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(54) ENCODING DEVICE, DECODING DEVICE AND PROGRAM THAT ENCODE OR DECODE EACH TARGET BLOCK BY DIVIDING AN IMAGE THAT INCLUDES THREE OR MORE COMPONENTS

(71) Applicant: **NIPPON HOSO KYOKAI**, Tokyo (JP)

(72) Inventors: **Shunsuke IWAMURA**, Tokyo (JP); **Shimpei NEMOTO**, Tokyo (JP); **Atsuro ICHIGAYA**, Tokyo (JP)

(73) Assignee: **NIPPON HOSO KYOKAI**, Tokyo (JP)

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(57) **ABSTRACT**

An encoding device encodes each encoding-target block. The encoding device includes: a predictor configured to generate, for each of the components, a prediction block corresponding to the encoding-target block; a residual generator configured to generate, for each of the components, a prediction residual that represents a difference between the encoding-target block and the prediction block; a color space transformer configured to perform a color space transform process on the prediction residual of each of the components; a transformer configured to generate transform coefficients by performing a transform process on the prediction residual; a quantization controller configured to determine a scaling list to be used in a quantization process on the transform coefficients; and a quantizer configured to perform the quantization process on the transform coefficients by using the determined scaling list, wherein the quantization controller is configured to determine the scaling list, based on the color space transform process.

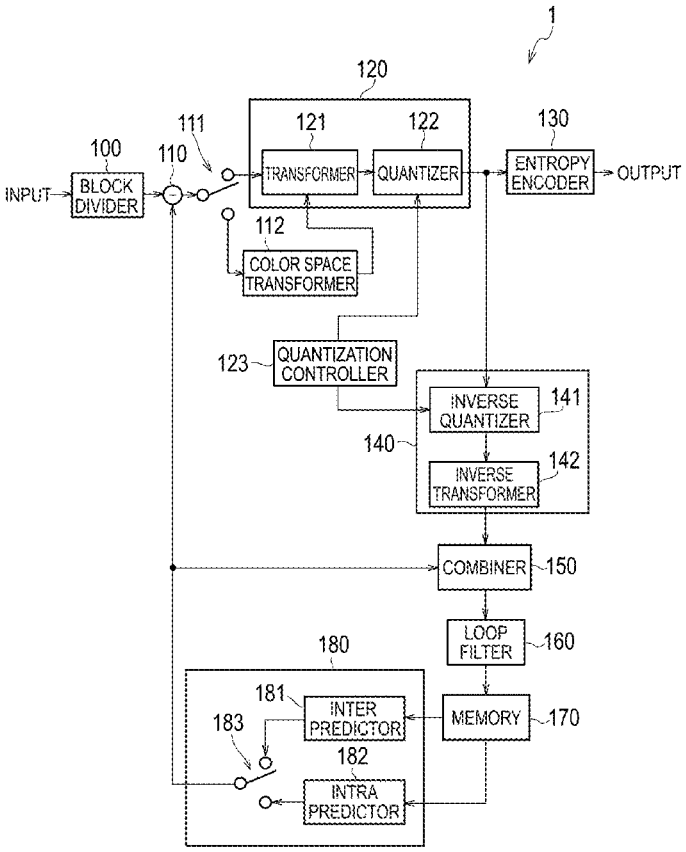


FIG. 1

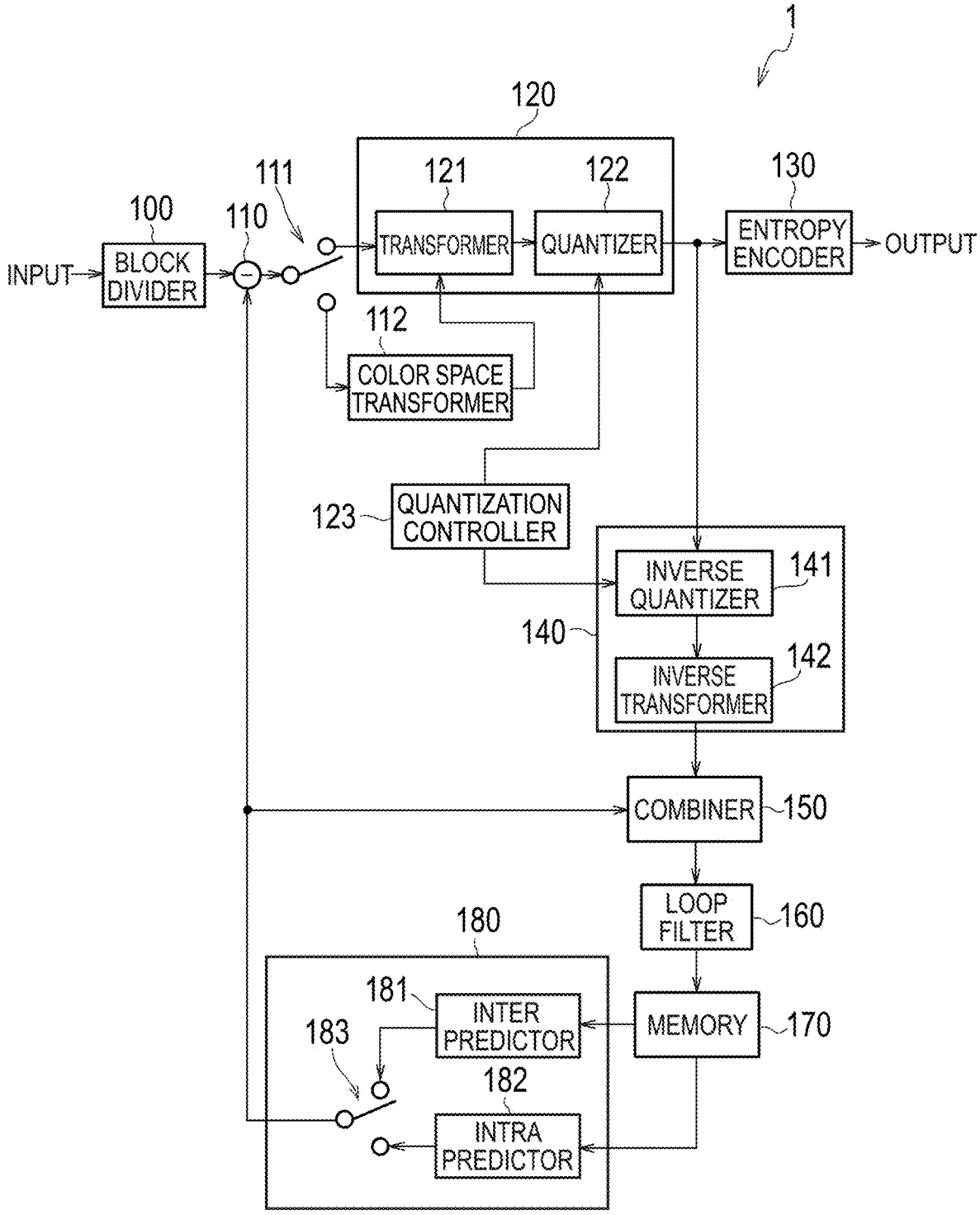

1
120
111
121
122
130
100
110
TRANSFORMER
QUANTIZER
ENTROPY ENCODER
INPUT
BLOCK DIVIDER
OUTPUT
112
COLOR SPACE TRANSFORMER
123
QUANTIZATION CONTROLLER
INVERSE QUANTIZER
141
140
INVERSE TRANSFORMER
142
COMBINER
150
LOOP FILTER
160
180
181
INTER PREDICTOR
MEMORY
170
183
182
INTRA PREDICTOR

