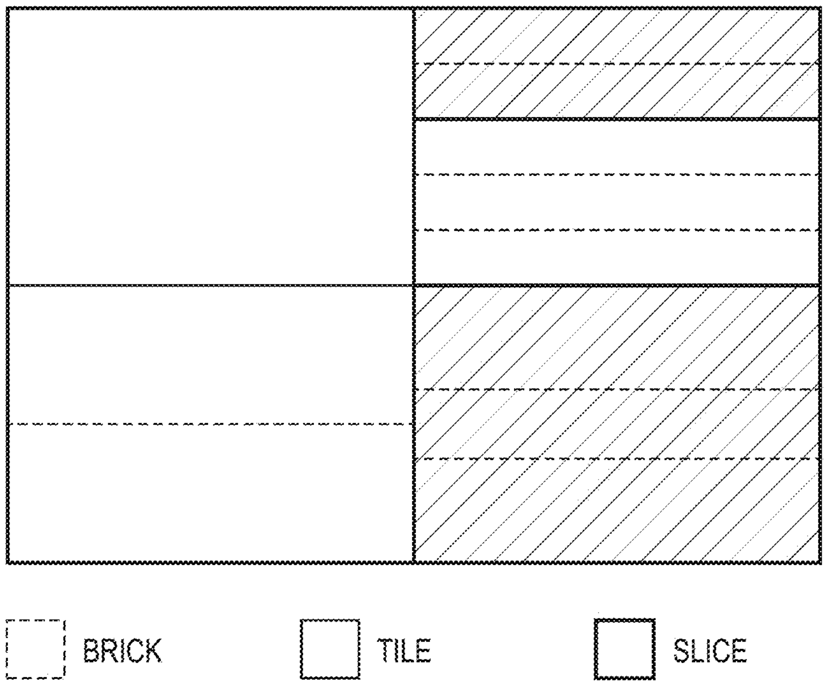


FIG. 8A

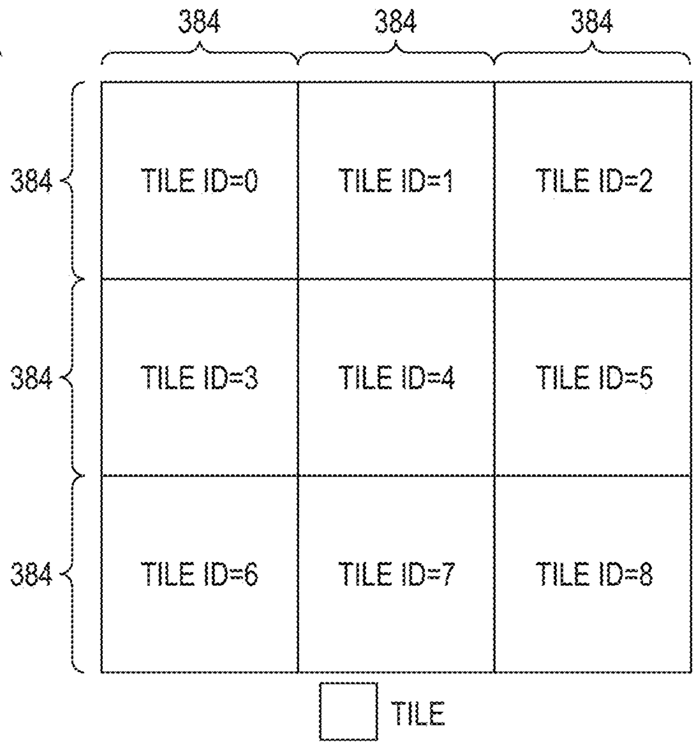

384
384
384
384
384
384
TILE ID=0
TILE ID=1
TILE ID=2
TILE ID=3
TILE ID=4
TILE ID=5
TILE ID=6
TILE ID=7
TILE ID=8
TILE

FIG. 8B

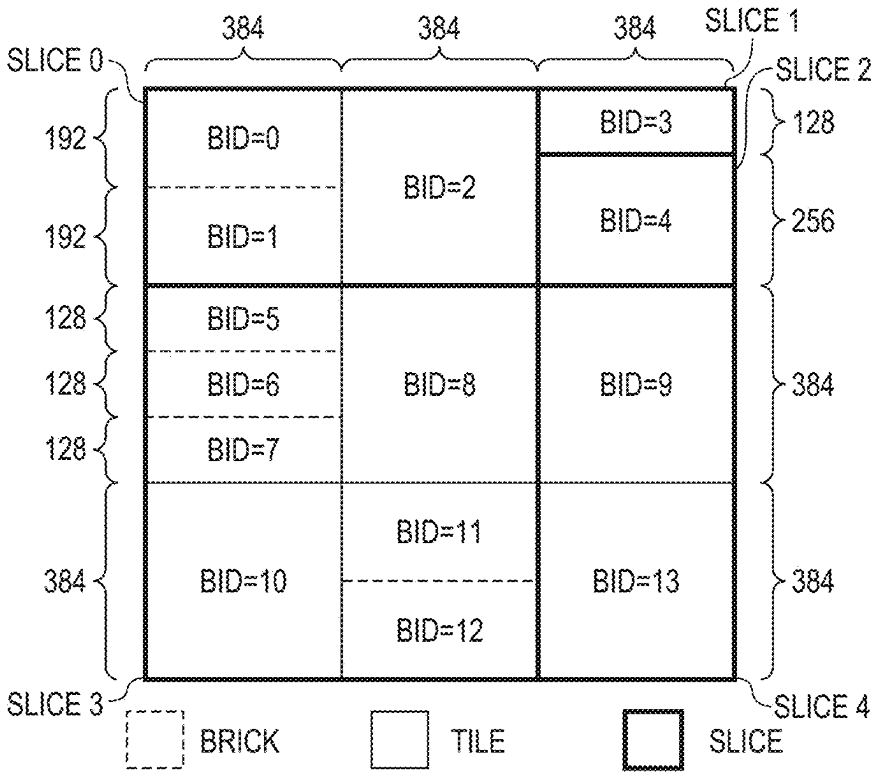

384
384
384
SLICE 0
SLICE 1
SLICE 2
192
192
128
128
128
384
128
256
384
384
BID=0
BID=1
BID=2
BID=3
BID=4
BID=5
BID=6
BID=7
BID=8
BID=9
BID=10
BID=11
BID=12
BID=13
SLICE 3
SLICE 4
BRICK
TILE
SLICE

FIG. 9A

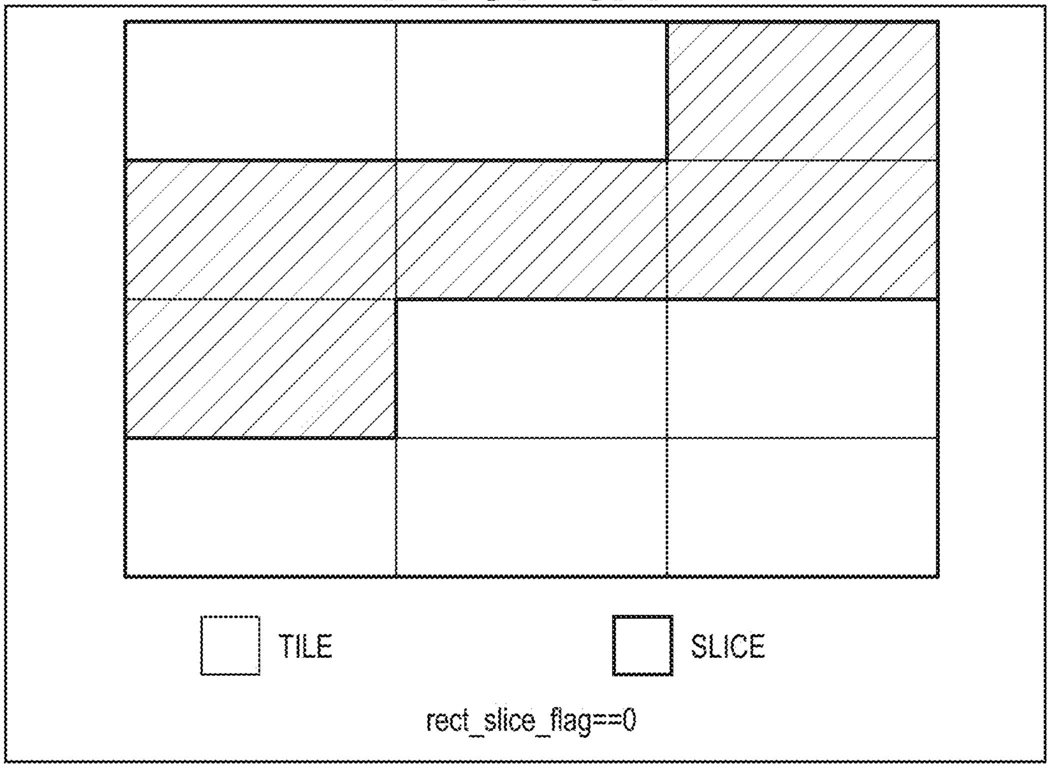


FIG. 9B

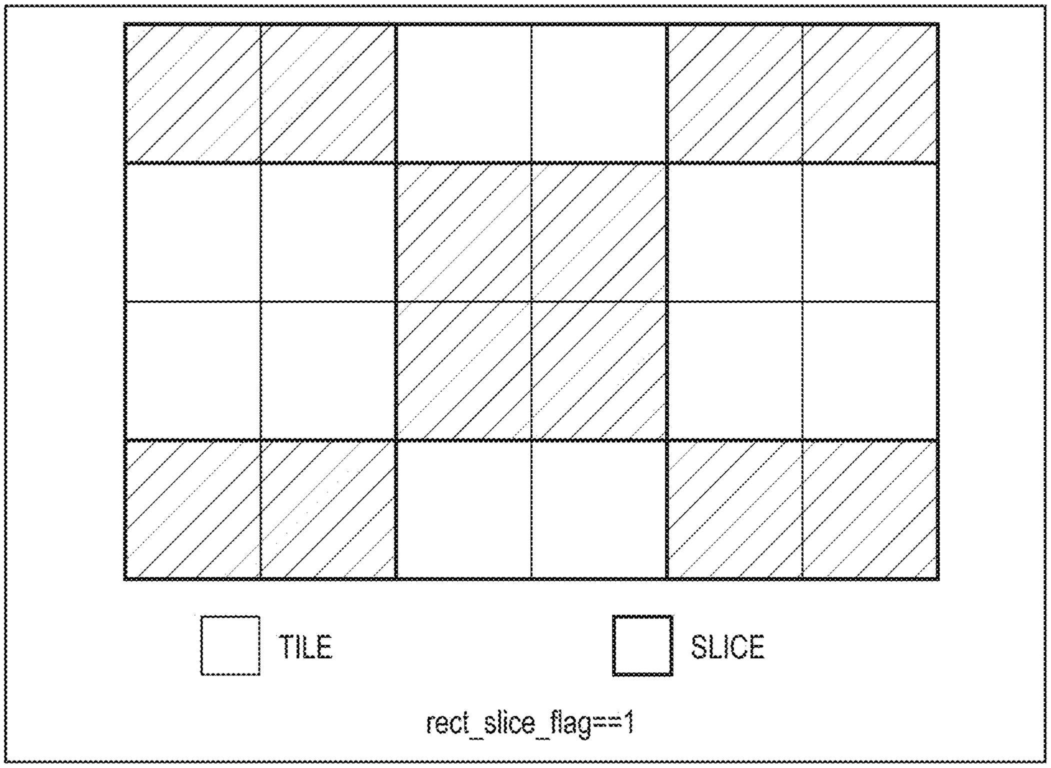


IMAGE ENCODING APPARATUS, IMAGE DECODING APPARATUS, IMAGE ENCODING METHOD, IMAGE DECODING METHOD, AND NON-TRANSITORY COMPUTER-READABLE STORAGE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation of U.S. patent application Ser. No. 17/556,542, filed on Dec. 20, 2021, which is a Continuation of International Patent Application No. PCT/JP2020/021184, filed May 28, 2020, which claims the benefit of Japanese Patent Application No. 2019-115750, filed Jun. 21, 2019, both of which are hereby incorporated by reference herein in their entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an encoding/decoding technique for an image.

