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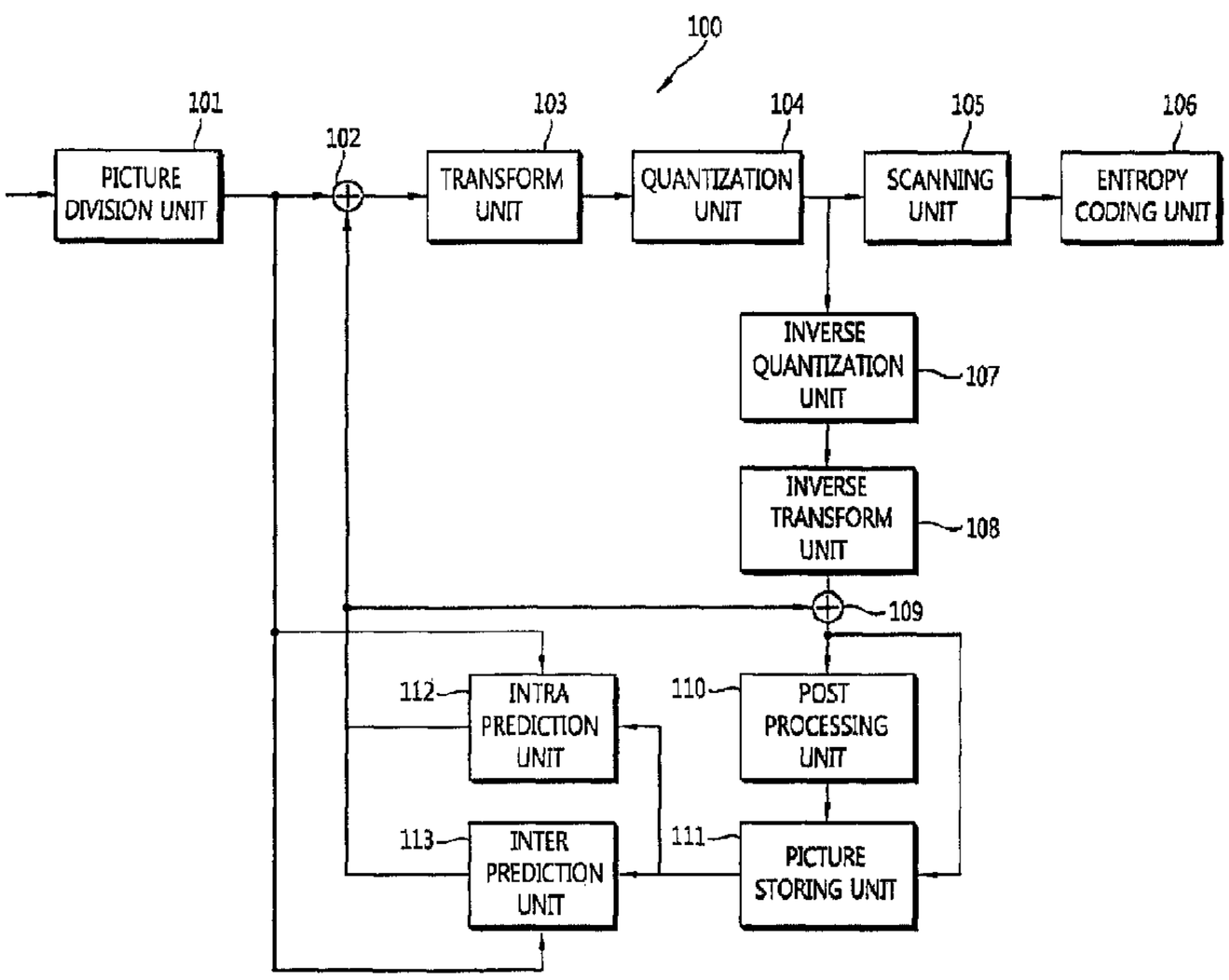
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(54) Title: METHOD OF GENERATING RECONSTRUCTED BLOCK



(57) Abrégé/Abstract:
Provided is a method that derives an intra prediction mode of a prediction unit, determines a size of a current block using transform size information, generates a prediction block of the current block according to the intra prediction mode, generating a residual block of the current block according to the intra prediction mode and generating a reconstructed block of the current block using the prediction block and the residual block. The sizes of the prediction block and the residual block are set equal to a size of a transform unit. Therefore, the distance of intra prediction becomes short, and the amount of coding bits of residual block is reduced by generating a prediction block very similar to original block. Also, the signaling bits required to signal intra prediction mode decrease by generating MPM group adaptively according to the neighboring intra prediction modes.

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ABSTRACT

Provided is a method that derives an intra prediction mode of a prediction unit, determines a size of a current block using transform size information, generates a prediction block of the current block according to the intra prediction mode, generating a residual block of the current block according to the intra prediction mode and generating a reconstructed block of the current block using the prediction block and the residual block. The sizes of the prediction block and the residual block are set equal to a size of a transform unit. Therefore, the distance of intra prediction becomes short, and the amount of coding bits of residual block is reduced by generating a prediction block very similar to original block. Also, the signaling bits required to signal intra prediction mode decrease by generating MPM group adaptively according to the neighboring intra prediction modes.