FIG. 2

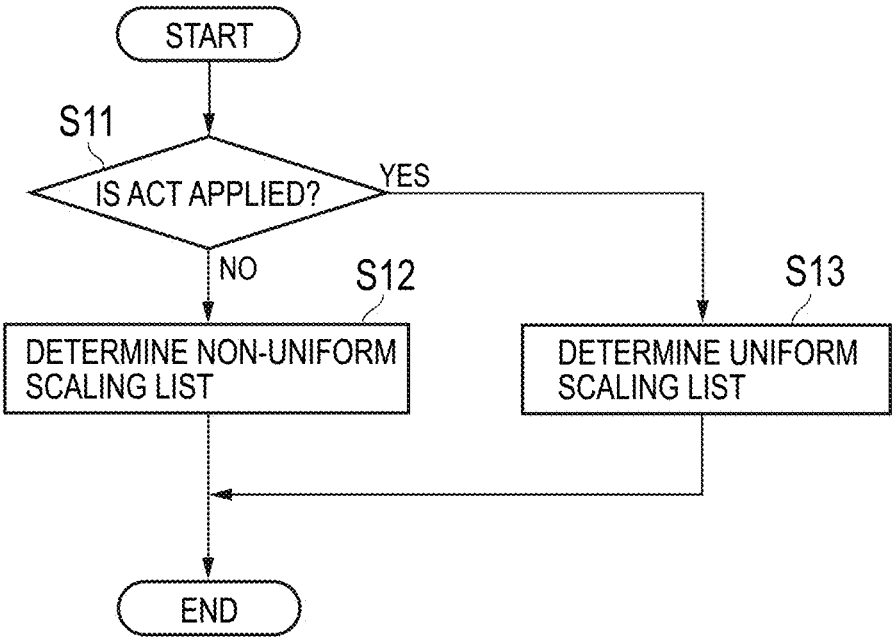

START
S11
IS ACT APPLIED?
YES
NO
S12
S13
DETERMINE NON-UNIFORM SCALING LIST
DETERMINE UNIFORM SCALING LIST
END

FIG. 3

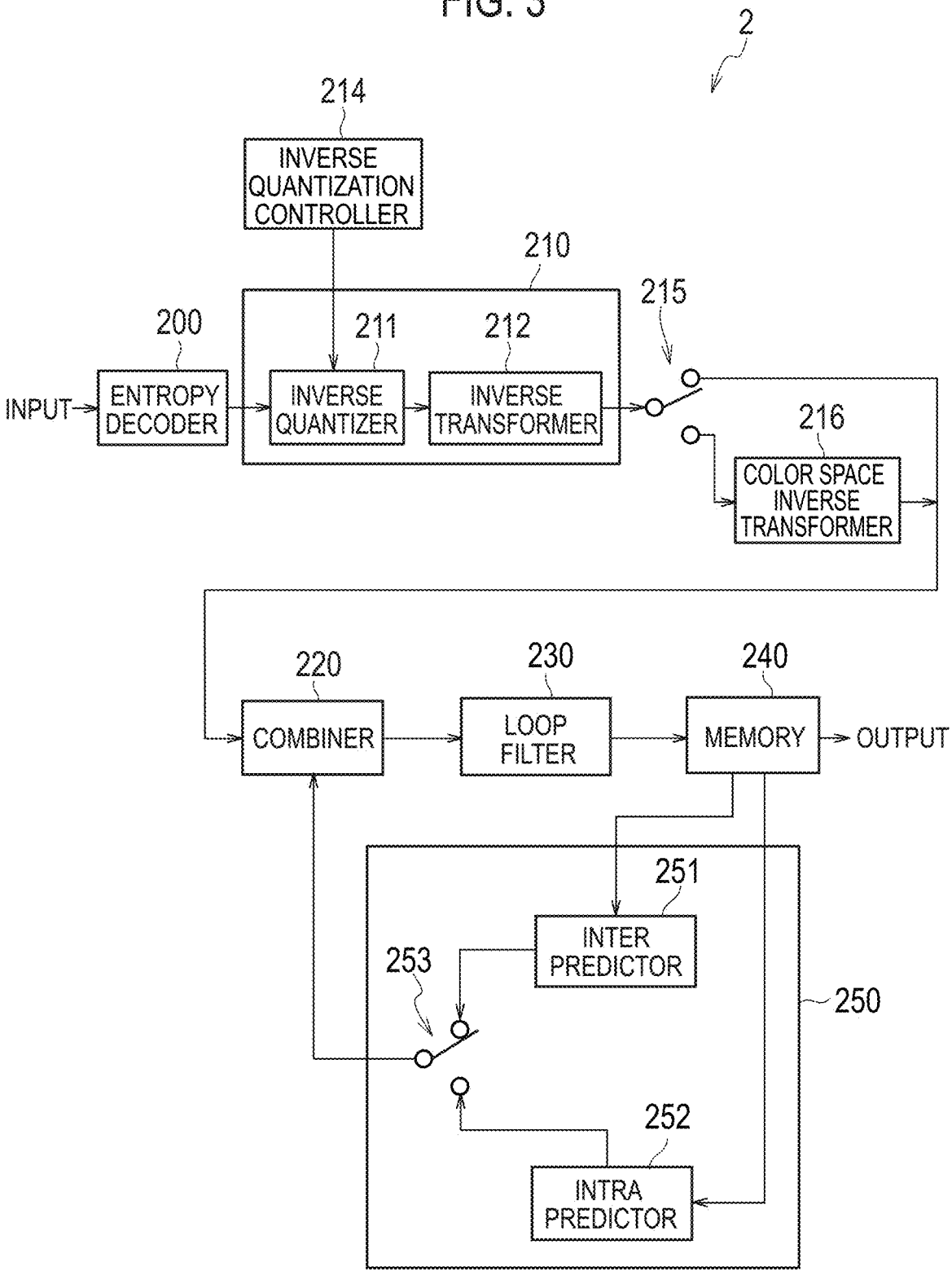
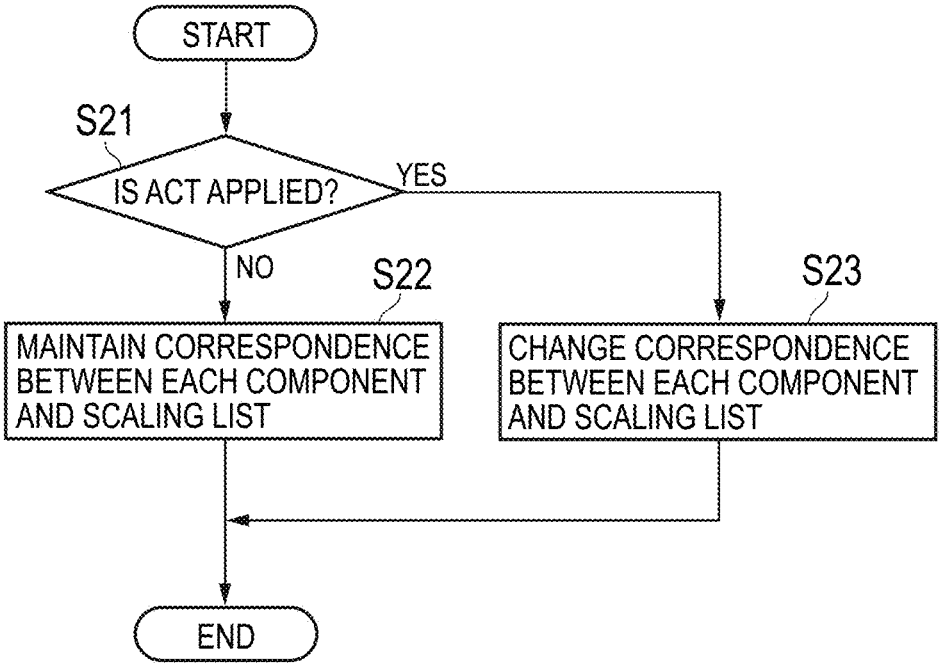

2
214
INVERSE QUANTIZATION CONTROLLER
210
215
200
211
212
INPUT
ENTROPY DECODER
INVERSE QUANTIZER
INVERSE TRANSFORMER
216
COLOR SPACE INVERSE TRANSFORMER
220
230
240
COMBINER
LOOP FILTER
MEMORY
OUTPUT
251
INTER PREDICTOR
253
250
252
INTRA PREDICTOR

FIG. 4


START
S21
IS ACT APPLIED?
YES
NO
S22
S23
MAINTAIN CORRESPONDENCE BETWEEN EACH COMPONENT AND SCALING LIST
CHANGE CORRESPONDENCE BETWEEN EACH COMPONENT AND SCALING LIST
END