Background Art

As an encoding method for compression recording of a moving image, an HEVC (High Efficiency Video Coding) encoding method (to be referred to as HEVC hereinafter) is known. In the HEVC, to improve the encoding efficiency, a basic block with a size larger than a conventional macroblock (16×16 pixels) is employed. The basic block of the large size is called a CTU (Coding Tree Unit), and its size is 64×64 pixels at maximum. The CTU is further divided into sub-blocks that are units to perform prediction or conversion.

Also, in the HEVC, a picture can be divided into a plurality of tiles or slices and encoded. The tiles or slices have little data dependence, and encoding/decoding processing can be executed in parallel. One of great advantages of the tile or slice division is that processing can be executed in parallel by a multicore CPU or the like to shorten the processing time.

In addition, each slice is encoded by a conventional binary arithmetic encoding method employed in the HEVC. That is, each syntax element is binarized to generate a binary signal. To each syntax element, an occurrence probability is given in advance as a table (to be referred to as an occurrence probability table hereinafter), and each binary signal is arithmetically encoded based on the occurrence probability table. At the time of decoding, the occurrence probability table is used as decoding information for subsequent decoding of a code. At the time of encoding, the occurrence probability table is used as encoding information for subsequent encoding. Every time encoding is performed, the occurrence probability table is updated based on statistical information representing whether the encoded binary signal is a symbol of a higher occurrence probability.

Also, the HEVC uses a method for processing entropy encoding/decoding in parallel, which is called Wavefront Parallel Processing (to be referred to as WPP hereinafter). In the WPP, a table of occurrence probability obtained when a block at a position designated in advance is encoded is applied to the block at the left end of the next row, thereby enabling parallel encoding processing of blocks on a row basis while suppressing lowering of the encoding efficiency.

To enable parallel processing on a block row basis, entry_point_offset_minus1 representing the start position of each block row in a bitstream and num_entry_point_offsets representing the number of entry_point_offset_minus1 are encoded in a slice header. PTL 1 discloses a technique associated with WPP.

In recent years, activities for international standardization of a more efficient encoding method that is the successor to the HEVC have been started. JVET (Joint Video Experts Team) has been established between ISO/IEC and ITU-T, and a VVC (Versatile Video Coding) encoding method (to be referred to as VVC hereinafter) has been standardized. In the VVC, it has been examined that a tile is further divided into rectangles (bricks) each formed from a plurality of block rows. In addition, each slice is configured to include one or more bricks.

In the VVC, bricks that form a slice can be derived in advance. In addition, the number of basic block rows included in each brick can be derived from another syntax. Hence, the number of entry_point_offset_minus1 representing the start positions of the basic block rows belonging to the slice can be derived without using num_entry_point_offset. For this reason, num_entry_point_offset is a redundant syntax.

CITATION LIST

Patent Literature

PTL 1: Japanese Patent Laid-Open No. 2014-11638

SUMMARY OF THE INVENTION

According to the first aspect of the present invention, there is provided an image encoding apparatus comprising: a division unit configured to divide an image into rectangular regions each including at least one block row formed from a plurality of blocks, and divide the image into rectangular slices or slices to be processed in raster order; a specifying unit configured to, in a case where the image is divided into the rectangular slices, specify, based on first information for specifying a rectangular region to be processed first in the plurality of rectangular regions included in the rectangular slice and second information for specifying a rectangular region to be processed last in the plurality of rectangular regions, the plurality of rectangular regions included in the rectangular slice, and specify, based on the number of blocks in a vertical direction in each of the plurality of specified rectangular regions, the number of pieces of information for specifying a start position of coded data of the block row in the rectangular slice; and a generation unit configured to generate a bitstream in which at least the pieces of information for specifying the start position, whose number is as many as the number specified by the specifying unit, the first information, the second information, and the coded data of the block row are multiplexed.

According to the second aspect of the present invention, there is provided an image decoding apparatus for decoding an image from a bitstream encoded by dividing an image into rectangular regions each including at least one block row formed from a plurality of blocks and dividing the image into rectangular slices or slices to be processed in raster order, comprising: a decoding unit configured to, in a case where the image is divided into the rectangular slices, decode, from the bitstream, first information for specifying a rectangular region to be processed first in the plurality of rectangular regions included in the rectangular slice and second information for specifying a rectangular region to be processed last in the plurality of rectangular regions; and a specifying unit configured to specify the plurality of rectangular regions included in the rectangular slice based on the first information and the second information, and specify, based on the number of blocks in a vertical direction in each of the plurality of specified rectangular regions, the number of pieces of information for specifying a start position of coded data of the block row in the rectangular slice, wherein the decoding unit decodes the coded data of the block row based on at least the number of pieces of information for specifying the start position, which is specified by the specifying unit, and the information for specifying the start position.

According to the third aspect of the present invention, there is provided an image encoding method, comprising: dividing an image into rectangular regions each including at least one block row formed from a plurality of blocks, and dividing the image into rectangular slices or slices to be processed in raster order; in a case where the image is divided into the rectangular slices, specifying, based on first information for specifying a rectangular region to be processed first in the plurality of rectangular regions included in the rectangular slice and second information for specifying a rectangular region to be processed last in the plurality of rectangular regions, the plurality of rectangular regions included in the rectangular slice, and specifying, based on the number of blocks in a vertical direction in each of the plurality of specified rectangular regions, the number of pieces of information for specifying a start position of coded data of the block row in the rectangular slice; and generating, a bitstream in which at least the pieces of information for specifying the start position, whose number is as many as the number specified in the specifying, the first information, the second information, and the coded data of the block row are multiplexed.

According to the fourth aspect of the present invention, there is provided an image decoding method of decoding an image from a bitstream encoded by dividing an image into rectangular regions each including at least one block row formed from a plurality of blocks and dividing the image into rectangular slices or slices to be processed in raster order, comprising: in a case where the image is divided into the rectangular slices, decoding from the bitstream, first information for specifying a rectangular region to be processed first in the plurality of rectangular regions included in the rectangular slice and second information for specifying a rectangular region to be processed last in the plurality of rectangular regions; and specifying the plurality of rectangular regions included in the rectangular slice based on the first information and the second information, and specifying, based on the number of blocks in a vertical direction in each of the plurality of specified rectangular regions, the number of pieces of information for specifying a start position of coded data of the block row in the rectangular slice, wherein in the decoding, the coded data of the block row is decoded based on at least the number of pieces of information for specifying the start position, which is specified in the specifying, and the information for specifying the start position.

According to the fifth aspect of the present invention, there is provided a non-transitory computer-readable storage medium for storing a computer program for causing a computer to execute: dividing an image into rectangular regions each including at least one block row formed from a plurality of blocks, and dividing the image into rectangular

slices or slices to be processed in raster order; in a case where the image is divided into the rectangular slices, specifying, based on first information for specifying a rectangular region to be processed first in the plurality of rectangular regions included in the rectangular slice and second information for specifying a rectangular region to be processed last in the plurality of rectangular regions, the plurality of rectangular regions included in the rectangular slice, and specifying, based on the number of blocks in a vertical direction in each of the plurality of specified rectangular regions, the number of pieces of information for specifying a start position of coded data of the block row in the rectangular slice; and generating, a bitstream in which at least the pieces of information for specifying the start position, whose number is as many as the number specified in the specifying, the first information, the second information, and the coded data of the block row are multiplexed.

According to the sixth aspect of the present invention, there is provided a non-transitory computer-readable storage medium for storing a computer program for causing a computer to execute an image decoding method of decoding an image from a bitstream encoded by dividing an image into rectangular regions each including at least one block row formed from a plurality of blocks and dividing the image into rectangular slices or slices to be processed in raster order, comprising: in a case where the image is divided into the rectangular slices, decoding from the bitstream, first information for specifying a rectangular region to be processed first in the plurality of rectangular regions included in the rectangular slice and second information for specifying a rectangular region to be processed last in the plurality of rectangular regions; and specifying the plurality of rectangular regions included in the rectangular slice based on the first information and the second information, and specifying, based on the number of blocks in a vertical direction in each of the plurality of specified rectangular regions, the number of pieces of information for specifying a start position of coded data of the block row in the rectangular slice, wherein in the decoding, the coded data of the block row is decoded based on at least the number of pieces of information for specifying the start position, which is specified in the specifying, and the information for specifying the start position.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing an example of the functional configuration of an image encoding apparatus;

FIG. **2** is a block diagram showing an example of the functional configuration of an image decoding apparatus;

FIG. **3** is a flowchart of encoding processing of an input image by the image encoding apparatus;

FIG. **4** is a flowchart of decoding processing of a bitstream by the image decoding apparatus;

FIG. **5** is a block diagram showing an example of the hardware configuration of a computer apparatus;

FIG. **6** is a view showing an example of the format of a bitstream;

FIG. **7** is a view showing a division example of an input image;

FIG. **8**A is a view showing an example of division of an input image;

FIG. **8**B is a view showing an example of division of an input image;

FIG. **9**A is a view showing the relationship between tiles and slices; and

FIG. **9**B is a view showing the relationship between tiles and slices.

DESCRIPTION OF THE EMBODIMENTS

Hereinafter, embodiments will be described in detail with reference to the attached drawings. Note, the following embodiments are not intended to limit the scope of the claimed invention. Multiple features are described in the embodiments, but limitation is not made to an invention that requires all such features, and multiple such features may be combined as appropriate.

Furthermore, in the attached drawings, the same reference numerals are given to the same or similar configurations, and redundant description thereof is omitted.