55928-4D2

【DESCRIPTION】

METHOD OF GENERATING RECONSTRUCTED BLOCK

The following is a divisional of CA 2,849,028, which was filed on November 2, 2012.

【Technical Field】

The present invention relates to a method and an apparatus of decoding an image, and more particularly, to a method and apparatus of adaptively generating a prediction block and residual block having equal size to a transform unit according to an intra prediction mode.

【Background Art】

In H.264/MPEG-4 AVC, one picture is divided into macroblocks to encode an image, the respective macroblocks are encoded by generating a prediction block using inter prediction or intra prediction.The difference between an original block and the prediction block is transformed to generate a transformed block, and the transformed block is quantized using a quantization parameter and one of a plurality of predetermined quantization matrices. The quantized coefficient of the quantized block are scanned by a predetermined scan type and then entropy-coded. The quantization parameteris adjusted per macroblock and encoded using a previous quantization parameter.

Meanwhile, techniques using various size of coding unit are introduced to improve the coding efficiency. Techniques increasing a number of intra prediction modes are also introduces to generate a prediction block more similar to an original block.

But, if the number of intra prediction modes increases, the amount of coding bits required for signaling the intra prediction mode becomes larger. Also, if the size of the coding unit is larger, the difference between an original block and a prediction block prediction block is greater.

Accordingly, more effective method is required to signal the intra prediction mode. More effective method is also required to minimize the difference between

the original block and the prediction block and to minimize the coding bits of residual block.

【Disclosure】

The present invention is directed to a method of deriving an intra prediction mode of a prediction unit, determining a size of a current block using transform size information, generating a prediction block and a residual block of the current block according to the intra prediction mode and generating a reconstructed block of the current block using the prediction block and the residual block.

According to one aspect of the present invention, there is provided a method of deriving an intra prediction mode for a current prediction unit by a decoding apparatus, the method comprising: entropy decoding, by the decoding apparatus, a mode group indicator and a prediction mode index from a received bit stream; constructing, by the decoding apparatus, a most probable mode (MPM) group using intra prediction modes of a left block and an above block, wherein the MPM group includes three intra prediction modes; determining, by the decoding apparatus, whether the mode group indicator indicates the MPM group; determining, by the decoding apparatus, an intra prediction mode specified by the prediction mode index among the three intra prediction modes in the MPM group as the intra prediction mode of the current prediction unit when the mode group indicator indicates the MPM group; and deriving, by the decoding apparatus, the intra prediction mode of the current prediction unit using the prediction mode index and the three intra prediction modes in the MPM group when the mode group indicator does not indicate the MPM group, wherein the MPM group includes two non-directional modes and vertical mode when only one of the intra prediction modes of the left and the above blocks is available and the available intra prediction mode is one of the two non-directional modes, and wherein, when only one of the intra prediction modes of the left and the above blocks is available and the available intra prediction mode is one of directional modes, the MPM group includes two non-directional modes and the available intra prediction mode.

Another aspect provides a method of generating a reconstructed block, comprising: deriving an intra prediction mode of a prediction unit, determining a size of a current block using transform size information, generating a prediction block of the current block according to the intra prediction mode, generating a residual block of the current block

according to the intra prediction mode and generating a reconstructed block of the current block using the prediction block and the residual block.

A method according to the present invention derives an intra prediction mode of a prediction unit, determines a size of a current block using transform size information, generates a prediction block of the current block according to the intra prediction mode, generates a residual block of the current block according to the intra prediction mode and generates a reconstructed block of the current block using the prediction block and the residual block. In some embodiments, the sizes of the prediction block and the residual block are set equal to a size of a transform unit. Therefore, the distance of intra prediction becomes short, and the amount of coding bits of the residual block is reduced by generating a prediction block very similar to original block. Also, in some embodiments, the signaling bits required to signal intra prediction mode decrease by generating MPM group adaptively according to the neighboring intra prediction modes.

【Description of Drawings】

FIG. 1 is a block diagram of an image coding apparatus according to an embodiment of the present invention.

FIG. 2 is a block diagram of an image decoding apparatus according to an embodiment of the present invention.

FIG. 3 is a flow chart illustrating a procedure of generating a reconstructed block in intra prediction according to an embodiment of the present invention.

FIG. 4 is a flow chart illustrating a procedure of deriving an intra prediction mode of a current prediction unit according to an embodiment of the present invention.

FIG. 5 is a conceptual diagram illustrating intra prediction modes according to an embodiment of the present invention.

FIG. 6 is a flow chart illustrating a procedure of generating a prediction block according to an embodiment of the present invention.

FIG. 7 is a conceptual diagram illustrating positions of reference pixels of a current block according to an embodiment of the present invention.

FIG. 8 is a flow chart illustrating a procedure of generating a residual block according to an embodiment of the present invention.

FIG. 9 is a flow chart illustrating a procedure of deriving quantization parameter according to an embodiment of the present invention.