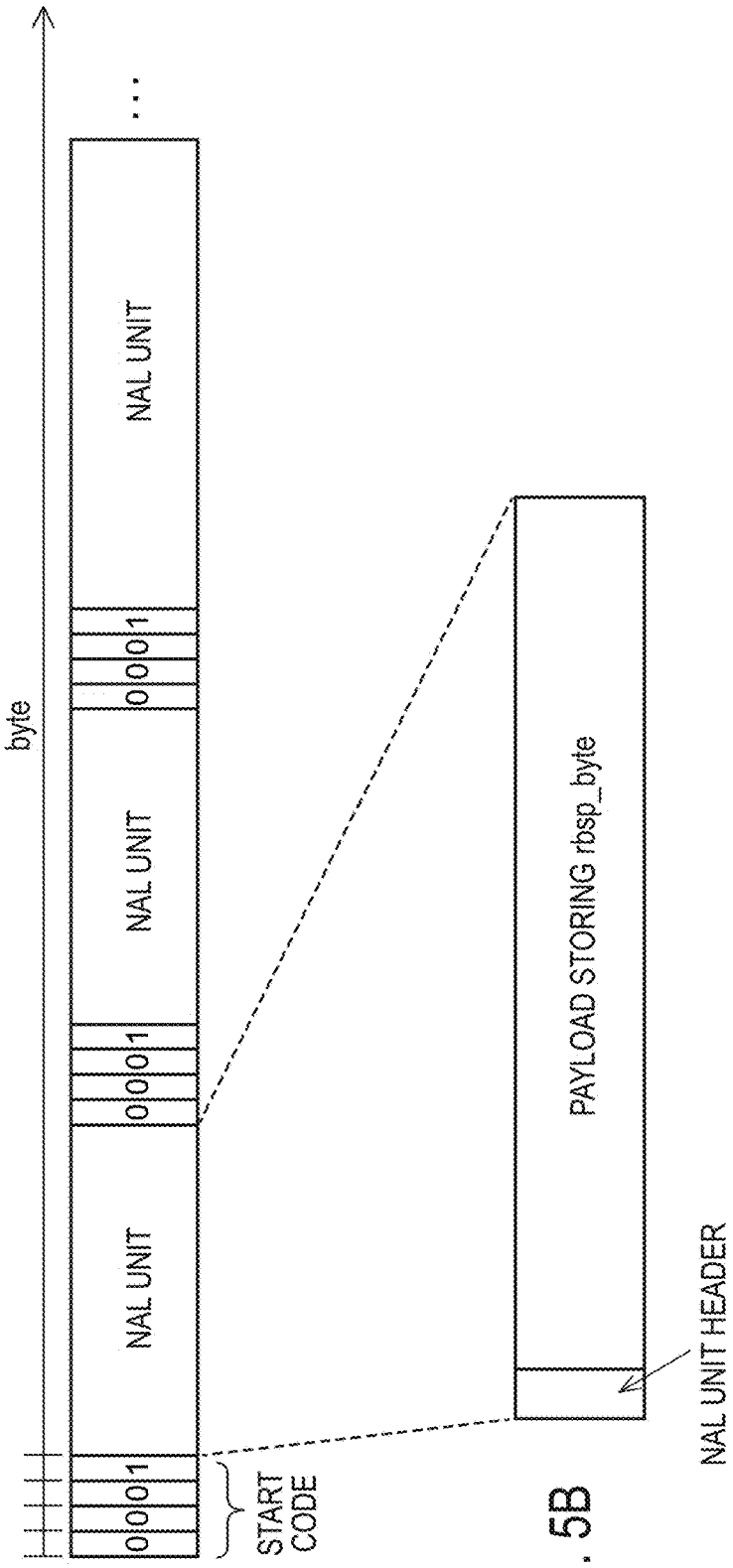

byte
NAL UNIT
NAL UNIT
NAL UNIT
0 0 0 1
START CODE
PAYLOAD STORING rbsp_byte
NAL UNIT HEADER

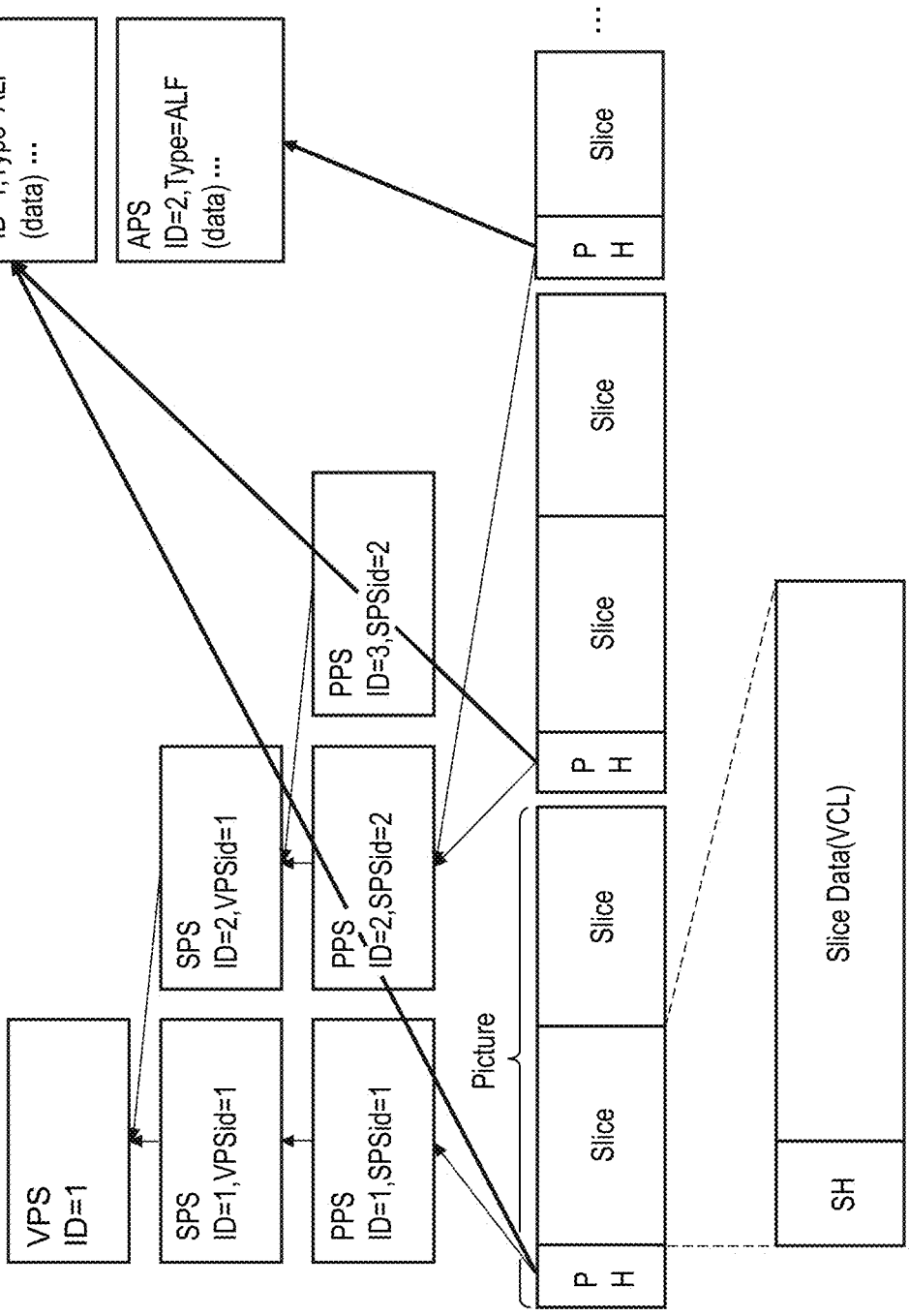
FIG. 5A

FIG. 5B

FIG. 6

nal_unit_type	Name of nal_unit_type	Content of NAL unit and RBSP syntax structure	NAL unit type class
0	TRAIL_NUT	Coded slice of a trailing picture slice_layer_rbsp()	VCL
1	STSA_NUT	Coded slice of an STSA picture slice_layer_rbsp()	VCL
2	RADL_NUT	Coded slice of a RADL picture slice_layer_rbsp()	VCL
3	RASL_NUT	Coded slice of a RASL picture slice_layer_rbsp()	VCL
4..6	RSV_VCL_4.. RSV_VCL_6	Reserved non-IRAP VCL NAL unit types	VCL
7 8	IDR_W_RADL IDR_N_LP	Coded slice of an IDR picture slice_layer_rbsp( )	VCL
9	CRA_NUT	Coded slice of a CRA picture slice_layer_rbsp( )	VCL
10	GDR_NUT	Coded slice of a GDR picture slice_layer_rbsp( )	VCL
11 12	RSV_IRAP_11 RSV_IRAP_12	Reserved IRAP VCL NAL unit types	VCL
13	DCI_NUT	Decoding capability information decoding_capability_infomation_rbsp( )	non-VCL
14	VPS_NUT	Video parameter set video_parameter_set _rbsp( )	non-VCL
15	SPS_NUT	Sequence parameter set seq_parameter_set_rbsp( )	non-VCL
16	PPS_NUT	Picture parameter set pic_parameter_set_rbsp( )	non-VCL
17 18	PREFIX_APS_NUT SUFFIX_APS_NUT	Adaptation parameter set adaptation_parameter_set_rbsp( )	non-VCL
19	PH_NUT	Picture header picture_header_rbsp( )	non-VCL
20	AUD_NUT	AU delimiter access_unit_delimiter_rbsp( )	non-VCL
21	EOS_NUT	End of sequence end_of_seq_rbsp( )	non-VCL
22	EOB_NUT	End of bitstream end_of_bitstream_rbsp( )	non-VCL
23 24	PREFIX_SEI_NUT SUFFIX_SEI_NUT	Supplemental enhancement infomation sei_rbsp( )	non-VCL
25	FD_NUT	Filler data filler_data_rbsp( )	non-VCL
26 27	RSV_NVCL_26 RSV_NVCL_27	Reserved non-VCL NAL unit types	non-VCL
28..31	UNSPEC_28.. UNSPEC_31	Unspecified non-VCL NAL unit types	non-VCL