First Embodiment

An example of the functional configuration of an image encoding apparatus according to this embodiment will be described first with reference to the block diagram of FIG. **1**. An input image as an encoding target is input to an image division unit **102**. The input image may be the image of each of frames that constitute a moving image, or may be a still image. The image division unit **102** divides the input image into "one or a plurality of tiles". A tile is a set of continuous basic blocks, which covers a rectangular region in the input image. The image division unit **102** further divides each tile into one or a plurality of bricks. A brick is a rectangular region (a rectangular region including at least one block row formed from a plurality of blocks each having a size smaller than that of a tile) formed by one or a plurality of rows of basic blocks (basic block rows) in a tile. The image division unit **102** also divides the input image into slices each formed from "one or a plurality of tiles" or "one or a plurality of bricks". The slice is the basic unit of encoding, and header information such as information representing a type of slice is added to each slice. FIG. **7** shows an example in which an input image is divided into four tiles, four slices, and 11 bricks. The upper left tile is divided into one brick, the lower left tile is divided into two bricks, the upper right tile is divided into five bricks, and the lower right tile is divided into three bricks. The left slice is configured to include three bricks, the upper right slice is configured to include two bricks, the right center slice is configured to include three bricks, and the lower right slice is configured to include three bricks. For each of the thus divided tiles, bricks, and slices, the image division unit **102** outputs, as division information, information concerning the size.

A block division unit **103** divides the image of a basic block row (basic block row image) output from the image division unit **102** into a plurality of basic blocks, and outputs the image of each basic block (block image) to the subsequent stage.

A prediction unit **104** divides the image of each basic block into sub-blocks and performs, for each sub-block, intra-prediction that is intra-frame prediction or inter-prediction that is inter-frame prediction, thereby generating a predicted image. Intra-prediction across a brick (intra-prediction using the pixels of the blocks of another brick) or motion vector prediction across a brick (motion vector prediction using the motion vectors of the blocks of another brick) is not performed. Also, the prediction unit **104** calculates prediction errors from the input image and the predicted image and outputs the prediction errors. In addition, the prediction unit **104** outputs information (prediction information) necessary for prediction, for example, pieces of information such as a sub-block division method, a prediction mode, and a motion vector together with the prediction errors.

A transformation/quantization unit **105** orthogonally transforms the prediction errors on a sub-block basis to obtain transformation coefficients, and quantizes the obtained transformation coefficients to obtain quantization coefficients. An inverse quantization/inverse transformation unit **106** inversely quantizes the quantization coefficients output from the transformation/quantization unit **105** to reproduce the transformation coefficients, and also inversely orthogonally transforms the reproduced transformation coefficients to reproduce the prediction errors.

A frame memory **108** functions as a memory that stores a reproduced image. An image reproduction unit **107** generates a predicted image by appropriately referring to the frame memory **108** based on the prediction information output from the prediction unit **104**, generates a reproduced image from the predicted image and the input prediction errors, and outputs the reproduced image.

An in-loop filter unit **109** performs in-loop filter processing such as deblocking filter processing or sample adaptive offset for the reproduced image, and outputs the image (filter image) that has undergone the in-loop filter processing.

An encoding unit **110** generates coded data (encoded data) by encoding the quantization coefficients output from the transformation/quantization unit **105** and the prediction information output from the prediction unit **104**, and outputs the generated coded data.

An integration encoding unit **111** generates header coded data using the division information output from the image division unit **102**, generates a bitstream including the generated header coded data and the coded data output from the encoding unit **110**, and outputs the bitstream. A control unit **199** controls the operation of the entire image encoding apparatus, and controls the operations of the above-described functional units of the image encoding apparatus.

Encoding processing for an input image by the image encoding apparatus having the configuration shown in FIG. **1** will be described next. In this embodiment, to facilitate the description, only processing of intra-prediction coding will be described. However, the embodiment is not limited to this, and can also be applied to processing of inter-prediction coding. Also, in this embodiment, for the sake of detailed description, the description will be made assuming that the block division unit **103** divides a basic block row image output from the image division unit **102** into "basic blocks each having a size of 64×64 pixels".

The image division unit **102** divides an input image into tiles and bricks. FIGS. **8**A and **8**B show an example of division of an input image by the image division unit **102**. In this embodiment, as shown in FIG. **8**A, an input image having a size of 1152× 1152 pixels is divided into nine tiles (the size of one tile is 384×384 pixels). Each tile is given an ID (tile ID) in the raster order from the upper left corner. The tile ID of the upper left tile is 0, and the tile ID of the lower right tile is 8.

FIG. **8**B shows an example of division of tiles, bricks, and slices in the input image. As shown in FIG. **8**B, each of the tile of tile ID=0 and the tile of tile ID=7 is divided into two bricks (the size of each brick is 384× 192 pixels). The tile of tile ID=2 is divided into two bricks (the size of the brick on the upper side is 384× 128 pixels, and the size of the brick on the lower side is 384×256 pixels). The tile of tile ID=3 is divided into three bricks (the size of each brick is 384× 128 pixels). The tiles of tile ID=1, 4, 5, 6, and 8 are not divided into bricks (equivalent to dividing one tile into one brick), and as a result, tile=brick. Each brick is given an ID sequentially from the upper side in the tiles of raster order. BID shown in FIG. **8**B is the ID of a brick. Also, the input image is divided into a slice including bricks corresponding to BID=0 to 2, a slice including a brick corresponding to BID=3, a slice including a brick corresponding to BID=4, a slice including bricks corresponding to BID=5 to 8 and 10 to 12, and a slice including bricks corresponding to BID=9 and 13. Note that each slice is also given an ID sequentially from the upper side in the slices of raster order. For example, slice 0 indicates the slice of ID=0, and slice 4 indicates the slice of ID=4.

For each of the divided tiles, bricks, and slices, the image division unit **102** outputs information concerning the size as division information to the integration encoding unit **111**. In addition, the image division unit **102** divides each brick into basic block row images and outputs the divided basic block row images to the block division unit **103**.

The block division unit **103** divides each of the basic block row images output from the image division unit **102** into a plurality of basic blocks, and outputs a block image (64×64 pixels) that is an image of each basic block to the prediction unit **104** of the subsequent stage.

The prediction unit **104** divides the image of each basic block into sub-blocks, decides an intra-prediction mode such as horizontal prediction or vertical prediction on a sub-block basis, and generates a predicted image based on the decided intra-prediction mode and encoded pixels. Furthermore, the prediction unit **104** calculates prediction errors from the input image and the predicted image, and outputs the calculated prediction errors to the transformation/quantization unit **105**. In addition, the prediction unit **104** outputs pieces of information such as a sub-block division method and an intra-prediction mode as prediction information to the encoding unit **110** and the image reproduction unit **107**.

The transformation/quantization unit **105** performs, on a sub-block basis, orthogonal transformation (orthogonal transformation processing corresponding to the size of a sub-block) for the prediction errors output from the prediction unit **104**, thereby obtaining transformation coefficients (orthogonal transformation coefficients). The transformation/quantization unit **105** quantizes the obtained transformation coefficients, thereby obtaining quantization coefficients. The transformation/quantization unit **105** outputs the obtained quantization coefficients to the encoding unit **110** and the inverse quantization/inverse transformation unit **106**.

The inverse quantization/inverse transformation unit **106** inversely quantizes the quantization coefficients output from the transformation/quantization unit **105** to reproduce the transformation coefficients, and further inversely orthogonally transforms the reproduced transformation coefficients to reproduce the prediction errors. The inverse quantization/inverse transformation unit **106** then outputs the reproduced prediction errors to the image reproduction unit **107**.

The image reproduction unit **107** generates a predicted image by appropriately referring to the frame memory **108** based on the prediction information output from the prediction unit **104**, and generates a reproduced image from the predicted image and the prediction errors input from the inverse quantization/inverse transformation unit **106**. The image reproduction unit **107** then stores the generated reproduced image in the frame memory **108**.

The in-loop filter unit **109** reads out the reproduced image from the frame memory **108**, and performs in-loop filter processing such as deblocking filter processing or sample adaptive offset for the readout reproduced image. The in-loop filter unit **109** then stores (restores) the image that has undergone the in-loop filter processing in the frame memory **108**.

The encoding unit **110** entropy-encodes the quantization coefficients output from the transformation/quantization unit **105** and the prediction information output from the prediction unit **104**, thereby generating coded data. The method of entropy encoding is not particularly designated, and Golomb coding, arithmetic encoding, Huffman coding, or the like can be used. The encoding unit **110** then outputs the generated coded data to the integration encoding unit **111**.

The integration encoding unit **111** generates header coded data using the division information output from the image division unit **102**, generates a bitstream by multiplexing the generated header coded data and the coded data output from the encoding unit **110**, and outputs the bitstream. The output destination of the bitstream is not limited to a specific output destination. The bitstream may be output to (stored in) a memory inside or outside the image encoding apparatus, or may be transmitted to an external apparatus capable of communicating with the image encoding apparatus via a network such as a LAN or the Internet.

Next, FIG. **6** shows an example of the format of a bitstream (coded data by VVC, which is encoded by the image encoding apparatus) output from the integration encoding unit **111**. The bitstream shown in FIG. **6** includes a sequence parameter set (SPS) that is header information including information concerning encoding of a sequence. Also, the bitstream shown in FIG. **6** includes a picture parameter set (PPS) that is header information including information concerning encoding of a picture. In addition, the bitstream shown in FIG. **6** includes a slice header (SLH) that is header information including information concerning encoding of a slice. Furthermore, the bitstream shown in FIG. **6** includes coded data of bricks (brick 0 to brick (N−1) in FIG. **6**).

The SPS includes image size information and basic block data division information. The PPS includes tile data division information that is the division information of tiles, brick data division information that is the division information of bricks, slice data division information 0 that is the division information of slices, and basic block row data synchronization information. The SLH includes slice data division information 1 and basic block row data position information.

The SPS will be described first. The SPS includes, as image size information, pic_width_in_luma_samples that is information **601** and pic_height_in_luma_samples that is information **602**. pic_width_in_luma_samples represents the size (number of pixels) of an input image in the horizontal direction, and pic_height_in_luma_samples represents the size (number of pixels) of the input image in the vertical direction. In this embodiment, since the input image shown in FIGS. **8**A and **8**B is used as the input image, pic_width_in_luma_samples=1152, and pic_height_in_luma_samples=1152. The SPS also includes, as basic block data division information, log 2_ctu_size_minus2 that is information **603**. log 2_ctu_size_minus2 represents the size of a basic block. The number of pixels of the basic block in the horizontal direction and the vertical direction is expressed by 1<<(log 2_ctu_size_minus2+2). In this embodiment, since the size of a basic block is 64×64 pixels, the value of log 2_ctu_size_minus2 is 4.

Next, the PPS will be described. The PPS includes pieces of information **604** to **607** as tile data division information.