FIG. 10 is a block diagram illustrating an apparatus of generating a reconstructed block according to an embodiment of the present invention.

【Description of Embodiments】

Hereinafter, various embodiments of the present invention will be described in detail with reference to the accompanying drawings. However, the present invention is not limited to the exemplary embodiments disclosed below, but can be implemented in various types. Therefore, many other modifications and variations

of the present invention are possible, and it is to be understood that within the scope of the disclosed concept, the present invention may be practiced otherwise than as has been specifically described.

FIG. 1 is a block diagram of an image coding apparatus 100 according to an embodiment of the present invention.

Referring to FIG. 1, the image coding apparatus 100 according to an embodiment of the present invention includes a picture division unit 101, a transform unit 103, a quantization unit 104, a scanning unit 105, an entropy coding unit 106, an inverse quantization unit 107, an inverse transform unit 108, a post-processing unit 110, a picture storing unit 111, an intra prediction unit 112, an inter prediction unit 113, a subtracter 102 and an adder 109.

The picture division unit 101 divides a picture or a slice into a plurality of largest coding units (LCUs), and divides each LCU into one or more coding units. The picture division unit 101 determines prediction mode of each coding unit and a size of prediction unit and a size of transform unit.

An LCU includes one or more coding units. The LCU has a recursive quad tree structure to specify a division structure. Information specifying the maximum size and the minimum size of the coding unit is included in a sequence parameter set. The division structure is specified by one or more split coding unit flags (split_cu_flags). The coding unit has a size of 2Nx2N.

A coding unit includes one or more prediction units. In intra prediction, the size of the prediction unit is 2Nx2N or NxN. In inter prediction, the size of the prediction unit is 2Nx2N, 2NxN, Nx2N or NxN. When the prediction unit is an asymmetric partition in inter prediction, the size of the prediction unit may also be one of hNx2N, (2-h)Nx2N, 2NxhN and 2Nx(2-h)N. The value of h is 1/2.

A coding unit includes one or more transform units. The transform unit has a recursive quad tree structure to specify a division structure. The division structure is specified by one or more split transform unit flags (split_tu_flags). Information specifying the maximum size and the minimum size of the transform unit is included in a sequence parameter set.

The intra prediction unit 112 determines an intra prediction mode of a current prediction unit and generates a prediction block using the intra prediction mode. The prediction block has the same size of the transform unit.

The inter prediction unit 113 determines motion information of the current prediction unit using one or more reference pictures stored in the picture storing unit 111, and generates a prediction block of the prediction unit. The motion information includes one or more reference picture indexes and one or more motion vectors.

The transform unit 103 transforms residual signals generated using an original block and a prediction block to generate a transformed block. The residual signals are transformed in transform units. A transform type is determined by the prediction mode and the size of the transform unit. The transform type is a DCT-based integer transform or a DST-based integer transform. For example, inter prediction, DCT-based integer transforms are used. In intra prediction mode, if the size of the transform unit is smaller than a predetermined size, the DST-based integer transforms are used, otherwise the DCT-based integer transforms are used.

The quantization unit 104 determines a quantization parameter for quantizing the transformed block. The quantization parameter is a quantization step size. The quantization parameter is determined per quantization unit. The size of the quantization unit is one of allowable sizes of coding unit. If a size of the coding unit is equal to or larger than the minimum size of the quantization unit, the coding unit becomes the quantization unit. A plurality of coding units may be included in a quantization unit. Theminimum size of the quantization unit is determined per picture and informationspecifying the minimum size of the quantization unit is included in a picture parameter set.

The quantization unit 104 generates a quantization parameter predictor and generates a differential quantization parameter by subtracting the quantization parameter predictor from the quantizationparameter. The differential quantization parameter is entropy coded and included in coding unit syntax.

The quantization parameter predictor is generated by using quantization parameters of neighboring coding units and a quantization parameter of previous coding unit as follows.

A left quantization parameter, an above quantization parameter and a previous quantization parameter are sequentially retrieved in this order. An average of the first two available quantization parameters retrieved in that order is set as the quantization parameter predictor when two or more quantization parameters are available, and when only one quantization parameter is available, the available quantization parameter is set as the quantization parameter predictor. That is, if the left and above quantization parameter are available, the average of the left and above quantization parameter is set as the quantization parameter predictor. If only one of the left and above quantization parameter is available, the average of the available quantization parameter and the previous quantization parameter is set as the quantization parameter predictor. If both of the left and above quantization parameter are unavailable, the previous quantization parameter is set as the quantization parameter predictor. The average is rounded off.

The quantization unit 104 quantizes the transformed block using a quantization matrix and the quantization parameter to generate a quantized block. The quantized block is provided to the inverse quantization unit 107 and the scanning unit 105.

The scanning unit 105 determines a scan pattern and applies the scan pattern to the quantized block. When CABAC (Context adaptive binary arithmetic coding) is used for entropy coding, the scan pattern is determined as follows.