FIG. 7


VPS
ID=1
SPS
ID=1,VPSid=1
PPS
ID=1,SPSid=1
SPS
ID=2,VPSid=1
PPS
ID=2,SPSid=2
PPS
ID=3,SPSid=2
APS
ID=1,Type=ALF
(data) ...
APS
ID=2,Type=ALF
(data) ...
Picture
P H
Slice
P H
Slice
P H
Slice
...
SH
Slice Data(VCL)

ENCODING DEVICE, DECODING DEVICE AND PROGRAM THAT ENCODE OR DECODE EACH TARGET BLOCK BY DIVIDING AN IMAGE THAT INCLUDES THREE OR MORE COMPONENTS

RELATED APPLICATIONS

[0001] The present application is a continuation of U.S. patent application Ser. No. 17/938,633, filed on Oct. 6, 2022, which is a continuation application of U.S. patent application Ser. No. 17/655,931, filed on Mar. 22, 2022, which is a continuation based on PCT Application No. PCT/JP2021/014872, filed on Apr. 8, 2021, which claims the benefit of Japanese Patent Application No. 2020-070106 filed on Apr. 8, 2020. The content of which is incorporated by reference herein in their entirety.

TECHNICAL FIELD

[0002] The present invention relates to an encoding device, a decoding device, and a program.

BACKGROUND ART

[0003] In a VVC specification draft, a technique called adaptive color transform (ACT) is adopted. In the technique, when the chroma format of an input video is 4:4:4, after acquisition of prediction residuals, which are differences between an encoding-target block obtained by dividing an original image and a prediction block obtained by predicting the encoding-target block, a color space (RGB space) of the prediction residuals is transformed into a YCgCo space, and encoding processes including a transform process, an entropy encoding process, and the like are performed on the prediction residuals after the color space transformation (see Non Patent Literature 1).

[0004] An encoding device can control, for each encoding-target block, whether or not ACT is applied, and outputs an ACT application flag for each encoding-target block in a stream. Accordingly, due to ACT, encoding-target blocks for which the transform process and the quantization process are applied to prediction residuals in the RGB space, and encoding-target blocks for which the transform process and the quantization process are applied after prediction residuals are transformed from the RGB space into the YCgCo space coexist in an entire image (picture).

[0005] Incidentally, VVC introduces a scaling list (also referred to as quantization matrix) that controls a quantization step for each frequency component, in quantization of transform coefficients obtained by performing the transform process on prediction residuals. A scaling list can be individually set for each of three color components (for example, luminance component, first chrominance component, and second chrominance component) included in an input video signal, and the encoding device signals, to the decoding side, information indicating whether or not a scaling list is applied and, when a scaling list is applied, what scaling list is applied.

CITATION LIST

Non Patent Literature

[0006] Non Patent Literature 1: JVET-Q2001 "Versatile Video Coding (Draft 8)"

DISCLOSURE OF INVENTION

[0007] An encoding device according to a first feature encodes each encoding-target block generated by dividing an image that includes three or more components including a first component, a second component, and a third component. The encoding device includes: a predictor configured to generate, for each of the components, a prediction block corresponding to the encoding-target block; a residual generator configured to generate, for each of the components, a prediction residual that represents a difference between the encoding-target block and the prediction block; a color space transformer configured to perform a color space transform process on the prediction residual of each of the components; a transformer configured to generate transform coefficients by performing a transform process on the prediction residual; a quantization controller configured to determine a scaling list to be used in a quantization process on the transform coefficients; and a quantizer configured to perform the quantization process on the transform coefficients by using the determined scaling list, wherein the quantization controller is configured to determine the scaling list, based on the color space transform process.

[0008] A decoding device according to a second feature decodes each decoding-target block generated by dividing an image that includes three or more components including a first component, a second component, and a third component. The decoding device includes: an entropy decoder configured to decode, for each of the components, quantized transform coefficients in the decoding-target block from a bit stream; a predictor configured to generate, for each of the components, a prediction block corresponding to the decoding-target block; an inverse quantization controller configured to determine a scaling list to be used in an inverse transform process for transform coefficients; an inverse quantizer configured to generate the transform coefficients by performing the inverse quantization process on the quantized transform coefficients; an inverse transformer configured to generate a prediction residual by performing the inverse transform process on the transform coefficients by using the determined scaling list; a color space inverse transformer configured to perform a color space inverse transform process on the prediction residual; and a combiner configured to generate a decoded block by combining the prediction residual and the prediction block, wherein the inverse quantization controller is configured to determine the scaling list, based on the color space inverse transform process.

[0009] A program according to a third feature causes a computer to function as the encoding device according to the first feature.

[0010] A program according to a fourth feature causes a computer to function as the decoding device according to the second feature.

BRIEF DESCRIPTION OF DRAWINGS

[0011] FIG. **1** is a diagram illustrating the configuration of an encoding device according to an embodiment.

[0012] FIG. **2** is a diagram illustrating operation of a quantization controller and an inverse quantization controller according to the embodiment.

[0013] FIG. **3** is a diagram illustrating a configuration of a decoding device according to the embodiment.

[0014] FIG. **4** is a diagram illustrating operation of the quantization controller and the inverse quantization controller according to a modification.

[0015] FIG. **5**A is a diagram illustrating a bit stream outputted by an entropy encoder.

[0016] FIG. **5**B is a diagram illustrating a bit stream outputted by an entropy encoder.

[0017] FIG. **6** is a diagram illustrating types of NAL unit.

[0018] FIG. **7** is a diagram illustrating relations among VPS, SPS, PPS, and APS.

DESCRIPTION OF EMBODIMENTS

[0019] With ACT, it is possible to control, for each encoding-target block, whether or not color space transformation of prediction residuals is performed. Accordingly, when an input video that is an RGB video is encoded, one of two adjacent encoding-target blocks can be an encoding-target block to which ACT is applied, and the other can be an encoding-target block to which ACT is not applied.

[0020] As indicated in Table 1, with respect to an encoding-target block to which ACT is applied, after prediction residuals are transformed from the RGB space into the YCgCo space, a first scaling list is applied to prediction residuals of Y component, a second scaling list is applied to prediction residuals of Cg component, and a third scaling list is applied to prediction residuals of Co component. On the other hand, with respect to an encoding-target block to which ACT is not applied, prediction residuals remain in the RGB space, and the first scaling list is applied to prediction residuals of R component, the second scaling list is applied to prediction residuals of G component, and the third scaling list is applied to prediction residuals of B component.

TABLE 1

	RGB space (ACT not applied)	YCgCo space (ACT applied)	Scaling list
First component	R component	Y component	First scaling list
Second component	G component	Cg component	Second scaling list
Third component	B component	Co component	Third scaling list

[0021] In general, it is known that many of luminance components in the RGB space are concentrated in the G component, and scaling lists used for a video in the RGB space are designed on the premise that a luminance signal is included mainly in the G component. Since it is known that a luminance signal includes many higher frequency components compared to a chrominance signal, a scaling list designed such as to be applied to a luminance signal is likely to differ in nature from a scaling list designed such as to be applied to a chrominance signal.

[0022] However, as a result of ACT being applied to prediction residuals, the first scaling list designed for the R component that does not include much of a luminance signal is applied to the Y component after ACT-based transformation. Accordingly, the scaling list that is originally designed for a component with different nature is applied, so that visual deterioration may be caused.

[0023] Hence, an object of the present disclosure is to restrain deterioration in image quality also when ACT is applied.