The information **604** is single_tile_in_pic_flag representing whether the input image is divided into a plurality of tiles and encoded. If single_tile_in_pic_flag=1, this indicates that the input image is not divided into a plurality of tiles and encoded. On the other hand, if single_tile_in_pic_flag=0, this indicates that the input image is divided into a plurality of tiles and encoded.

The information **605** is information included in the tile data division information when single_tile_in_pic_flag=0. The information **605** is uniform_tile_spacing_flag representing whether each tile has the same size. If uniform_tile_spacing_flag=1, this indicates that each tile has the same size. If uniform_tile_spacing_flag=0, this indicates that a tile that does not have the same size exists.

The information **606** and the information **607** are pieces of information included in the tile data division information when uniform_tile_spacing_flag=1. The information **606** is tile_cols_width_minus1 representing (the number of horizontal basic blocks of a tile−1). The information **607** is tile_rows_height_minus1 representing (the number of vertical basic blocks of a tile−1). The number of horizontal tiles of the input image is obtained as a quotient in a case in which the number of horizontal basic blocks of the input image is divided by the number of horizontal basic blocks of a tile. If a remainder is generated by this division, a number obtained by adding 1 to the quotient is defined as "the number of horizontal tiles of the input image". In addition, the number of vertical tiles of the input image is obtained as a quotient in a case in which the number of vertical basic blocks of the input image is divided by the number of vertical basic blocks of a tile. If a remainder is generated by this division, a number obtained by adding 1 to the quotient is defined as "the number of vertical tiles of the input image". Also, the total number of tiles in the input image can be obtained by calculating the number of horizontal tiles of the input image×the number of vertical tiles of the input image.

Note that since a tile whose size is different from others is included if uniform_tile_spacing_flag=0, the number of horizontal tiles of the input image, the number of vertical tiles of the input image, and the vertical and horizontal sizes of each tile are converted into codes.

The PPS also includes pieces of information **608** to **613** as brick data division information. The information **608** is brick_splitting_present_flag. If brick_splitting_present_flag=1, this indicates that one or more tiles in the input image are divided into a plurality of bricks. On the other hand, if brick_splitting_present_flag=0, this indicates that each tile in the input image is formed by a single brick.

The information **609** is information included in the brick data division information when brick_splitting_present_flag=1. The information **609** is brick_split_flag[ ] representing, for each tile, whether the tile is divided into a plurality of bricks. brick_split_flag[ ] representing whether the ith tile is divided into a plurality of bricks is expressed as brick_split_flag[i]. If brick_split_flag[i]=1, this indicates that the ith tile is divided into a plurality of bricks. If brick_split_flag[i]=0, this indicates that the ith tile is formed by a single brick.

The information **610** is uniform_brick_spacing_flag[i] representing whether, if brick_split_flag[i]=1, the bricks that form the ith tile have the same size. If brick_split_flag[i]=0 for all i, the information **610** is not included in the brick data division information. For i that satisfies brick_split_flag[i]=1, the information **610** includes uniform_brick_spacing_flag[i]. If uniform_brick_spacing_flag[i]=1, this indicates that the bricks that form the ith tile have the same size. On the other hand, if uniform_brick_spacing_flag[i]=0, this indicates that a brick whose size is different from others exists among the bricks that form the ith tile.

The information **611** is information included in the brick data division information when uniform_brick_spacing_flag[i]=1. The information **611** is brick_height_minus1 [i] representing (the number of vertical basic blocks of a brick in the ith tile−1).

Note that the number of vertical basic blocks of a brick can be obtained by dividing the number of vertical pixels of the brick by the number of vertical pixels of a basic block (64 pixels in this embodiment). Also, the number of bricks that form a tile is obtained as a quotient in a case in which the number of vertical basic blocks of the tile is divided by the number of vertical basic blocks of a brick. If a remainder is generated by this division, a number obtained by adding 1 to the quotient is defined as "the number of bricks that form the tile". For example, assume that the number of vertical basic blocks of a tile is 10, and the value of brick_height_minus1 is 2. At this time, the tile is divided into four bricks including, sequentially from the upper side, a brick in which the number of basic block rows is 3, a brick in which the number of basic block rows is 3, a brick in which the number of basic block rows is 3, a brick in which the number of basic block rows is 1.

The information **612** is num_brick_rows_minus1[i] representing (the number of bricks that form the ith tile−1) for i that satisfies uniform_brick_spacing_flag[i]=0.

Note that in this embodiment, if uniform_brick_spacing_flag[i]=0, num_brick_rows_minus1 [i] representing (the number of bricks that form the ith tile−1) is included in the brick data division information. However, the present invention is not limited to this.

For example, assume that the number of bricks that form the ith tile is 2 or more when brick_split_flag[i]=1. Then, num_brick_rows_minus2[i] representing (the number of bricks that form the tile−2) may be encoded in place of num_brick_rows_minus1[i]. This can decrease the number of bits of a syntax representing the number of bricks that form the tile. For example, if the tile is formed by two bricks, and num_brick_rows_minus1[i] is Golomb-coded, 3-bit data "010" indicating "1" is encoded. On the other hand, if num_brick_rows_minus2[i] representing (the number of bricks that form the tile−2) is Golomb-coded, 1-bit data "0" indicating 0 is encoded.

The information **613** is brick_row_height_minus1[i][j] representing (the number of vertical basic blocks of the ith brick in the ith tile−1) for i that satisfies uniform_brick_spacing_flag[i]=0. brick_row_height_minus1[i][j] is encoded as many as the number of num_brick_rows_minus1 [i]. Note that if num_brick_rows_minus2[i] described above is used, brick_row_height_minus1[i][j] is encoded as many as the number of num_brick_rows_minus2[i]+1. The number of vertical basic blocks of a brick at the lower end of a tile can be obtained by subtracting the total sum of "brick_row_height_minus1+1" from the number of vertical basic blocks of the tile. For example, assume that the number of vertical basic blocks of the tile=10, num_brick_rows_minus1=3, and brick_row_height_minus1=2, 1, 2. At this time, the number of vertical basic blocks of a brick at the lower end of the tile is 10-(3+2+3)=2.

In addition, the PPS includes pieces of information **614** to **618** as slice data division information 0. The information **614** is single_brick_per_slice_flag. If single_brick_per_slice_flag=1, this indicates that all slices in the input image are formed by single bricks. On the other hand, if single_brick_per_slice_flag=0, this indicates that one or more slices in the input image are formed by a plurality of bricks. That is, it is indicated that each slice is formed by only one brick.

The information **615** is rect_slice_flag, and is information included in slice data division information 0 when single_brick_per_slice_flag=0. rect_slice_flag represents whether tiles included in a slice have a rectangular shape or are arranged in the raster order. FIG. **9**A shows the relationship between tiles and slices when rect_slice_flag=0, and shows that tiles in a slice are encoded in the raster order. On the other hand, FIG. **9**B shows the relationship between tiles and slices when rect_slice_flag=1, and shows that a plurality of tiles in each slice are rectangular.

The information **616** is num_slices_in_pic_minus1 and is information included in the slice data division information 0 when rect_slice_flag=1, and single_brick_per_slice_flag=0. num_slices_in_pic_minus1 represents (the number of slices in the input image−1).

The information **617** is top_left_brick_idx[i] representing, for each slice in the input image, the index of the upper left brick of the slice (ith slice).

The information **618** is bottom_right_brick_idx_delta[i] representing the difference between the index of the upper left brick of the ith slice in the input image and the index of the lower right brick. Here, "the upper left brick of the ith slice in the input image" is the brick to be processed first in the slice. Also, "the lower right brick of the ith slice in the input image" is the brick to be processed last in the slice.

Here, i ranges from 0 to num_slices_in_pic_minus1. Since the index of the upper left brick of the first slice in a frame is always 0, top_left_brick_idx[0] of the first slice is not encoded. In this embodiment, i in top_left_brick_idx[i] and bottom_right_brick_idx_delta[i] ranges from 0 to num_slices_in_pic_minus1. However, the present invention is not limited to this. For example, the lower right brick of the final slice (the (num_slices_in_pic_minus1)th slice) is always the brick having the largest BID. For this reason, bottom_right_brick_idx_delta[num_slices_in_pic_minus1] need not be encoded. Also, based on top_left_brick_idx[i] and bottom_right_brick_idx_delta[i] of each slice other than the final slice, bricks included in each slice other than the final slice are already specified. Hence, bricks included in the final slice can be specified as all bricks that are not included in the slices before that. In that case, the upper left brick of the final slice can be specified as the brick having the smallest BID in the remaining bricks. For this reason, top_left_brick_idx[num_slices_in_pic_minus1] need not be encoded. This can further decrease the bit amount of the header.

In addition, information **619** is encoded and included in the PPS as basic block row data synchronization information. The information **619** is entropy_coding_sync_enabled_flag. If entropy_coding_sync_enabled_flag=1, a table of occurrence probability obtained when a basic block at a predetermined position of the basic block row adjacent on the upper side is processed is applied to the block at the left end. This makes it possible to perform parallel processing of entropy encoding/decoding on a basic block row basis.

The SLH will be described next. Pieces of information **620** and **621** are encoded and included in the SLH as slice data division information 1. The information **620** is slice address included in the slice data division information 1 when rect_slice_flag=1 or the number of bricks in the input image is 2 or more. If rect_slice_flag=0, slice_address indicates the BID at the top of a slice. If rect_slice_flag=1, slice_address indicates the number of a current slice.

The information **621** is num_bricks_in_slice_minus1 included in the slice data division information 1 when rect_slice_flag=0 and single_brick_per_slice_flag=0. num_bricks_in_slice_minus1 represents (the number of bricks in the slice−1).

The SLH includes information **622** as basic block row data position information. The information **622** is entry_point_offset_minus1[ ]. If entropy_coding_sync_enabled_flag=1, entry_point_offset_minus1 [ ] is encoded and included as many as the number of (the number of basic block rows in a slice−1) in the basic block row data position information.

entry_point_offset_minus1 [ ] represents the entry point of the coded data of a basic block row, that is, the start position of the coded data of a basic block row. entry_point_offset_minus1 [j−1] represents the entry point of the coded data of the jth basic block row. The start position of the coded data of the 0th basic block row is the same as the start position of the coded data of the slice to which the basic block row belongs, and is therefore omitted. {The size of the coded data of the (j−1)th basic block row−1} is encoded as entry_point_offset_minus1 [j−1].

Encoding processing of an input image (generation processing of a bitstream having the configuration shown in FIG. **6**) by the image encoding apparatus according to this embodiment will be described next with reference to the flowchart of FIG. **3**.

First, in step S**301**, the image division unit **102** divides an input image into tiles, bricks, and slices. For each of the divided tiles, bricks, and slices, the image division unit **102** then outputs information concerning the size to the integration encoding unit **111** as division information. In addition, the image division unit **102** divides each brick into basic block row images, and outputs the divided basic block row images to the block division unit **103**.