In intra prediction, the scan pattern is determined by the intra prediction mode and the size of the transform unit. The size of the transform unit, the size of transformedblock and the size of the quantized block are same.The scan pattern is selected among a diagonal scan, vertical scan and horizontal scan. The quantized transform coefficients of the quantized block are split into significant flags, coefficient signs and coefficientlevels. The scan pattern is applied to the significant flags, coefficient signs and coefficient levels respectively. The significant flag indicates whether the corresponding quantized transform coefficient is zero or not. The coefficient sign indicates a sign of non-zero quantized transform coefficient, and the coefficients level indicates an absolute value of non-zero quantized transform coefficient.

When the size of the transform unit is equal to or smaller than a first size, the horizontal scan is selected for the vertical mode and a predetermined number of

neighboring intra prediction modesof the vertical mode in directionality, the vertical scan is selected for the horizontal mode and the predetermined number of neighboring intra prediction modes of the horizontal mode in directionality, and the diagonal scan is selected for the other intra prediction modes. When the size of the transform unit is larger than the first size, the diagonal scan is used. The first size is 8x8.

In inter prediction, a predetermined scan pattern is used regardless of the size of the transform unit. The predetermined scan pattern is the diagonal scan when the CABAC is used for entropy coding.

When the size of the transform unit is larger than a second size, the quantized block is divided into a main subset and a plurality of remainingsubsets and the determined scan pattern is applied to each subset. Significant flags, coefficient signs and coefficients levels of each subset are scanned respectively according to the determined scan pattern. The main subset includes DC coefficient and the remaining subsets covers the region other than the region covered by the main subset. Thesecond size is 4x4. A size of the subset may be 4x4 block or may vary according to the scan pattern. The subset contains 16 transform coefficients.

The scan pattern for scanning the subsets is the same as the scan pattern for scanning quantized transform coefficients of each subset. The quantized transform coefficients of each subset are scanned in the reverse direction. The subsets are also scanned in the reverse direction.

Last non-zero coefficient positionis encoded and transmitted to the decoder. The last non-zero coefficient position specifies a position of last non-zero quantized transform coefficient within the transform unit. Non-zero subset flag is set for each subset other than the main subset and the last subset. The last subset covers the last non-zero coefficient.The non-zero subset flag indicates whether the subset contains non-zero coefficients or not.

The inverse quantization unit 107 inversely quantizes the quantized transform coefficients of the quantized block.

The inverse transform unit 108 inversely transforms the inverse quantized block to generate residual signals of the spatial domain.

The adder 109generates a reconstructed block by adding the residual block and the prediction block.

The post-processing unit 110 performs a deblocking filtering process for removing blocking artifact generated in a reconstructed picture.

The picture storing unit 111 receives post-processed image from the post-processing unit 110, and stores the image in picture units. A picture may be a frame or a field.

The entropy coding unit 106 entropy-codes the one-dimensional coefficient information received from the scanning unit 105, intra prediction information received from the intra prediction unit 112, motion information received from the inter prediction unit 113, and so on.

FIG. 2 is a block diagram of an image decoding apparatus 200 according to an embodiment of the present invention.

The image decoding apparatus 200 according to an embodiment of the present invention includes an entropy decoding unit 201, an inverse scanning unit 202, an inverse quantization unit 203, an inverse transform unit 204, an adder 205, a post processing unit 206, a picture storing unit 207, an intra prediction unit 208 and an inter prediction unit 209.

The entropy decoding unit 201 extracts the intra prediction information, the inter prediction information and the one-dimensional coefficient information from a received bit stream. The entropy decoding unit 201 transmits the inter prediction information to the inter prediction unit 209, the intra prediction information to the intra prediction unit 208 and the coefficient information to the inverse scanning unit 202.

The inverse scanning unit 202 uses an inverse scan pattern to generate quantized block. When CABAC is used for entropy coding, the scan pattern is determined as follows.

In intra prediction, the inverse scan pattern is determined by the intra prediction mode and the size of the transform unit. The inverse scan pattern is selected among a diagonal scan, vertical scan and horizontal scan. The selected inverse scan pattern is applied to significant flags, coefficient signs and coefficients levels respectively to generate the quantized block.

When the size of the transform unit is equal to or smaller than a first size, the horizontal scan is selected for the vertical mode and a predetermined number of

neighboring intra prediction modes of to the vertical mode, the vertical scan is selected for the horizontal mode and the predetermined number of neighboring intra prediction modes of the horizontal mode, and the diagonal scan is selected for the other intra prediction modes. When the size of the transform unit is larger than the first size, the diagonal scan is used. When the size of the transform unit is larger than the first size, the diagonal scan is selected for all intra prediction modes.The first size is 8x8.

When the size of the transform unit is larger than the first size, the diagonal scan is selected for all intra prediction modes.

In inter prediction, the diagonal scan is used.

When the size of the transform unit is larger than the second size, the significant flags, the coefficient signs and the coefficients levels are inversely scanned in the unit of subset using the determined inverse scan pattern to generate subsets, and the subsets are inversely scanned to generate the quantized block.The second size is 4x4. The size of the subset may be 4x4 block or a non-square block determined by the scan pattern. The non-square block includes 16 transform coefficients. For example, the size of the subset is 8x2 for the horizontal scan, 2x8 for the vertical scan and 4x4 for the diagonal scan.