[0024] An encoding device and a decoding device according to an embodiment are described with reference to the accompanying drawings. The encoding device and the decoding device according to the embodiment encode and decode videos such as MPEG (Moving Picture Experts Group) videos. In the description of the drawings below, the same or similar reference signs are used for the same or similar parts.

Encoding Device

[0025] A configuration of an encoding device according to the present embodiment will be described first. FIG. **1** is a diagram illustrating a configuration of an encoding device **1** according to the present embodiment.

[0026] As illustrated in FIG. **1**, the encoding device **1** includes a block divider **100**, a residual generator **110**, a switcher **111**, a color space transformer **112**, a transformer/quantizer **120**, a quantization controller **123**, an entropy encoder **130**, an inverse quantizer/inverse transformer **140**, a combiner **150**, a loop filter **160**, a memory **170**, and a predictor **180**.

[0027] The block divider **100** divides an original image which is an input image in frame (or picture) units that constitutes a video into a plurality of image blocks and outputs the image blocks obtained by division to the residual generator **110**. The size of the image blocks may be 32×32 pixels, 16×16 pixels, 8×8 pixels, or 4×4 pixels. The shape of the image blocks is not limited to square and may be rectangular (non-square). The image block is a unit (encoding-target block) in which the encoding device **1** performs encoding and is a unit (decoding-target block) in which a decoding device performs decoding. Such an image block is sometimes referred to as a CU (Coding Unit).

[0028] In the present embodiment, a description is given mainly of a case where an input image is of an RGB signal, with a chroma format of 4:4:4. The "R" component corresponds to a first component, the "G" component corresponds to a second component, and the "B" component corresponds to a third component. The block divider **100** outputs blocks by performing division into blocks with respect to each of the R component, the G component, and the B component included in an image. In the description of the encoding device below, when the components are not distinguished from each other, each encoding-target block is simply referred to as encoding-target block.

[0029] The residual generator **110** calculates prediction residuals that represent differences (errors) between an encoding-target block outputted by the block divider **100** and a prediction block obtained by the predictor **180** predicting the encoding-target block. More specifically, the residual generator **110** calculates the prediction residuals by subtracting each pixel value of the prediction block from each pixel value of the encoding-target block, and outputs the calculated prediction residuals to the switcher **111**. In the present embodiment, the residual generator **110** generates the prediction residuals of each component, based on differences between the encoding-target block of each component and the prediction block of each component.

[0030] The switcher **111** outputs the prediction residuals of each component outputted by the residual generator **110**, to any one of the transformer/quantizer **120** and the color space transformer **112**. The switcher **111** outputs the prediction residuals to the transformer/quantizer **120** when a color space transform process (ACT) is not performed, and out-

puts the prediction residuals to the color space transformer **112** when the color space transform process is performed.

[0031] The color space transformer **112** performs the color space transform process on the prediction residuals of each component and outputs prediction residuals after the color space transform process to the transformer/quantizer **120**. The color space transformer **112** generates the new prediction residuals by performing transform calculation as follows, with respect to the R component, the G component, and the B component of the prediction residuals in the encoding-target block.

$$Co=R-B$$

$$t=B+(Co>>1)$$

$$Cg=G-t$$

$$Y=t+(Cg>>1)$$

[0032] In the above, ">>" represents an arithmetic right shift. Moreover, the "Y" component corresponds to the first component, the "Gg" component corresponds to the second component, and the "Co" component corresponds to the third component.

[0033] The color space transformer **112** can control, for each encoding-target block, whether or not the color space transform process is performed. The entropy encoder **130** signals, in a bit stream, a flag indicating whether or not the color space transform process is performed on a current encoding-target block.

[0034] Note that in the color space transform process by the color space transformer **112**, the prediction residuals formed of the new components may be generated by performing addition, subtraction, multiplication, division, a shift process, or the like on each original component, and color space transformation does not necessarily need to be performed. The color space transform process does not need to be transformation that affects all of the components. For example, the color space transformer **112** may apply such a color space transform process that maintains the first component without changing, uses a mean value of the second component and the third component for the new second component, and uses a difference between the second component and the third component for the new third component.

[0035] The transformer/quantizer **120** executes a transform process and a quantization process on each of blocks. The transformer/quantizer **120** includes a transformer **121** and a quantizer **122**.

[0036] The transformer **121** calculates transform coefficients by performing the transform process on the prediction residuals (referred to as prediction residuals, regardless of whether or not the color space transform process is applied) outputted by the switcher **111** or the color space transformer **112**, and outputs the calculated transform coefficients to the quantizer **122**. More specifically, the transformer **121** generates the transform coefficients for each component by performing the transform process on the prediction residuals on a block basis. The transform process may be frequency transformation such as discrete cosine transform (DCT), discrete sine transform (DST), and/or discrete wavelet transform. In addition, the transformer **121** outputs information related to the transform process to the entropy encoder **130**.

[0037] The transform process includes transform skip in which no transform process is performed, and which is adopted in HEVC (High Efficiency Video Codec) and the VVC (Versatile Video Coding) specification draft. In a transform skip mode in HEVC, transform coefficients are obtained by scaling prediction residuals, without performing the horizontal or vertical transform process. However, the transform skip according to the present embodiment also includes transformation in which the transform process is only horizontally applied, and transformation in which the transform process is only vertically applied. Moreover, the transformer **121** may perform a secondary transform process in which a transform process is further applied to the transform coefficients obtained through the transform process. The secondary transform process may be applied only to a partial area of the transform coefficients.

[0038] The quantization controller **123** determines a scaling list (quantization matrix) to be used in a quantization process on the transform coefficients generated by the transformer **121**. Here, as a scaling list, a uniform scaling list (a flat scaling list) in which all elements of the scaling list have equal values (for example, the values of all elements are 16) is defined beforehand. The quantization controller **123** can set a plurality of non-uniform scaling lists in which each element is set at a different value. Note that in a case where a scaling list to be used on a block with a large size is defined with a small size and is enlarged when the scaling list is actually used, different values are not necessarily set for all elements. The entropy encoder **130** outputs, in a stream, information indicating which scaling list is used to perform the quantization process. Note that each non-uniform scaling list is also a scaling list in which at least partially different values can be set as the values of the elements of the scaling list, that is, a variable scaling list.

[0039] In the present embodiment, the quantization controller **123** determines a scaling list, based on whether or not the color space transformer **112** performs the color space transform process. More specifically, in a case where it is set to use the non-uniform scaling list in which the values of the elements of the scaling list are at least partially different, the quantization controller **123** determines whether the non-uniform scaling list is used or the uniform scaling list is used, based on whether or not the color space transformer **112** performs the color space transform process (that is, whether the switcher **111** outputs the prediction residuals to the color space transformer **112**).

[0040] For example, when the color space transformer **112** does not perform the color space transform process, the quantization controller **123** determines the non-uniform scaling list as the scaling list to be used by the quantizer **122** in the quantization process. When the color space transformer **112** performs the color space transform process, the quantization controller **123** determines the uniform scaling list as the scaling list to be used by the quantizer **122** in the quantization process.

[0041] Here, since a non-uniform scaling list is set for each color component, the non-uniform scaling lists differ in nature, according to the respective target components. Accordingly, when an encoding-target block to which ACT is applied and an encoding-target block to which ACT is not applied coexist in one image (picture), application of the non-uniform scaling list causes deterioration in image quality. In the present embodiment, when the color space transformer **112** performs the color space transform process (that is, when ACT is applied), the uniform scaling list is used, whereby deterioration in image quality can be restrained.

[0042] The quantizer **122** quantizes the transform coefficients outputted from the transformer **121** by using a quantization parameter and the scaling list, and outputs the quantized transform coefficients to the entropy encoder **130** and the inverse quantizer/inverse transformer **140**. Here, the scaling list used by the quantizer **122** in the quantization process is determined by the quantization controller **123**. Moreover, the quantizer **122** outputs information related to the quantization process (specifically, information on the quantization parameter and the scaling list used in the quantization process) to the entropy encoder **130** and the inverse quantizer **141**.

[0043] The quantization parameter is a parameter for which one value is set for one block. Specifically, the quantization parameter is a parameter that is applied in common to each transform coefficient in a block, and is a parameter that determines quantization granularity (step size).

[0044] A scaling list constitutes a matrix (quantization matrix) including values that are set for each component in one block. More specifically, a scaling list includes values (weighted coefficients) that are set for each component including i×j elements depending on a block size, and is used to adjust quantization granularity for each of components ranging from low to high frequencies of the transform coefficients. With respect to a non-uniform scaling list, the entropy encoder **130** signals to the decoding side.