In step S**302**, the block division unit **103** divides each basic block row image into a plurality of basic blocks, and outputs a block image that is the image of each basic block to the prediction unit **104** of the subsequent stage.

In step S**303**, the prediction unit **104** divides the image of each basic block output from the block division unit **103** into sub-blocks, decides an intra-prediction mode on a sub-block basis, and generates a predicted image based on the decided intra-prediction mode and encoded pixels. Also, the prediction unit **104** calculates prediction errors based on the input image and the predicted image, and outputs the calculated prediction errors to the transformation/quantization unit **105**. In addition, the prediction unit **104** outputs pieces of information such as a sub-block division method and an intra-prediction mode to the encoding unit **110** and the image reproduction unit **107** as prediction information.

In step S**304**, the transformation/quantization unit **105** orthogonally transforms the prediction errors output from the prediction unit **104** on a sub-block basis, thereby obtaining transformation coefficients (orthogonal transformation coefficients). The transformation/quantization unit **105** then quantizes the obtained transformation coefficients, thereby obtaining quantization coefficients. The transformation/quantization unit **105** outputs the obtained quantization coefficients to the encoding unit **110** and the inverse quantization/inverse transformation unit **106**.

In step S**305**, the inverse quantization/inverse transformation unit **106** inversely quantizes the quantization coefficients output from the transformation/quantization unit **105** to reproduce the transformation coefficients, and further inversely orthogonally transforms the reproduced transformation coefficients, thereby reproducing the prediction errors. The inverse quantization/inverse transformation unit **106** then outputs the reproduced prediction errors to the image reproduction unit **107**.

In step S**306**, the image reproduction unit **107** generates a predicted image by appropriately referring to the frame memory **108** based on the prediction information output from the prediction unit **104**, and generates a reproduced image from the predicted image and the prediction errors input from the inverse quantization/inverse transformation unit **106**. The image reproduction unit **107** then stores the generated reproduced image in the frame memory **108**.

In step S**307**, the encoding unit **110** generates coded data by entropy-encoding the quantization coefficients output from the transformation/quantization unit **105** and the prediction information output from the prediction unit **104**.

Here, if entropy_coding_sync_enabled_flag=1, an occurrence probability table obtained when a basic block at a predetermined position of the basic block row adjacent on the upper side is processed is applied before the basic block at the left end of the next basic block row is processed. In this embodiment, a description will be made assuming that entropy_coding_sync_enabled_flag=1.

In step S**308**, the control unit **199** determines whether encoding of all basic blocks in a slice is completed. As the result of this determination, if encoding of all basic blocks in a slice is completed, the process advances to step S**309**. On the other hand, if a basic block that has not been encoded yet (unencoded basic block) remains among the basic blocks in the slice, the process returns to step S**303** to encode the unencoded basic block.

In step S**309**, the integration encoding unit **111** generates header coded data using the division information output from the image division unit **102**, generates a bitstream including the generated header coded data and the coded data output from the encoding unit **110**, and outputs the bitstream.

If the input image is divided as shown in FIGS. **8**A and **8**B, single_tile_in_pic_flag of tile data division information is 0, and uniform_tile_spacing_flag is 1. In addition, tile_cols_width_minus1 is 5, and tile_rows_height_minus1 is 5.

brick_splitting_present_flag of brick data division information is 1. Tiles corresponding to tile ID=1, 4, 5, 6, and 8 are not divided into bricks. Hence, brick_split_flag[1], brick_split_flag[4], brick_split_flag[5], brick_split_flag[6], and brick_split_flag[8] are 0. Tiles corresponding to tile ID=0, 2, 3, and 7 are divided into bricks. Hence, brick_split_flag[0], brick_split_flag[2], brick_split_flag[3], and brick_split_flag[7] are 1.

Also, each of the tiles corresponding to tile ID=0, 3, and 7 is divided into bricks of the same size. Hence, uniform_brick_spacing_flag[0], uniform_brick_spacing_flag[3], and uniform_brick_spacing_flag[7] are 1. As for the tile corresponding to tile ID=2, the size of the brick of BID=3 is different from the size of the brick of BID=4. Hence, uniform_brick_spacing_flag[2] is 0.

brick_height_minus1[0] is 2, and brick_height_minus1[3] is 1. Also, brick_height_minus1 [7] is 2. Note that brick_height_minus1 is encoded when uniform_brick_spacing is 1.

brick_row_height_minus1[2][0] is 1. Note that when not num_brick_rows_minus1[2] but the syntax of num_brick_rows_minus2[2] described above is encoded instead, the value is 0.

Also, in this embodiment, since one slice includes a plurality of bricks, single_brick_per_slice_flag in slice data division information 0 is 0. Additionally, in this embodiment, since a slice includes a plurality of tiles in a rectangular shape, rect_slice_flag is 1. As shown in FIG. **8**B, since the number of slices in the input image is 5, num_slices_in_pic_minus1 is 4.

top_left_brick_idx[0] of slice 0 is not encoded because 0 is self-evident. bottom_right_brick_idx_delta[0] is 2 (=2-0). top_left_brick_idx[1] of slice 1 is 3, and bottom_right_brick_idx_delta[1] is 0 (=3-3). top_left_brick_idx[2] of slice 2 is 4, and bottom_right_brick_idx_delta[2] is 0 (=4-4). top_left_brick_idx[3] of slice 3 is 5, and bottom right_brick_idx_delta[3] is 7 (=12-5). top_left_brick_idx[4] of slice 4 is 9, and bottom_right_brick_idx_delta[4] is 4 (=13-9). Note that as described above, top_left_brick_idx[4] and bottom_right_brick_idx_delta[4] need not be encoded.

In addition, as for entry_point_offset_minus1 [ ], (the size of the coded data of the (j−1)th basic block row in the slice−1) sent from the encoding unit **110** is encoded as entry_point_offset_minus1[j−1]. The number of entry_point_offset_minus1 [ ] in the slice equals (the number of basic block rows in the slice−1). In this embodiment, since bottom_right_brick_idx_delta[0] is 2, it can be found that slice 0 is formed from the bricks of BID=0 to 2.

Here, brick_height_minus1[0] is 2, and tile_rows_height_minus1 is 5. Accordingly, both the number of basic block rows of the brick corresponding to BID=0 and the number of basic block rows of the brick corresponding to BID=1 are brick_height_minus1[0]+1=3. In addition, the number of basic block rows of the brick corresponding to BID=2 is tile_rows_height_minus1+1=6. Hence, the number of basic block rows of slice 0 is 3+3+6=12. Hence, j ranges from 0 to 10.

As for slice 1, since top_left_brick_idx[1] is 3, and bottom_right_brick_idx_delta[1] is 0, it is found that the slice is formed from the brick of BID=3. In addition, since brick_row_height_minus1[2][0] is 1, the number of basic block rows of slice 1 (the brick of BID=3) is 2. Hence, the range of j is only 0.

As for slice 2, since top_left_brick_idx[2] is 4, and bottom_right_brick_idx_delta[2] is 0, it is found that the slice is formed from the brick of BID=4. In addition, brick_row_height_minus1[2][0] is 1, num_brick_rows_minus1[2] is 1, and tile_rows_height_minus1 is 5. Accordingly, the number of basic block rows of slice 2 (the brick of BID=4) is {(tile_rows_height_minus1+1)−(brick_row_height_minus1[2][0]+1)}=4. Hence, j ranges from 0 to 2.

Slice 3 is formed from the bricks of BID=5 to 8 and 10 to 12. Since tile_rows_height_minus1 is 5, it is found that the number of basic block rows of each of the bricks of BID=8 and 10 is 6 (=tile_rows_height_minus1+1). In addition, since brick_height_minus1[3] is 1, it is found that the number of basic block rows of each of the bricks of BID=5 to 7 is 2 (=brick_height_minus1[3]+1). Also, since brick_height_minus1[7] is 2, it is found that the number of basic block rows of each of the bricks of BID=11 and 12 is 3 (=brick_height_minus1[7]+1). It is therefore found that the total number of basic block rows of all bricks that form slice 3 is 2+2+2+6+6+3+3=24. Hence, j ranges from 0 to 22.

Slice 4 is formed from the brick of BID=9 and the brick of BID=13. Since tile_rows_height_minus1 is 5, the number of basic block rows of each of the brick of BID=9 and the brick of BID=13 is 6 (=tile_rows_height_minus1+1). It is therefore found that the total number of basic block rows of all bricks that form slice 4 is 6+6=12. Hence, j ranges from 0 to 10.

By this processing, the number of basic block rows in each slice is determined. In this embodiment, since the number of entry_point_offset_minus1 can be derived from another syntax, it is not necessary to encode num_entry_point_offset and include it in the header, unlike the conventional method. Hence, according to this embodiment, it is possible to decrease the data amount of the bitstream.

In step **S310**, the control unit **199** determines whether encoding of all basic blocks in the input image is completed. As the result of this determination, if encoding of all basic blocks in the input image is completed, the process advances to step **S311**. On the other hand, if a basic block that has not been encoded yet remains in the input image, the process returns to step **S303** to perform the subsequent for the unencoded basic block.

In step **S311**, the in-loop filter unit **109** performs in-loop filter processing for the reproduced image generated in step **S306**, and outputs the image that has undergone the in-loop filter processing.

As described above, according to this embodiment, it is not necessary to encode information representing how many pieces of information representing the start positions of coded data of basic block rows included in a brick are encoded and include the information in a bitstream, and a bitstream capable of deriving the information can be generated.

Second Embodiment

In this embodiment, an image decoding apparatus for decoding a bitstream generated by the image encoding apparatus according to the first embodiment will be described. Note that conditions common to the first embodiment, such as the configuration of a bitstream, are the same as described in the first embodiment, and a description thereof will be omitted.

An example of the functional configuration of the image decoding apparatus according to this embodiment will be described with reference to the block diagram of FIG. **2**. A separation decoding unit **202** acquires a bitstream generated by the image encoding apparatus according to the first embodiment. The bitstream acquisition method is not limited to a specific acquisition method. For example, a bitstream may be acquired directly or indirectly from the image encoding apparatus via a network such as a LAN or the Internet, or a bitstream stored inside or outside the image decoding apparatus may be acquired. The separation decoding unit **202** then separates coded data concerning information and coefficients concerning decoding processing from the acquired bitstream and sends these to a decoding unit **203**. Also, the separation decoding unit **202** decodes the coded data of the header of the bitstream. In this embodiment, division information is generated by decoding header information concerning image division, such as the sizes of tiles, bricks, slices, and basic blocks, and the generated division information is output to an image reproduction unit **205**. That is, the separation decoding unit **202** performs an operation reverse to that of the integration encoding unit **111** shown in FIG. **1**.

The decoding unit **203** decodes the coded data output from the separation decoding unit **202**, thereby reproducing quantization coefficients and prediction information. An inverse quantization/inverse transformation unit **204** inversely quantizes the quantization coefficients to generate transformation coefficients, and inversely orthogonally transforms the generated transformation coefficients to reproduce prediction errors.