The inverse scan pattern used for generating each subset is the same as the inverse scan pattern used for generating the quantized block. The significant flags, the coefficient signs and the coefficient levels are inversely scanned in the reverse direction. The subsets are also inversely scanned in the reverse direction.

The last non-zero coefficient position and the non-zero subset flags are received from the encoder. The number of encoded subsets is determined according to the last non-zero coefficient position and the inverse scan pattern.The non-zero subset flags are used to selectsubsets to be generated. The main subset and the last subset are generated using the inverse scan pattern.

The inverse quantization unit 203 receives the differential quantization parameter from the entropy decoding unit 201 and generates the quantization parameter predictor. The quantization parameter predictor is generated through the same operation of the quantization unit 104 of FIG. 1. Then, the inverse quantization unit 203 adds the differential quantization parameter and the quantization parameter predictor to generate the quantization parameter of the

current coding unit. If the size of the current coding unit is equal to or larger than the minimum size of the quantization unit and the differential quantization parameter for the current coding unit is not received from the encoder, the differential quantization parameter is set to 0.

The inverse quantization unit 203 inversely quantizes the quantized block.

The inverse transform unit 204 inversely transforms the inverse-quantized block to restore a residual block. The inverse transform type is adaptively determined according to the prediction mode and the size of the transform unit. The inverse transform type is the DCT-based integer transform or the DST-based integer transform. For example, inter prediction, DCT-based integer transforms are used. In intra prediction mode, if the size of the transform unit is smaller than a predetermined size, the DST-based integer transforms are used, otherwise the DCT-based integer transforms are used.

The intra prediction unit 208 restores the intra prediction mode of the current prediction unit using the received intra prediction information, and generates a prediction block according to the restored intra prediction mode.

The inter prediction unit 209 restores the motion information of the current prediction unit using the received inter prediction information, and generates a prediction block using the motion information.

The post-processing unit 206 operates the same as the post-processing unit 110 of FIG. 1.

The picture storing unit 207 receives post-processed image from the post-processing unit 206, and stores the image in picture units. A picture may be a frame or a field.

The adder 205 adds the restored residual block and a prediction block to generate a reconstructed block.

FIG. 3 is a flow chart illustrating a procedure of generating a reconstructed block in intra prediction according to an embodiment of the present invention.

First, an intra prediction mode of a current prediction unit is derived (S1100).

FIG. 4 is a flow chart illustrating a procedure of deriving the intra prediction mode of the current prediction unit according to an embodiment of the present invention.

Intra prediction parameters of the current prediction unit are extracted from a received bit stream (S1110).

The intra prediction parameters are s mode group indicator and a prediction mode index. The mode group indicator is a flag indicating whether the intra prediction mode of the current prediction unit belongs to a most probable mode group (MPM group). If the flag is 1, the intra prediction unit of the current prediction unit belongs to the MPM group. If the flag is 0, the intra prediction unit of the current prediction unit belongs to a residual mode group. The residual mode group includes all intra prediction modes other than the intra prediction modes of the MPM group. The prediction mode index specifies the intra prediction mode of the current prediction unit within the group specified by the mode group indicator.

The MPM group is constructed using intra prediction modes of the neighboring prediction units (S1120). The intra prediction modes of the MPM group are adaptively determined by a left intra prediction mode and an above intra prediction mode. The left intra prediction mode is the intra prediction mode of the left neighboring prediction unit, and the above intra prediction mode is the intra prediction mode of the above neighboring prediction unit. The MPM group is comprised of three intra prediction modes.

If the left or above neighboring prediction unit does not exist, the intra prediction mode of the left or above neighboring unit is set as unavailable. For example, if the current prediction unit is located at the left or upper boundary of a picture, the left or above neighboring prediction unit does not exist. If the left or above neighboring unit is located within other slice or other tile, the intra prediction mode of the left or above neighboring unit is set as unavailable. If the left or above neighboring unit is inter-coded, the intra prediction mode of the left or above neighboring unit is set as unavailable. If the above neighboring unit is located within other LCU, the intra prediction mode of the left or above neighboring unit is set as unavailable.

FIG. 5 is a conceptual diagram illustrating intra prediction modes according to an embodiment of the present invention. As shown in FIG. 5, the number of intra prediction modes is 35. The DC mode and the planar mode are non-directional intra prediction modes and the others are directional intra prediction modes.

When both of the left intra prediction mode and the above intra prediction mode are available and are different each other, the left intra prediction mode and the above intra prediction mode are included in the MPM group and one additional intra prediction mode is added to the MPM group. Index 0 is assigned to one intra prediction mode of small mode number and index 1 is assigned to the other. Or index 0 is assigned to the left intra prediction mode and index 1 is assigned to the above intra prediction mode. The added intra prediction mode is determined by the left and above intra prediction modes as follows.