[0045] The entropy encoder **130** performs entropy encoding on the quantized transform coefficients outputted by the quantizer **122**, generates a bit stream (encoded data) by performing data compression, and outputs the bit stream to the decoding side. For the entropy encoding, Huffman coding and/or CABAC (Context-based Adaptive Binary Arithmetic Coding) or the like can be used. Moreover, the entropy encoder **130** adds information related to the transform process inputted from the transformer **121** into the bit stream and signals to the decoding side, and adds information related to a prediction process inputted from the predictor **180** into the bit stream and signals to the decoding side. Further, the entropy encoder **130** adds a color space transform flag indicating whether or not ACT is applied, for each encoding-target block, into the bit stream and signals to the decoding side.

[0046] The inverse quantizer/inverse transformer **140** executes an inverse quantization process and an inverse transform process on each of blocks. The inverse quantizer/inverse transformer **140** includes an inverse quantizer **141** and an inverse transformer **142**.

[0047] The inverse quantizer **141** performs the inverse quantization process corresponding to the quantization process performed by the quantizer **122**. More specifically, the inverse quantizer **141** inverse quantizes the quantized transform coefficients outputted by the quantizer **122** by using the quantization parameter (Qp) and the scaling list to restore the transform coefficients, and outputs the restored transform coefficients to the inverse transformer **142**. Here, the scaling list used by the inverse quantizer **141** in the inverse quantization process is determined by the quantization controller **123**.

[0048] The inverse transformer **142** performs the inverse transform process corresponding to the transform process performed by the transformer **121** based on transform type information outputted from the transformer **121**. For example, when the transformer **121** performs the discrete cosine transform, the inverse transformer **142** performs inverse discrete cosine transform. The inverse transformer **142** restores the prediction residual by performing the inverse transform process on the transform coefficients outputted from the inverse quantizer **141**, and outputs a restoration prediction residual that is the restored prediction residual to the combiner **150**.

[0049] The combiner **150** combines the restoration prediction residual outputted from the inverse transformer **142** with a prediction block outputted from the predictor **180** in pixel units. The combiner **150** decodes (reconstructs) an encoding-target block by adding individual pixel values of the restoration prediction residual to individual pixel values of the prediction block, and outputs a decoded block to the loop filter **160**. The decoded block is sometimes referred to as a reconstructed block.

[0050] The loop filter **160** performs a filter process on the decoded block outputted from the combiner **150** and outputs the decoded block after the filter process to the memory **170**.

[0051] The memory **170** stores the decoded block after the filter process outputted from the loop filter **160** and accumulates the decoded block as decoded images in frame units. The memory **170** outputs the stored decoded block or decoded images to the predictor **180**.

[0052] The predictor **180** performs the prediction process in units of the block. The predictor **180** generates a prediction block for each component by performing prediction processes such as intra prediction and inter prediction on each encoding-target block. The predictor **180** according to the present embodiment includes an inter predictor **181**, an intra predictor **182**, and a switcher **183**.

[0053] The inter predictor **181** performs inter prediction utilizing an inter-frame correlation. Specifically, the inter predictor **181** calculates a motion vector through a scheme such as block matching by using the decoded image stored in the memory **170** as a reference image, generates an inter prediction block by predicting the encoding-target block, and outputs the generated inter prediction block to the switcher **183**. Here, the inter predictor **181** selects an optimal inter prediction method from inter prediction using a plurality of reference images (typically, bi-prediction), inter prediction using one reference image (uni-directional prediction), and performs the inter prediction by using the selected inter prediction method. The inter predictor **181** outputs information regarding the inter prediction (the motion vector and the like) to the entropy encoder **130**.

[0054] The intra predictor **182** performs intra prediction utilizing an intra-frame spatial correlation. Specifically, the intra predictor **182** generates an intra prediction block by referring to decoded pixels present around the encoding-target block of the decoded image stored in the memory **170**, and outputs the generated intra prediction block to the switcher **183**. The intra predictor **182** selects an intra prediction mode to be applied to the encoding-target block from among a plurality of intra prediction modes, and predicts the encoding-target block by using the selected intra prediction mode.

[0055] The switcher **183** switches the inter prediction block outputted from the inter predictor **181** and the intra prediction block outputted from the intra predictor **182** and outputs one of the prediction blocks to the residual generator **110** and the combiner **150**.

[0056] As described above, the encoding device **1** according to the present embodiment encodes each encoding-target

block that is generated by dividing an image that includes three or more components including the first component, the second component, and the third component. The encoding device **1** includes: the predictor **180** configured to generate, for each of the components, a prediction block corresponding to an encoding-target block; the residual generator **110** configured to generate, for each of the components, a prediction residual that represents a difference between the encoding-target block and the prediction block; the color space transformer configured to perform the color space transform process on the prediction residual; the transformer **121** configured to generate transform coefficients by performing the transform process on the prediction residual; the quantization controller **123** configured to determine a scaling list to be used in the quantization process on the transform coefficients; and the quantizer **122** configured to perform the quantization process on the transform coefficients by using the determined scaling list.

[0057] Next, operation of the quantization controller **123** according to the present embodiment is described. FIG. **2** is a diagram illustrating the operation of the quantization controller **123** according to the present embodiment. The quantization controller **123** performs the operation in FIG. **2** on each encoding-target block. Note that the operation in FIG. **2** is operation based on the premise that it is set to use the non-uniform scaling list, based on a factor other than ACT (color space transform process).

[0058] As illustrated in FIG. **2**, in step S**11**, the quantization controller **123** determines whether or not ACT (color space transform process) is applied to an encoding-target block.

[0059] When ACT is not applied to the encoding-target block (step S**11**: NO), in step S**12**, the quantization controller **123** determines the non-uniform scaling list as the scaling list to be used in the transform process on the encoding-target block. The non-uniform scaling list may be one designed suitably for a characteristic of each component in the RGB space. For example, the non-uniform scaling list may be one designed on the premise that a luminance signal is included mainly in the G component. For example, the quantization controller **123** applies the non-uniform first scaling list to prediction residuals of the R component, applies the non-uniform second scaling list to prediction residuals of the G component, and applies the non-uniform third scaling list to prediction residuals of the B component.

[0060] When ACT is applied to the encoding-target block (step S**11**: YES), in step S**13**, the quantization controller **123** determines the uniform scaling list as the scaling list to be used in the transform process on the encoding-target block. The uniform scaling list is a preset scaling list, that is, a scaling list shared between the encoding side and the decoding side beforehand. For example, the quantization controller **123** applies the uniform scaling list to each of prediction residuals of the Y component, prediction residuals of the Cg component, and prediction residuals of the Co component.

[0061] As described above, the encoding device **1** according to the present embodiment uses the uniform scaling list when ACT is applied. Thus, deterioration in image quality can be restrained even if an encoding-target block to which ACT is applied and an encoding-target block to which ACT is not applied coexist in one image (picture).

Decoding Device

[0062] Next, a decoding device according to the present embodiment is described, focusing mainly on differences from the encoding device **1**. FIG. **3** is a diagram illustrating a configuration of the decoding device **2** according to the present embodiment.

[0063] As illustrated in FIG. **3**, the decoding device **2** includes an entropy decoder **200**, an inverse quantizer/inverse transformer **210**, an inverse quantization controller **214**, a switcher **215**, a color space inverse transformer **216**, a combiner **220**, a loop filter **230**, a memory **240**, and a predictor **250**.

[0064] The entropy decoder **200** decodes encoded data (bit stream) and outputs quantized transform coefficients corresponding to a decoding-target block to the inverse quantizer/inverse transformer **210**. Moreover, the entropy decoder **200** acquires information related to a transform process and a quantization process and outputs the information related to the transform process and the quantization process to the inverse quantizer/inverse transformer **210**. Further, the entropy decoder **200** acquires information related to a prediction process and outputs the information related to the prediction process to the predictor **250**. The entropy decoder **200** acquires a color space transform flag for each encoding-target block, and outputs the acquired color space transform flag to the inverse quantization controller **214** and the switcher **215**.

[0065] The inverse quantization controller **214** performs operation similar to the operation of the quantization controller **123** of the encoding device **1**, based on the color space transform flag (see FIG. **2**).

[0066] The inverse quantizer/inverse transformer **210** executes an inverse quantization process and an inverse transform process on each of blocks. The inverse quantizer/inverse transformer **210** includes an inverse quantizer **211** and an inverse transformer **212**.