A frame memory **206** is a memory configured to store the image data of a reproduced picture. The image reproduction unit **205** generates a predicted image by appropriately referring to the frame memory **206** based on the input prediction information. The image reproduction unit **205** then generates a reproduced image from the generated predicted image and the prediction errors reproduced by the inverse quantization/inverse transformation unit **204**. For the reproduced image, the image reproduction unit **205** specifies the positions of tiles, bricks, and slices in the input image based on the division information input from the separation decoding unit **202**, and outputs the positions.

An in-loop filter unit **207** performs in-loop filter processing such as deblocking filter processing for the reproduced image, and outputs the image that has undergone the in-loop filter processing, like the above-described in-loop filter unit **109**. A control unit **299** controls the operation of the entire image decoding apparatus, and controls the operations of the above-described functional units of the image decoding apparatus.

Decoding processing of a bitstream by the image decoding apparatus having the configuration shown in FIG. **2** will be described next. A description will be made below assuming that a bitstream is input to the image decoding apparatus on a frame basis. However, a bitstream of a still image corresponding to one frame may be input to the image decoding apparatus. Also, in this embodiment, to facilitate the description, only intra-prediction decoding processing will be described. However, the embodiment is not limited to this, and can also be applied to inter-prediction decoding processing.

The separation decoding unit **202** separates coded data concerning information and coefficients concerning decoding processing from an input bitstream and sends these to the decoding unit **203**. Also, the separation decoding unit **202** decodes the coded data of the header of the bitstream. More specifically, the separation decoding unit **202** decodes basic block data division information, tile data division information, brick data division information, slice data division information 0, basic block row data synchronization information, basic block row data position information, and the like in FIG. **6**, thereby generating division information. The separation decoding unit **202** then outputs the generated division information to the image reproduction unit **205**. Also, the separation decoding unit **202** reproduces the coded data of each basic block of picture data and outputs it to the decoding unit **203**.

The decoding unit **203** decodes the coded data output from the separation decoding unit **202**, thereby reproducing quantization coefficients and prediction information. The reproduced quantization coefficients are output to the inverse quantization/inverse transformation unit **204**, and the reproduced prediction information is output to the image reproduction unit **205**.

The inverse quantization/inverse transformation unit **204** inversely quantizes the input quantization coefficients to generate transformation coefficients, and inversely orthogonally transforms the generated transformation coefficients to reproduce prediction errors. The reproduced prediction errors are output to the image reproduction unit **205**.

The image reproduction unit **205** generates a predicted image by appropriately referring to the frame memory **206** based on the prediction information input from the separation decoding unit **202**. The image reproduction unit **205** then generates a reproduced image from the generated predicted image and the prediction errors reproduced by the inverse quantization/inverse transformation unit **204**. For the reproduced image, the image reproduction unit **205** specifies the shapes of tiles, bricks, and slices as shown in, for example, FIG. **7** and their positions in the input image based on the division information input from the separation decoding unit **202**, and outputs (stores) these to (in) the frame memory **206**. The images stored in the frame memory **206** are used when referred to at the time of prediction.

The in-loop filter unit **207** performs in-loop filter processing such as deblocking filter processing for the reproduced image read out from the frame memory **206**, and outputs (stores) the image that has undergone the in-loop filter processing to (in) the frame memory **206**.

The control unit **299** outputs the reproduced image stored in the frame memory **206**. The output destination of the reproduced image is not limited to a specific output destination. For example, the control unit **299** may output the reproduced image to a display device provided in the image decoding apparatus and cause the display device to display the reproduced image. Also, for example, the control unit **299** may transmit the reproduced image to an external apparatus via a network such as a LAN or the Internet.

Decoding processing of a bitstream (decoding processing of a bitstream having the configuration shown in FIG. **6**) by the image decoding apparatus according to this embodiment will be described next with reference to the flowchart of FIG. **4**.

In step S**401**, the separation decoding unit **202** separates coded data concerning information and coefficients concerning decoding processing from an input bitstream and sends these to the decoding unit **203**. Also, the separation decoding unit **202** decodes the coded data of the header of the bitstream. More specifically, the separation decoding unit **202** decodes basic block data division information, tile data division information, brick data division information, slice data division information, basic block row data synchronization information, basic block row data position information, and the like in FIG. **6**, thereby generating division information. Then, the separation decoding unit **202** outputs the generated division information to the image reproduction unit **205**. In addition, the separation decoding unit **202** reproduces the coded data of each basic block of picture data and outputs it to the decoding unit **203**.

In this embodiment, the division of the input image that is the encoding source of the bitstream is the division shown in FIGS. **8**A and **8**B. Information concerning the input image that is the encoding source of the bitstream and its division can be derived from the division information.

From pic_width_in_luma_samples included in image size information, it is possible to specify that the size (horizontal size) of the input image in the horizontal direction is 1,152 pixels. Also, from pic_height_in_luma_samples included in image size information, it is possible to specify that the size (vertical size) of the input image in the vertical direction is 1,152 pixels.

Also, since log 2_ctu_size_minus2=4 in the basic block data division information, the size of a basic block can be derived as 64×64 pixels from 1<<log 2_ctu_size_minus2+2.

Since single_tile_in_pic_flag=0 in the tile data division information, it can be specified that the input image is divided into a plurality of tiles. Since uniform_tile_spacing_flag=1, it can be specified that the tiles (except those at the ends) have the same size.

In addition, since tile_cols_width_minus1=5, and tile_rows_height_minus1=5, it is possible to specify that each tile is formed by 6×6 basic blocks. That is, it is possible to specify that each tile is formed by 384×384 pixels. Since the input image has a size of 1152×1152 pixels, it is found that the input image is divided into three tiles in the horizontal direction and three tiles in the vertical direction, that is, a total of nine tiles and then encoded.

Also, since brick_splitting_present_flag=1 in the brick data division information, it is possible to specify that at least one tile in the input image is divided into a plurality of bricks.

In addition, brick_split_flag[1], brick_split_flag[4], brick_split_flag[5], brick_split_flag[6], and brick_split_flag[8] are 0. It is therefore possible to specify that the tiles corresponding to tile ID=1, 4, 5, 6, and 8 are not divided into bricks. In this embodiment, since the number of basic block rows is 6 in all tiles, it is found that the number of basic block rows of each of the bricks of the tiles corresponding to tile ID=1, 4, 5, 6, and 8 is 6.

On the other hand, brick_split_flag[0], brick_split_flag[2], brick_split_flag[3], and brick_split_flag[7] are 1. It is therefore possible to specify that the tiles corresponding to tile ID=0, 2, 3, and 7 are divided into bricks. In addition, uniform_brick_spacing_flag[0], uniform_brick_spacing_flag[3], and uniform_brick_spacing_flag[7] are all 1. It is therefore possible to specify that each of the tiles corresponding to tile ID=0, 3, and 7 is divided into bricks of the same size.

In addition, both brick_height_minus1[0] and brick_height_minus1[7] are 2. Hence, it is possible to specify that in both the tile corresponding to tile ID=0 and the tile corresponding to tile ID=7, the number of vertical basic blocks of each brick in the tile is 3. It is also possible to specify that in both the tile corresponding to tile ID=0 and the tile corresponding to tile ID=7, the number of bricks in the tile is 2 (=the number of basic block rows in the tile (6)/the number of vertical basic blocks of each brick in the tile (3)".

In addition, brick_height_minus1[3] is 1. It is therefore possible to specify that the number of vertical basic blocks of each brick in the tile corresponding to tile ID=3 is 2. It is also possible to specify that the number of bricks in the tile corresponding to tile ID=3 is 3 (=the number of basic block rows in the tile (6)/the number of vertical basic blocks of each brick in the tile (2)".

As for the tile corresponding to tile ID=2, since num_brick_rows_minus1[2]=1, it is possible to specify that the tile is formed by two bricks. Also, uniform_brick_spacing_flag[2]=0. Hence, it can be specified that a brick whose size is different from the other exists in the tile corresponding to tile ID=2. brick_row_height_minus1[2][0]=1, brick_row_height_minus1[2][1]=3, and the number of vertical basic blocks is 6 in all tiles. It is therefore possible to specify that the tile corresponding to tile ID=2 is formed, sequentially from the upper side, by a brick in which the number of vertical basic blocks is 2 and a brick in which the number of vertical basic blocks is 4. Note that brick_row_height_minus1[2][1]=3 may not be encoded. This is because if the number of bricks in a tile is 2, the height of the second brick can be obtained from the height of the tile and the height of the first brick in the tile (brick_row_height_minus1[2][0]=1).

In addition, since single_brick_per_slice_flag=0 in slice data division information 0, it can be specified that at least one slice is formed by a plurality of bricks. In this embodiment, if uniform_brick_spacing_flag[i]=0, num_brick_rows_minus1 [i] representing (the number of bricks that form the ith tile−1) is included in the brick data division information. However, the present invention is not limited to this.

For example, assume that the number of bricks that form the ith tile is 2 or more when brick_split_flag[i]=1. Then, num_brick_rows_minus2[i] representing (the number of bricks that form the tile−2) may be decoded in place of num_brick_rows_minus1[i]. This can decode the bitstream in which the number of bits of a syntax representing the number of bricks that form the tile is decreased.

Next, the coordinates of the upper left and the lower right boundaries of each brick are obtained. The coordinates are represented by the horizontal position and the vertical position of a basic block while setting the upper left corner of the input image to the origin. For example, the coordinates of the upper left boundary of the basic block that is third from the left and second from the top are (3, 2), and the coordinates of the lower right boundary are (4, 3).

The coordinates of the upper left boundary of the brick of BID=0 in the tile corresponding to tile ID=0 are (0, 0). Since the number of basic block rows of the brick of BID=0 is 3, and the number of horizontal basic blocks is 6 in all tiles, the coordinates of the lower right boundary are (3, 3).

The coordinates of the upper left boundary of the brick of BID=1 in the tile corresponding to tile ID=0 are (0, 3). Since the number of basic block rows of the brick of BID=1 is 3, and the number of horizontal basic blocks is 6 in all tiles, the coordinates of the lower right boundary are (6, 6).

The coordinates of the upper left boundary of the tile corresponding to tile ID=1 (the brick of BID=2) are (6, 0). Since the number of basic block rows of the brick of BID=2 is 6, and the number of horizontal basic blocks is 6 in all tiles, the coordinates of the lower right boundary are (12, 6).

The coordinates of the upper left boundary of the brick of BID=3 in the tile corresponding to tile ID=2 are (12, 0). Since the number of basic block rows of the brick of BID=3 is 2, the coordinates of the lower right boundary are (18, 2).

The coordinates of the upper left boundary of the brick of BID=4 in the tile corresponding to tile ID=2 are (12, 2). Since the number of basic block rows of the brick of BID=4 is 4, the coordinates of the lower right boundary are (18, 6).