If one of the left and above intra prediction modes is a non-directional mode and the other is a directional mode, the other non-directional mode is added to the MPM group. For example, if the one of the left and above intra prediction modes is the DC mode, the planar mode is added to the MPM group. If the one of the left and above intra prediction modes is the planar mode, the DC mode is added to the MPM group. If both of the left and above intra prediction modes are non-directional modes, the vertical mode is added to the MPM group. If both of the left and above intra prediction modes are directional modes, the DC mode or the planar mode is added to the MPM group.

When only one of the left intra prediction mode and the above intra prediction mode is available, the available intra prediction mode is included in the MPM group and two additional intra prediction modes are added to the MPM group. The added two intra prediction modes are determined by the available intra prediction modes as follows.

If the available intra prediction mode is a non-directional mode, the other non-directional mode and the vertical mode are added to the MPM group. For example, if the available intra prediction mode is the DC mode, the planar mode and the vertical mode are added to the MPM group. If the available intra prediction mode is the planar mode, the DC mode and the vertical mode are added to the MPM group. If the available intra prediction mode is a directional mode, two non-directional modes (DC mode and planar mode) are added to the MPM group.

When both of the left intra prediction mode and the above intra prediction mode are available and are the same as each other, the available intra prediction mode is included in the MPM group and two additional intra prediction modes are added to

the MPM group. The added two intra prediction modes are determined by the available intra prediction modes as follows.

If the available intra prediction mode is a directional mode, two neighboring directional modes are added to the MPM group. For example, if the available intra prediction mode is the mode 23, the left neighboring mode (mode 1) and the right neighboring mode (mode 13) are added to the MPM group. If the available intra prediction mode is the mode 30, the two neighboring modes (mode 2 and mode 16) are added to the MPM group. If the available intra prediction mode is a non-directional mode, the other non-directional mode and the vertical mode are added to the MPM group. For example, if the available intra prediction mode is the DC mode, the planar mode and the vertical mode are added to the MPM group.

When both of the left intra prediction mode and the above intra prediction modeare unavailable, three additional intra prediction modes are added to the MPM group. The three intra prediction modes are the DC mode, the planar mode and the vertical mode. Indexes 0, 1 and 2 are assigned to the three intra prediction modes in the order of the DC mode, the planar mode and the vertical mode or in the order of the planar mode, the DC mode and the vertical mode.

It is determined whether the mode group indicator indicates the MPM group (S1130).

If the mode group indicator indicates the MPM group, the intra prediction of the MPM group specified by the prediction mode index is set as the intra prediction mode of the current prediction unit (S1140).

If the mode group indicator does not indicate the MPM group, the three intra predictions of the MPM group are reordered in the mode number order (S1150). Among the three intra prediction modes of the MPM group, the intra prediction mode with lowest mode number is set to a first candidate, the intra prediction mode with middle mode number is set to a second candidate, and the intra prediction mode with highest mode number is set to a third candidate.

The prediction mode index is compared with the first candidate (S1160). If the prediction mode index is equal to or greater than the first candidate of the MPM group, the value of the prediction mode index is increased by one. Otherwise, the value of the prediction mode index is maintained.

The prediction mode index is compared with the second candidate (S1170). If the prediction mode index is equal to or greater than the second candidate of the MPM group, the value of the prediction mode index is increased by one. Otherwise, the value of the prediction mode index is maintained.

The prediction mode index is compared with the third candidate (S1180). If the prediction mode index is equal to or greater than the third candidate of the MPM group, the value of the prediction mode index is increased by one. Otherwise, the value of the prediction mode index is maintained.

The value of the final prediction mode index is set as the mode number of the intra prediction mode of the current prediction unit (S1190).

Next, a size of a current block is determined to generate a prediction block (S1200).

The size of the current block is equal to the size of the transform unit. The size of the current block is determined using the size of the prediction unit and transform size information. A prediction block and a residual block of the current block have same size of the transform unit. The transform size information includes one or more split_tu_flags used for indicating the split structure.

If the size of the transform unit is equal to the size of the current prediction unit, the current prediction unit is set as the current block.

If the size of the transform unit is smaller than the size of the current prediction unit, the prediction unit is comprised of a plurality of sub-blocks. Each sub-block is set as the current block. In this case, the steps S1300, S1400 and S1500 are performed for the first sub-block of the prediction unit. Then, the steps S1300, S1400 and S1500 are repeatedly performed for the remaining sub-blocks of the prediction unit in decoding order. Same intra prediction mode is used for all the sub-blocks within the prediction unit.

Next, a prediction block is generated according to the intra prediction mode (S1300).

FIG. 6 is a flow chart illustrating a procedure of generating the prediction block according to an embodiment of the present invention.

It is determined whether all reference pixels of the current block are available, and reference pixels are generated if one or more reference pixels are unavailable (S1210). The current block is the current prediction unit or the sub-block of the current prediction unit. The size of the current block is the size of the transform unit.