[0067] The inverse quantizer **211** performs the inverse quantization process corresponding to the quantization process performed by the quantizer **122** of the encoding device **1**. The inverse quantizer **211** inverse quantizes the quantized transform coefficients outputted by the entropy decoder **200**, by using a quantization parameter (Qp) and a scaling list to restore transform coefficients in the decoding-target block, and outputs the restored transform coefficients to the inverse transformer **212**. Here, the scaling list used in the inverse quantization process by the inverse quantizer **211** is determined by the inverse quantization controller **214**.

[0068] The inverse transformer **212** performs the inverse transform process corresponding to the transform process performed by the transformer **121** of the encoding device **1**. The inverse transformer **212** restores prediction residuals by performing the inverse transform process on the transform coefficients outputted by the inverse quantizer **211**, and outputs the restored prediction residuals (restoration prediction residuals) to the switcher **215**.

[0069] The switcher **215** outputs the prediction residuals of each component outputted by the inverse transformer **212**, to any one of the combiner **220** and the color space inverse transformer **216** based on the color space transform flag. The switcher **215** outputs the prediction residuals to the combiner **220** when a color space inverse transform process (ACT) is not performed, and outputs the prediction residuals to the color space inverse transformer **216** when the color space inverse transform process is performed.

[0070] The color space inverse transformer **216** performs the color space inverse transform process that is an inverse process of the color space transform process performed by the color space transformer **112** of the encoding device **1**, and outputs prediction residuals after the color space inverse transform process to the combiner **220**. More specifically, by using the Y component, the Cg component, and the Co component of the restoration prediction residuals, inverse transform calculation is performed as follows.

$$t=Y-(Cg>>1)$$

$$G=Cg+t$$

$$B=t-(Co>>1)$$

$$R=Co+B$$

[0071] The combiner **220** decodes (reconstructs) an original block by combining the prediction residuals outputted by the switcher **215** or the color space inverse transformer **216** and a prediction block outputted by the predictor **250** on a pixel-by-pixel basis, and outputs the decoded block to the loop filter **230**.

[0072] The loop filter **230** performs a filter process on the decoded block outputted by the combiner **220**, and outputs the decoded block after the filter process to the memory **240**.

[0073] The memory **240** stores each decoded block outputted by the combiner **220** and accumulates the decoded blocks as a decoded image in a unit of the frame. The memory **240** outputs the decoded blocks or the decoded image to the predictor **250**. Moreover, the memory **240** outputs decoded images in units of the frame to an outside of the decoding device **2**.

[0074] The predictor **250** performs prediction for each component in units of the block. The predictor **250** includes an inter predictor **251**, an intra predictor **252**, and a switcher **253**.

[0075] The inter predictor **251** performs inter prediction that utilizes correlation between frames. Specifically, the inter predictor **251** generates an inter prediction block by predicting an encoding-target block by using a decoded image stored in the memory **240** for a reference image, based on information related to inter prediction (for example, motion vector information) outputted by the entropy decoder **200**, and outputs the generated inter prediction block to the switcher **253**.

[0076] The intra predictor **252** performs intra prediction that utilizes spatial correlation within a frame. Specifically, the intra predictor **252** generates an intra prediction block by referring to decoded pixels around an encoding-target block in a decoded image stored in the memory **240**, by using an intra prediction mode corresponding to information related to intra prediction (for example, intra prediction mode information) outputted by the entropy decoder **200**, and outputs the generated intra prediction block to the switcher **253**.

[0077] The switcher **253** switches between the inter prediction block outputted by the inter predictor **251** and the intra prediction block outputted by the intra predictor **252**, and outputs one of the prediction blocks to the combiner **220**.

[0078] As described above, the decoding device **2** according to the present embodiment decodes each decoding-target block that is generated by dividing an image that includes three or more components including the first component, the second component, and the third component. The decoding device **2** includes: the entropy decoder **200** configured to decode, for each of the components, quantized transform coefficients in a decoding-target block from a bit stream; the predictor **250** configured to generate, for each of the components, a prediction block corresponding to the decoding-target block; the inverse quantization controller **214** configured to determine a scaling list to be used in the inverse transform process for transform coefficients; the inverse quantizer **211** configured to generate the transform coefficients by performing the inverse transform process on the quantized transform coefficients; the inverse transformer **212** configured to generate a prediction residual by performing the inverse transform process on the transform coefficients by using the determined scaling list; the color space inverse transformer **216** configured to perform the color space inverse transform process on the prediction residual; and the combiner **220** configured to generate a decoded block by combining the prediction residual and the prediction block.

[0079] The inverse quantization controller **214** determines a scaling list, based on the color space inverse transform process (color space transform flag). In the present embodiment, in a case where it is set by the encoding side to use the non-uniform scaling list, the inverse quantization controller **214** determines whether the non-uniform scaling list is used, or the uniform scaling list, based on whether or not the color space inverse transformer **216** performs the color space inverse transform process.

[0080] For example, in the case where it is set by the encoding side to use the non-uniform scaling list, the inverse quantization controller **214** determines the non-uniform scaling list as the scaling list to be used in the inverse quantization process when the color space inverse transformer **216** does not perform the color space inverse transform process. When the color space inverse transformer **216** performs the color space inverse transform process, the inverse quantization controller **214** determines the uniform scaling list as the scaling list to be used in the inverse quantization process.

[0081] As described above, the decoding device **2** according to the present embodiment uses the uniform scaling list when ACT is applied. Thus, deterioration in image quality can be restrained even if an encoding-target block to which ACT is applied and an encoding-target block to which ACT is not applied coexist in one image (picture).

Modification

[0082] Next, a modification of the embodiment is described, focusing mainly on differences from the embodiment.

[0083] In the present modification, in a case where it is set by the encoding device **1** to use the non-uniform scaling list, the non-uniform scaling list is used even if ACT (color space transform process) is applied. However, the quantization controller **123** of the encoding device **1** changes correspondences between the three or more components included in an image and the respective scaling lists for the components, based on whether or not ACT is applied.

[0084] FIG. **4** is a diagram illustrating operation of the quantization controller **123** according to the present modification.

[0085] As illustrated in FIG. **4**, when the color space transform process is not performed (step S**21**: NO), in step

S22, the quantization controller **123** of the encoding device **1** determines the first scaling list for the R component that is the first component, the second scaling list for the G component that is the second component, and the third scaling list for the B component that is the third component (see Table 2).

TABLE 2

	RGB space (ACT not applied)	Scaling list
First component	R component	First scaling list
Second component	G component	Second scaling list
Third component	B component	Third scaling list

[0086] When the color space transformer performs the color space transform process (step S**21**: YES), in step S**23**, the correspondences are changed such that the second scaling list is determined for the Y component that is the first component (see Table 3).

TABLE 3

	YCgCo space (ACT applied)	Scaling list
First component	Y component	Second scaling list
Second component	Cg component	Third scaling list
Third component	Co component	First scaling list

[0087] Since many of luminance components in the RGB space are concentrated in the G component, the second scaling list for the G component is applied to the Y component. Thus, since the appropriate scaling list can be applied to the Y component, deterioration in image quality can be restrained. Note that in the example in Table 3, the correspondences are changed such that the third scaling list is determined for the Cg component that is the second component, and the first scaling list is determined for the Co component that is the third component.

[0088] Similarly, in the case where it is set by the encoding device **1** to use the non-uniform scaling list, the inverse quantization controller **214** of the decoding device **2** changes correspondences between the three or more components included in an image and the respective scaling lists for the components, based on whether or not ACT is applied (that is, the color space inverse transformer **216** performs the color space inverse transform process).

[0089] When the color space inverse transformer **216** does not perform the color space inverse transform process, the inverse quantization controller **214** determines the first scaling list for the R component that is the first component, the second scaling list for the G component that is the second component, and the third scaling list for the B component that is the third component (see Table 2). When the color space inverse transformer **216** performs the color space inverse transform process, the inverse quantization controller **214** determines the second scaling list for the Y component that is the first component (see Table 3).

[0090] Note that in the present modification, when the correspondences between the components and the scaling lists are changed, it is assumed that the changed correspondences (that is, the correspondences between the Y component, the Cg component, the Co component and the first to third scaling lists) are fixed (see Table 3). However, such correspondences may be configured to be variable by signaling the correspondences from the encoding device **1** (entropy encoder **130**) to the decoding device **2**. For example, the encoding device **1** (entropy encoder **130**) may signal information indicating the changed correspondences (that is, the correspondences between the Y component, the Cg component, the Co component and the first to third scaling lists) by adding the information into an adaptation parameter set (APS), which will be described later.