The coordinates of the upper left boundary of the brick of BID=5 in the tile corresponding to tile ID=3 are (0, 6). Since the number of basic block rows of the brick of BID=5 is 2, the coordinates of the lower right boundary are (6, 8).

The coordinates of the upper left boundary of the brick of BID=6 in the tile corresponding to tile ID=3 are (0, 8). Since the number of basic block rows of the brick of BID=6 is 2, the coordinates of the lower right boundary are (6, 10).

The coordinates of the upper left boundary of the brick of BID=7 in the tile corresponding to tile ID=3 are (0, 10). Since the number of basic block rows of the brick of BID=7 is 2, the coordinates of the lower right boundary are (6, 12).

The coordinates of the upper left boundary of the tile corresponding to tile ID=4 (the brick of BID=8) are (6, 6). Since the number of basic block rows of the brick of BID=8 is 6, and the number of horizontal basic blocks is 6 in all tiles, the coordinates of the lower right boundary are (12, 12).

The coordinates of the upper left boundary of the tile corresponding to tile ID=5 (the brick of BID=9) are (12, 6). Since the number of basic block rows of the brick of BID=9 is 6, and the number of horizontal basic blocks is 6 in all tiles, the coordinates of the lower right boundary are (18, 12).

The coordinates of the upper left boundary of the tile corresponding to tile ID=6 (the brick of BID=10) are (0, 12). Since the number of basic block rows of the brick of BID=10 is 6, and the number of horizontal basic blocks is 6 in all tiles, the coordinates of the lower right boundary are (6, 18).

The coordinates of the upper left boundary of the brick of BID=11 in the tile corresponding to tile ID=7 are (6, 12). Since the number of basic block rows of the brick of BID=11 is 3, and the number of horizontal basic blocks is 6 in all tiles, the coordinates of the lower right boundary are (12, 15).

The coordinates of the upper left boundary of the brick of BID=12 in the tile corresponding to tile ID=7 are (6, 15). Since the number of basic block rows of the brick of BID=12 is 3, and the number of horizontal basic blocks is 6 in all tiles, the coordinates of the lower right boundary are (12, 18).

The coordinates of the upper left boundary of the tile corresponding to tile ID=8 (the brick of BID=13) are (12, 12). Since the number of basic block rows of the brick of BID=13 is 6, and the number of horizontal basic blocks is 6 in all tiles, the coordinates of the lower right boundary are (18, 18).

Next, bricks included in each slice are specified. Since num_slices_in_pic_minus1=4, it is possible to specify that the number of slices in the input image is 5. In addition, a corresponding brick can be specified from slice_address of a processing target slice. That is, if slice_address is N, it is found that the processing target slice is slice N.

In slice 0, bottom_right_brick_idx_delta[0] is 2. It is therefore possible to specify that bricks included in slice 0 are bricks included in a rectangular region surrounded by the coordinates of the upper left boundary of the brick of BID=0 and the coordinates of the lower right boundary of the brick of BID=2. Since the coordinates of the upper left boundary of the brick of BID=0 are (0, 0), and the coordinates of the lower right boundary of the brick of BID=2 are (12, 6), it can be specified that the bricks included in slice 0 are the bricks of BID=0 to 2.

In slice 1, since top_left_brick_idx[1] is 3, and bottom_right_brick_idx_delta[1] is 0, it can be specified that the brick included in slice 1 is the brick of BID=3.

In slice 2, since top_left_brick_idx[2] is 4, and bottom_right_brick_idx_delta[2] is 0, it can be specified that the brick included in slice 2 is the brick of BID=4.

In slice 3, top_left_brick_idx[3] is 5, and bottom_right_brick_idx_delta[3] is 7. Since the coordinates of the upper left boundary of the brick of BID=5 are (0, 6), and the coordinates of the lower right boundary of the brick of BID=12 are (12, 18), it can be specified that bricks included in the region whose upper left coordinates are (0, 6) and whose lower right coordinates are (12, 18) are included in slice 3. As a result, it is possible to specify that the bricks corresponding to BID=5 to 8 and 10 to 12 are the bricks included in slice 3. The coordinates of the lower right boundary of the brick corresponding to BID=9 are (18, 12), and the coordinates of the lower right boundary of the brick corresponding to BID=13 are (18, 18). Since both bricks fall outside the range of slice 3, it is determined that these do not belong to slice 3.

In slice 4, top_left_brick_idx[4] is 9, and bottom_right_brick_idx_delta[4] is 4. Since the coordinates of the upper left boundary of the brick of BID=9 are (12, 6), and the coordinates of the lower right boundary of the brick of BID=13 are (18, 18), it can be specified that bricks included in the region whose upper left coordinates are (12, 6) and whose lower right coordinates are (18, 18) are included in slice 4. As a result, it is possible to specify that the bricks corresponding to BID=9 and 13 are the bricks included in slice 4. Here, the coordinates of the upper left boundary of the brick corresponding to BID=10 are (0, 12), the coordinates of the upper left boundary of the brick corresponding to BID=11 are (6, 12), and the coordinates of the upper left boundary of the brick corresponding to BID=12 are (6, 15). Since all bricks fall outside the range of slice 4, it is determined that these do not belong to slice 4.

In this embodiment, the bricks included in slice 4 that is the final slice of the input image are specified from top_left_brick_idx[4] and bottom_right_brick_idx_delta[4]. However, the present invention is not limited to this. That the bricks included in slices 0 to 3 are the bricks of BID=0 to 2, BID=3, BID=4, and BID=5 to 8 and 10 to 12 is already derived, and that the input image is formed by the 14 bricks of BID=0 to 13 is already derived. For this reason, it can be specified that the bricks included in the final slice are the remaining bricks of BID=9 and 13. Hence, even if top_left_brick_idx[4] and bottom_right_brick_idx_delta[4] are not encoded, the bricks included in the final slice can be specified. In this way, the bitstream in which the bit amount of the header portion is decreased can be decoded.

In addition, entropy_coding_sync_enabled_flag=1 in the basic block row data synchronization information. Hence, it is found that entry_point_offset_minus1 [j−1] representing (the size of the coded data of the (j−1)th basic block row in the slice−1) is encoded in the bitstream. The number is the number of basic block rows of the slice to be processed−1.

In this embodiment, since the bricks belonging to each slice can be specified, as described above, entry_point_offset_minus1 [j] is encoded as many as the number obtained by subtracting 1 from the sum of the numbers of basic block rows of the bricks belonging to the slice.

In slice 0, the number of basic block rows (3) of the brick corresponding to BID=0+the number of basic block rows (3) of the brick corresponding to BID=1+the number of basic block rows (6) of the brick corresponding to BID=2=sum (3+3+6=12), and the sum (3+3+6=12)-1=11. Hence, for slice 0, 11 entry_point_offset_minus1 [ ] are encoded. In this case, j ranges from 0 to 10.

In slice 1, the number of basic block rows (2) of the brick corresponding to BID=3−1=1. Hence, for slice 1, one entry_point_offset_minus1 [ ] is encoded. In this case, the range of j is only 0.

In slice 2, the number of basic block rows (4) of the brick corresponding to BID=4−1=3. Hence, for slice 2, 3 entry_point_offset_minus1 [ ] are encoded. In this case, j ranges from 0 to 2.

In slice 3, the sum of the numbers of basic block rows of the bricks corresponding to BID=5 to 8 and 10 to 12=(2+2+2+6+6+3+3=24), and the sum (2+2+2+6+6+3+3=24)-1=23. Hence, for slice 3, 23 entry_point_offset_minus1 [ ] are encoded. In this case, j ranges from 0 to 22.

In slice 4, the sum of the number of basic block rows (6) of the brick corresponding to BID=9 and the number of basic block rows (6) of the brick corresponding to BID=13=(6+6=12), and the sum (6+6=12)-1=11. Hence, for slice 4, 11 entry_point_offset_minus1 [ ] are encoded. In this case, j ranges from 0 to 10.

As described above, even if num_entry_point_offset is not encoded as in the conventional method, the number of entry_point_offset_minus1 can be derived from another syntax. Since the start position of the data of each basic block row can be known, decoding processing can be performed in parallel on a basic block row basis. The division information derived by the separation decoding unit **202** is sent to the image reproduction unit **205** and used to specify the position of the processing target in the input image in step S**404**.

In step S**402**, the decoding unit **203** decodes the coded data separated by the separation decoding unit **202**, thereby reproducing quantization coefficients and prediction information. In step S**403**, the inverse quantization/inverse transformation unit **204** inversely quantizes the input quantization coefficients to generate transformation coefficients, and inversely orthogonally transforms the generated transformation coefficients to reproduce prediction errors.

In step S**404**, the image reproduction unit **205** generates a predicted image by appropriately referring to the frame memory **206** based on the prediction information input from the decoding unit **203**. The image reproduction unit **205** then generates a reproduced image from the generated predicted image and the prediction errors reproduced by the inverse quantization/inverse transformation unit **204**. For the reproduced image, the image reproduction unit **205** specifies the positions of tiles, bricks, and slices in the input image based on the division information input from the separation decoding unit **202**, composites these to the positions, and outputs (stores) these to (in) the frame memory **206**.

In step S**405**, the control unit **299** determines whether all basic blocks of the input image are decoded. As the result of this determination, if all basic blocks of the input image are decoded, the process advances to step S**406**. On the other hand, if an undecoded basic block remains in the input image, the process returns to step S**402** to perform decoding processing for the undecoded basic block.

In step S**406**, the in-loop filter unit **207** performs in-loop filter processing for the reproduced image read out from the frame memory **206**, and outputs (stores) the image that has undergone the in-loop filter processing to (in) the frame memory **206**.

As described above, according to this embodiment, it is possible to decode the input image from "the bitstream that does not include information representing how many pieces of information representing the start positions of coded data of basic block rows included in a brick are encoded", which is generated by the image encoding apparatus according to the first embodiment.

Note that the image encoding apparatus according to the first embodiment and the image decoding apparatus according to the second embodiment may be separate apparatuses. The image encoding apparatus according to the first embodiment and the image decoding apparatus according to the second embodiment may be integrated into one apparatus.

Third Embodiment

The functional units shown in FIG. **1** or **2** may be implemented by hardware, and some of these may be implemented by software. In the latter case, the functional units other than the frame memory **108** and the frame memory **206** may be implemented by software (computer program). A computer apparatus capable of executing such a computer program can be applied to the above-described image encoding apparatus or image decoding apparatus.

An example of the hardware configuration of the computer apparatus applicable to the above-described image encoding apparatus or image decoding apparatus will be described with reference to the block diagram of FIG. **5**. Note that the hardware configuration shown in FIG. **5** is merely an example of the hardware configuration of the computer apparatus applicable to the above-described image encoding apparatus or image decoding apparatus, and changes and modification can appropriately be made.