FIG. 7 is a conceptual diagram illustrating positions of reference pixels of the current block according to an embodiment of the present invention. As shown in FIG. 7, the reference pixels of the current blocks are comprised of above reference pixels located at (x=0, . . .,2N-1, y=-1), left reference pixels located at (x=1-, y=0, . . ., 2M-1) and a corner pixel located at (x=-1, y=-1). N is the width of the current block and M is the height of the current block.

If one or more reference pixels are unavailable, one or more reference pixels are generated as follows.

If all reference pixels are unavailable, a constant value is substituted for the values of all the reference pixels. The constant value is 2^{L-1}, and the value of L is the number of bits used to represent luminance pixel value.

If available reference pixels are located at only one side of the unavailable reference pixel, the value of the reference pixel nearest to the unavailable pixel is substituted for the unavailable reference pixel.

If available reference pixels are located at both sides of the unavailable reference pixel, the value of the reference pixel nearest to the unavailable pixel in a predetermined direction is substituted for each unavailable reference pixel.

The reference pixels are adaptively filtered based on the intra prediction mode and the size of the current block (S1220). The size of the current block is the size of the transform unit.

In the DC mode, the reference pixels are not filtered. In the vertical mode and the horizontal mode, the reference pixels are not filtered. In the directional modes other than the vertical and horizontal modes, the reference pixels are adaptively according to the size of the current block.

If the size of the current block is 4x4, the reference pixels are not filtered in all intra prediction modes. For the size 8x8, 16x16 and 32x32, the number of intra prediction mode where the reference pixels are filtered increases as the size of the current block becomes larger.

A prediction block of the current block is generated using the reference pixels according to the restored intra prediction mode (S1230).

In the DC mode, the prediction pixels are generated by copying average value of the N reference pixels located at (x=0, ...N-1, y=-1) and the M reference pixels located at (x=-1, y=0,...M-1). The prediction pixel adjacent to the reference pixel is filtered by one or two adjacent reference pixels.

In the vertical mode, the prediction pixels are generated by copying the value of the vertical corresponding reference pixel. The prediction pixels adjacent to the left reference pixel are filtered using the corner pixel and the left neighboring pixel.

In the horizontal mode, the prediction pixels are generated by copying the value of the horizontal corresponding reference pixel. The prediction pixels adjacent to the above reference pixel are filtered using the corner pixel and the upper neighboring pixel.

Next, a residual block is generated according to the intra prediction mode (S1400).

FIG.8 is a flow chart illustrating a procedure of generating the residual block according to an embodiment of the present invention.

The encoded residual signals are entropy-decoded to generate quantized coefficient information (S1410). When CABAC is used for entropy coding, the coefficients information includes significant flags, coefficient signs and coefficient levels. The significant flag indicates whether the corresponding quantized transform coefficient is zero or not. The coefficient sign indicates a sign of non-zero quantized transform coefficient, and the coefficients level indicates an absolute value of non-zero quantized transform coefficient.

An inverse scan pattern is determined and a quantized block is generated according the inverse scan pattern (S1420). The step is performed by the inverse scanning unit 220 of FIG.2. Therefore, the same operation of the inverse scanning unit 220 is performed to determine the inverse scan pattern and to generate the quantized block.

The quantized block is inversely quantized using a quantization parameter (S1430).

FIG. 9 is a flow chart illustrating a procedure of deriving quantization parameter according to an embodiment of the present invention.

A minimum size of the quantization unit is derived (S1431). The minimum size of the quantization unit is equal to a size of LCU or a size of sub-block of LCU. The minimum size of the quantization unit is determined per picture. A parameter (cu_qp_delta_enabled_info) specifying the depth of the minimum size of the quantization unit is extracted from PPS. The minimum size of the quantization unit is derived as following equation:

Log2(MinQUSize) = Log2(MaxCUSize) –cu_qp_delta_enabled_info

The MinQUSize is the minimum size of the quantization unit. The MaxCUSize is the size of LCU. Only one parameter is used for deriving the minimum size of the quantization unit.

A differential quantization parameter (dQP) of the current coding unit is restored (S1432). The dQP is restored per quantization unit. For example, if the size of the current coding unit is equal to or larger than the minimum size of the quantization unit, the dQP is restored for the current coding unit. If the current coding unit does not contain an encoded dQP, the dQP is set to zero. If the quantization unit includes plural coding units, a first coding unit containing the dQP and the following coding unit within the quantization unit have same dQP.

The encoded dQP is arithmetically decoded to generate a bin string, and the bin string is converted into the dQP. The bin string comprises a bin for indicating the dQP is zero or not. When the dQP is not zero, the bin string further comprises a bin for sign of the dQP, and a bin string for indicating absolute value of the dQP.

A quantization parameter predictor of the current coding unit is generated (S1433). The quantization parameter predictor is generated using the same operation of the inverse quantization unit 230 of FIG. 2.

If the quantization unit includes plural coding units, the quantization parameter predictor of the first coding unit in the decoding order is generated, and the generated quantization parameter predictor is used for all the coding units within the quantization unit.

The quantization parameter is generated using the dQP and the quantization parameter predictor (S1434).