Other Embodiments

[0091] The entropy encoder **130** of the encoding device **1** may output a sequence parameter set (SPS) or an adaptation parameter set (APS) that includes information (control flag) indicating whether or not operation of determining a scaling list based on the color space transform process is performed. The entropy decoder **200** of the decoding device **2** may acquire the SPS or the APS including the information indicating whether or not operation of determining a scaling list based on the color space inverse transform process is performed.

[0092] Moreover, the entropy encoder **130** of the encoding device **1** may output an SPS or an APS including information (control flag) indicating which one of the operation of determining a scaling list according to the embodiment and the operation of determining a scaling list according to the modification **1** is used. The entropy decoder **200** of the decoding device **2** may acquire the SPS or the APS including the information indicating which one of the operation of determining a scaling list according to the embodiment and the operation of determining a scaling list according to the modification **1** is used. The entropy encoder **130** of the encoding device **1** may be configured to signal the control flag, depending on whether or not the chroma format is 4:4:4, or may be configured to control signaling of the control flag, depending on applicability of ACT to a sequence, which is indicated in an SPS or the like. More specifically, a configuration may be made such that the control flag is signaled only when a flag indicating that ACT can be applied to an encoding-target sequence is signaled in an SPS. Moreover, a configuration may be made such that signaling of the control flag is controlled depending on a flag in an APS indicating whether or not a scaling list for a chrominance signal is included in the APS. More specifically, the control flag may be configured to be signaled only when a scaling list for a chrominance signal is included in an APS.

[0093] FIG. **5**A and FIG. **5**B are diagrams illustrating a bit stream outputted by the entropy encoder **130**.

[0094] As illustrated in FIG. **5**A, a bit stream includes a plurality of NAL units and start codes provided at a head of each NAL unit. The start code has 4 bytes and is controlled such that the 0001 (=0x00000001) is not generated in the NAL unit. As illustrated in FIG. **5**B, each NAL unit includes a NAL unit header and a payload.

[0095] FIG. **6** is a diagram illustrating types of the NAL unit. The types of the NAL unit are identified by nal_unit_type in a NAL unit header. The types of the NAL unit are classified into a VCL (Video Coding Layer) class and a non-VCL class. The VCL class is a class corresponding to an encoded bit stream of a slice including an encoding target CTU (Coding Tree Unit). The VCL class is a class corresponding to control information required for decoding, such as a VPS (Video Parameter Set), an SPS (Sequence Parameter Set), a PPS (Picture Parameter Set) and an APS (Adap-

tation Parameter Set). The VPS, the SPS, the PPS and the APS are signaled by different NAL units respectively.

[0096] FIG. **7** is a diagram illustrating relations among VPS, SPS, PPS, and APS.

[0097] As illustrated in FIG. **7**, the VPS has its own ID (vps_video_parameter_set_id) and is referred to from the SPS. The VPS stores information regarding the entire decoding of the bit stream. For example, the VPS includes information of a maximum number of layers and a DPB (Decoded Picture Buffer) or the like.

[0098] The SPS has its own ID (sps_seq_parameter_set_id) and is referred to from the PPS. In addition, the SPS has an ID (sps_video_parameter_set_id) of the VPS that the SPS itself refers to. The SPS stores information required for decoding a sequence. For example, the SPS includes information of a chroma format, a maximum width/height, a bit depth, subpicture information (a number, start coordinates of each subpicture, a width and a height or the like), ON/OFF control in sequence units of each encoding tool (each function) and/or VUI (Video usability information) or the like. The information of the ON/OFF control in sequence units includes a flag (sps_scaling_list_enebled_flag) indicating whether or not to apply the scaling list.

[0099] PPS has an own ID (pps_pic_parameter_set_id) and is referenced by PH (Picture Header). Moreover, PPS has an ID of SPS (pps_seq_parameter_set_id) that the PPS references. PPS stores information necessary to decode a picture. For example, PPS includes information such as a width and a height of the picture, tile partition information (the numbers of tiles in vertical and horizontal directions, definition of a width, a height, and the like of each row and each column), and/or slice partition information (slice shape after partitioning (rect/non-rect); in case of rect, the number of tiles in width and height directions in each rect).

[0100] The PH is header information for each picture. The slice in the picture refers to the PH. The slice can implicitly discriminate the picture including itself so that it is not required to define an ID of the PH. On the other hand, the PH holds an ID (ph_pic_parameter_set_id) of the PPS that is a referent. The PH stores control information for the picture. For example, PH includes information on on/off control of each encoding tool (each function) for the picture. PH includes information indicating that application of each of tools, ALF, LMCS, and scaling list, is enabled or disabled. The information on the on/off control on a picture basis includes a flag (ph_scaling_list_present_flag) indicating whether or not a scaling list is applied. When one or more tools are applied, PH includes an ID of APS that stores parameter information on the one or more tools.

[0101] APS is a syntax structure for parameter transmission, for an encoding tool that needs to transmit relatively many parameters, such as ALF, LMCS, and scaling list. APS has an own ID, and the ID is referenced by PH.

[0102] By signaling control information (control flag) according to the embodiment and the modification in an SPS, the quantization process can be controlled with one control flag even if a plurality of scaling lists are specified, and an amount of flag information can therefore be reduced. On the other hand, by signaling control information (control flag) according to the embodiment and the modification in an APS, it can be determined, for each of a plurality of set scaling lists, whether or not the applied scaling list is controlled depending on application of color space transformation, and the more flexible quantization process can therefore be achieved.

[0103] A program may be provided to cause a computer to execute the operations of the image encoding device **1**. A program may be provided to cause a computer to execute the operations of the image decoding device **2**. The program may be stored in a computer-readable medium. The program can be installed on a computer from a computer-readable medium having the program stored thereon. The computer-readable medium having the program stored thereon may be a non-transitory recording medium. The non-transitory recording medium may include, but is not limited to, a CD-ROM and a DVD-ROM for example.

[0104] The encoding device **1** may be embodied as a semiconductor integrated circuit (chipset, SoC, etc.) by integrating the circuits that execute the respective operations of the encoding device **1**. The decoding device **2** may be embodied as a semiconductor integrated circuit (chipset, SoC, etc.) by integrating the circuits that execute the respective operations of the decoding device **2**.

[0105] The embodiments have been described in detail above with reference to the drawings. Specific configurations are not limited to the above-described configurations, and various design changes, and the like are possible within the scope not deviating from the gist.

1. An encoding device that encodes each encoding-target block generated by dividing an image that includes three or more components including a first component, a second component, and a third component, the encoding device comprising:

a predictor configured to generate, for each of the components, a prediction block corresponding to the encoding-target block;

a residual generator configured to generate, for each of the components, a prediction residual that represents a difference between the encoding-target block and the prediction block;

a residual update controller configured to generate a new prediction residual by using an update process for updating the prediction residual for at least one of the three or more components;

a transformer configured to generate transform coefficients by performing a transform process on the new prediction residual;

a quantization controller configured to determine a scaling list to be used in a quantization process on the transform coefficients;

a quantizer configured to perform the quantization process on the transform coefficients by using the determined scaling list; and

an entropy encoder configured to output a sequence parameter set including information indicating whether or not operation of determining the scaling list based on the update process is performed.

2. A decoding device that decodes each decoding-target block generated by dividing an image that includes three or more components including a first component, a second component, and a third component, the decoding device comprising:

an entropy decoder configured to decode, for each of the components, quantized transform coefficients in the decoding-target block from a bit stream;

a predictor configured to generate, for each of the components, a prediction block corresponding to the decoding-target block;

an inverse quantization controller configured to determine a scaling list to be used in an inverse quantization process;

an inverse quantizer configured to generate transform coefficients by performing the inverse quantization process on the quantized transform coefficients by using the determined scaling list;

an inverse transformer configured to generate a prediction residual by performing an inverse transform process on the transform coefficients;

a residual update controller configured to generate a new prediction residual by using an update process for updating the prediction residual for at least one of the three or more components;

the entropy decoder is configured to acquire a sequence parameter set including information indicating whether or not operation of determining the scaling list based on the update process is performed.

3. A non-transitory computer-readable recording medium storing a program causing a computer to function as the encoding device according to claim **1**.

4. A non-transitory computer-readable recording medium storing a program causing a computer to function as the decoding device according to claim **2**.

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