A CPU **501** executes various kinds of processing using computer programs and data stored in a RAM **502** or a ROM **503**. Accordingly, the CPU **501** controls the operation of the entire computer apparatus, and also executes or controls each process described as processing to be performed by the above-described image encoding apparatus or image decoding apparatus. That is, the CPU **501** can function as the functional units (other than the frame memory **108** and the frame memory **206**) shown in FIG. **1** or **2**.

The RAM **502** includes an area configured to store computer programs and data loaded from the ROM **503** or an external storage device **506** and an area configured to store data received from the outside via an I/F **507**. Also, the RAM **502** includes a work area used by the CPU **501** to execute various kinds of processing. The RAM **502** can thus appropriately provide various kinds of areas. The setting data, the activation program, and the like of the computer apparatus are stored in the ROM **503**.

An operation unit **504** is a user interface such as a keyboard, a mouse, or a touch panel screen. When a user operates the operation unit **504**, various kinds of instructions can be input to the CPU **501**.

A display unit **505** is formed by a liquid crystal screen, a touch panel screen, or the like and can display the processing result of the CPU **501** by an image, characters, or the like. Note that the display unit **505** may be a device such as a projector that projects an image or characters.

The external storage device **506** is a mass information storage device such as a hard disk drive. The external storage device **506** stores an OS (Operating System) and computer programs and data used to cause the CPU **501** to execute or control each process described above as processing to be performed by the above-described image encoding apparatus or image decoding apparatus.

The computer programs stored in the external storage device **506** include a computer program configured to cause the CPU **501** to execute or control the functions of the functional units other than the frame memory **108** and the frame memory **206** in FIG. **1** or **2**. In addition, the data stored in the external storage device **506** include information described as known information in the above description and various kinds of information associated with encoding and decoding.

The computer programs and data stored in the external storage device **506** are appropriately loaded into the RAM **502** under the control of the CPU **501** and processed by the CPU **501**.

The frame memory **108** provided in the image encoding apparatus shown in FIG. **1** or the frame memory **206** provided in the image decoding apparatus shown in FIG. **2** can be implemented using a memory device such as the above-described RAM **502** or external storage device **506**.

The I/F **507** is an interface configured to perform data communication with an external apparatus. For example, if the computer apparatus is applied to the image encoding apparatus, the image encoding apparatus can output a generated bitstream to the outside via the I/F **507**. In addition, if the computer apparatus is applied to the image decoding apparatus, the image decoding apparatus can receive a bitstream via the I/F **507**. Also, the image decoding apparatus can transmit the result of decoding the bitstream to the outside via the I/F **507**. All the CPU **501**, the RAM **502**, the ROM **503**, the operation unit **504**, the display unit **505**, the external storage device **506**, and the I/F **507** are connected to a bus **508**.

Note that the detailed numerical values used in the above description are merely used to make a detailed description and are not intended to limit the above-described embodiments to these numerical values. Some or all of the above-

described embodiments may appropriately be combined. Some or all of the above-described embodiments may selectively be used.

According to the configuration of the present invention, it is possible to decrease the code amount of a bitstream by decreasing redundant syntaxes.

Other Embodiments

Embodiment(s) of the present invention can also be realized by a computer of a system or apparatus that reads out and executes computer executable instructions (e.g., one or more programs) recorded on a storage medium (which may also be referred to more fully as a 'non-transitory computer-readable storage medium') to perform the functions of one or more of the above-described embodiment(s) and/or that includes one or more circuits (e.g., application specific integrated circuit (ASIC)) for performing the functions of one or more of the above-described embodiment(s), and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiment(s) and/or controlling the one or more circuits to perform the functions of one or more of the above-described embodiment(s). The computer may comprise one or more processors (e.g., central processing unit (CPU), micro processing unit (MPU)) and may include a network of separate computers or separate processors to read out and execute the computer executable instructions. The computer executable instructions may be provided to the computer, for example, from a network or the storage medium. The storage medium may include, for example, one or more of a hard disk, a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)™), a flash memory device, a memory card, and the like.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

The invention claimed is:

1. An image encoding apparatus for encoding an image including a rectangular region including at least one block row formed from a plurality of blocks, comprising:

an encoding unit configured to encode, into a bitstream, a first flag related to enablement of parallel processing, first information used for identifying a rectangular region to be processed first among a plurality of rectangular regions included in a target slice which is a slice in the image, second information used for identifying a rectangular region to be processed last among the plurality of rectangular regions, and third information corresponding to the number of blocks, in a vertical direction, of the rectangular region in the image; and

an identifying unit configured to identify, for the target slice, the number of syntax elements each of which is used to identify a start position of coded data of a block row, based on the first information, the second information, and the third information, in a state where a value of the first flag is 1, a second flag, which is in a picture parameter set of the bitstream and is related to a mode of a slice, indicates that a mode in which a slice is rectangular is used, and the target slice in the image includes a plurality of rectangular regions in a horizontal direction or a vertical direction,

wherein fourth information for determining a size of each of blocks forming the block row is encoded into a sequence parameter set of the bitstream, and the syntax elements, the number of which is the number identified by the identifying unit, are included in a slice header of the bitstream, and

wherein fifth information corresponding to a width of the image is encoded into the bitstream.

2. An image decoding apparatus for decoding an image from a bitstream obtained by encoding an image including a rectangular region including at least one block row formed from a plurality of blocks, comprising:

a decoding unit configured to decode, from the bitstream, a first flag related to enablement of parallel processing, first information used for identifying a rectangular region to be processed first among a plurality of rectangular regions included in a target slice which is a slice in the image, second information used for identifying a rectangular region to be processed last among the plurality of rectangular regions, and third information corresponding to the number of blocks, in a vertical direction, of the rectangular region in the image; and

an identifying unit configured to identify, for the target slice, the number of syntax elements each of which is used to identify a start position of coded data of a block row, based on the first information, the second information, and the third information, in a state where a value of the first flag is 1, a second flag, which is decoded from a picture parameter set of the bitstream and is related to a mode of a slice, indicates that a mode in which a slice is rectangular is used, and the target slice in the image includes a plurality of rectangular regions in a horizontal direction or a vertical direction,

wherein a size of each of blocks forming the block row is determined from fourth information decoded from a sequence parameter set of the bitstream, and the syntax elements, the number of which is the number identified by the identifying unit, are included in a slice header of the bitstream, and

wherein fifth information corresponding to a width of the image is decoded from the bitstream.

3. The image decoding apparatus according to claim **2**, wherein the first flag is an entropy coding sync enabled flag, and the second flag is a rect slice flag.

4. The image decoding apparatus according to claim **2**, wherein when the value of the first flag is 1, parallel processing of entropy decoding on a basic block row basis is available.

5. An image encoding method for encoding an image including a rectangular region including at least one block row formed from a plurality of blocks, comprising:

encoding, into a bitstream, a first flag related to enablement of parallel processing, first information used for identifying a rectangular region to be processed first among a plurality of rectangular regions included in a target slice which is a slice in the image, second information used for identifying a rectangular region to be processed last among the plurality of rectangular regions, and third information corresponding to the number of blocks, in a vertical direction, of the rectangular region in the image; and

identifying, for the target slice, the number of syntax elements each of which is used to identify a start position of coded data of a block row, based on the first information, the second information, and the third information, in a state where a value of the first flag is 1, a second flag, which is in a picture parameter set of the bitstream and is related to a mode of a slice, indicates that a mode in which a slice is rectangular is used, and the target slice in the image includes a plurality of rectangular regions in a horizontal direction or a vertical direction,

wherein fourth information for determining a size of each of blocks forming the block row is encoded into a sequence parameter set of the bitstream, and the syntax elements, the number of which is the identified number, are included in a slice header of the bitstream, and

wherein fifth information corresponding to a width of the image is encoded into the bitstream.

6. An image decoding method for decoding an image from a bitstream obtained by encoding an image including a rectangular region including at least one block row formed from a plurality of blocks, comprising:

decoding, from the bitstream, a first flag related to enablement of parallel processing, first information used for identifying a rectangular region to be processed first among a plurality of rectangular regions included in a target slice which is a slice in the image, second information used for identifying a rectangular region to be processed last among the plurality of rectangular regions, and third information corresponding to the number of blocks, in a vertical direction, of the rectangular region in the image; and

identifying, for the target slice, the number of syntax elements each of which is used to identify a start position of coded data of a block row, based on the first information, the second information, and the third information, in a state where a value of the first flag is 1, a second flag, which is decoded from a picture parameter set of the bitstream and is related to a mode of a slice, indicates that a mode in which a slice is rectangular is used, and the target slice in the image includes a plurality of rectangular regions in a horizontal direction or a vertical direction,

wherein a size of each of blocks forming the block row is determined from fourth information decoded from a sequence parameter set of the bitstream, and the syntax elements, the number of which is the identified number, are included in a slice header of the bitstream, and

wherein fifth information corresponding to a width of the image is decoded from the bitstream.

7. The image decoding apparatus according to claim **2**, wherein each of the syntax elements is used to identify a start position of coded data of a block row which is formed from a plurality of blocks and which is included in a rectangular region in the target slice.

8. The image decoding apparatus according to claim **2**, wherein information of the number of syntax elements is not signaled in the bitstream.

9. The image decoding apparatus according to claim **2**, wherein the rectangular region to be processed first among the plurality of rectangular regions included in the target slice is a rectangular region at the top-left corner among the plurality of rectangular regions, and the rectangular region to be processed last among the plurality of rectangular regions is a rectangular region at the bottom-right corner among the plurality of rectangular regions.

10. The image decoding apparatus according to claim **2**, wherein each of the blocks forming the block row corresponds to a CTU (Coding Tree Unit) and can be divided into smaller blocks.

11. The image decoding apparatus according to claim **2**, wherein the size of each block is determined by performing arithmetic left shift of 1 by a result of summing a predetermined value and a value of the fourth information.

12. The image decoding apparatus according to claim **2**, wherein the decoding unit decodes the coded data of the block row based on at least the number identified by the identifying unit and the syntax element for identifying the start position.

13. The image decoding method according to claim **6**, wherein each of the syntax elements is used to identify a start position of coded data of a block row which is formed from a plurality of blocks and which is included in a rectangular region in the target slice.

14. The image decoding method according to claim **6**, wherein information of the number of syntax elements is not signaled in the bitstream.

15. The image decoding method according to claim **6**, wherein the rectangular region to be processed first among the plurality of rectangular regions included in the target slice is a rectangular region at the top-left corner among the plurality of rectangular regions, and the rectangular region to be processed last among the plurality of rectangular regions is a rectangular region at the bottom-right corner among the plurality of rectangular regions.

16. The image decoding method according to claim **6**, wherein each of the blocks forming the block row corresponds to a CTU (Coding Tree Unit) and can be divided into smaller blocks.

17. The image decoding method according to claim **6**, wherein the size of each block is determined by performing arithmetic left shift of 1 by a result of summing a predetermined value and a value of the fourth information.

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