Meanwhile, the user-defined quantization matrices are also restored. A set of the user-defined quantization matrices is received from the encoding apparatus through the SPS or the PPS. The user-defined quantization matrix is restored using inverse DPCM. The diagonal scan is used for the DPCM. When the size of the user-defined quantization matrix is larger than 8x8, the user-defined quantization matrix is restored by up-sampling the coefficients of the received 8x8 quantization matrix. The DC coefficient of the user-defined quantization matrix is extracted from the SPS or the PPS. For example, if the size of the user-defined quantization matrix is 16x16, coefficients of the received 8x8 quantization matrix are up-sampled using 1:4 up-sampling.

A residual block is generated by inversely transforming the inverse-quantized block (S1440). An inverse transform type is adaptively determined according to the prediction mode and the size of the transform unit. The inverse transform type is the DCT-based integer transform or the DST-based integer transform. In intra prediction mode, if the size of the transform unit is smaller than a predetermined size, the DST-based integer transforms are used, otherwise the DCT-based integer transforms are used.

Next, a reconstructed block is generated by adding the prediction block and the residual block (S1500).

FIG. 10 is a block diagram illustrating an apparatus 300 of generating a reconstructed block according to an embodiment of the present invention.

As shown in FIG. 10, the apparatus 300 according to an embodiment of the present invention includes an intra prediction mode deriving unit 310, a prediction size determining unit 320, a prediction block generating unit 330, a residual block generating unit 340 and a reconstructed block generating unit 350.

The intra prediction mode deriving unit 310 derives the intra prediction mode of the current prediction unit. The intra prediction mode deriving unit 310 performs the same procedure of FIG. 4 to derive the intra prediction mode.

The prediction size determining unit 320 determines the size of the current block using the size of the current prediction unit and the transform size information. The size of the current block is equal to the size of the transform unit. A prediction block and a residual block of the current block have same size of the transform unit.

The current prediction unit or a sub-block of the current prediction unit is set as the current block based on the transform size information.

The prediction block generating unit 330 generates the prediction block of the current block using the intra prediction mode. The prediction block generating unit 330 includes a reference pixel generator 331, a reference pixel filter 332 and a prediction block generator 333.

The reference pixel generator 331 generates reference pixels if one or more reference pixels of the current block are unavailable. If all reference pixels are unavailable, the value of 2^{L-1} is substituted for the values of all the reference pixels. The value of L is the number of bits used to represent luminance pixel value. If available reference pixels are located at only one side of the unavailable reference pixel, the value of the reference pixel nearest to the unavailable pixel is substituted for the unavailable reference pixel. If available reference pixels are located at both sides of the unavailable reference pixel, the value of the reference pixel nearest to the unavailable pixel in a predetermined direction is substituted for each unavailable reference pixel.

The reference pixel filter 332 adaptively filters the reference pixels based on the intra prediction mode and the size of the transform unit.

In the DC mode, the reference pixels are not filtered. In the vertical mode and the horizontal mode, the reference pixels are not filtered. In the directional modes other than the vertical and horizontal modes, the reference pixels are adaptively according to the size of the current block.

If the size of the current block is 4x4, the reference pixels are not filtered in all intra prediction modes. For the size 8x8, 16x16 and 32x32, the number of intra prediction mode where the reference pixels are filtered increases as the size of the current block becomes larger. For example, the reference pixels are not filtered in the vertical mode and a predetermined number of neighboring intra prediction mode of the vertical mode. The reference pixels are also not filtered in the horizontal mode and the predetermined number of neighboring intra prediction mode of the horizontal mode. The predetermined number is one of 0~7 and decreases as the size of the current block increases.

The prediction block generator 333 generates a prediction block of the current block using the reference pixels according to the intra prediction mode.

In the DC mode, the prediction pixels are generated by copying average value of the N reference pixels located at (x=0, ...N-1, y=-1) and the M reference pixels located at (x=-1, y=0, ..M-1).The prediction pixel adjacent to the reference pixel is filtered by one or two adjacent reference pixels.

In the vertical mode, the prediction pixels are generated by copying the value of the vertical reference pixel. The prediction pixels adjacent to the left reference pixel are filtered using the corner reference pixel and the left neighboring reference pixel.

In the horizontal mode, the prediction pixels are generated by copying the value of the horizontal reference pixel. The prediction pixels adjacent to the above reference pixel are filtered using the corner reference pixel and the above neighboring reference pixel.

The residual block generating unit 340 generates the residual block of the current block using the intra prediction mode. The same procedure of FIG. 8 is performed by the residual block generating unit 340.

The reconstructed block generating unit 350 adds the prediction block and the residual block to generate the reconstructed block of the current block.

While the invention has been shown and described with reference to certain exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention as defined by the appended claims.

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CLAIMS:

1. A method of deriving an intra prediction mode for a current prediction unit by a decoding apparatus, the method comprising:

entropy decoding, by the decoding apparatus, a mode group indicator and a prediction mode index from a received bit stream;

constructing, by the decoding apparatus, a most probable mode (MPM) group using intra prediction modes of a left block and an above block, wherein the MPM group includes three intra prediction modes;

determining, by the decoding apparatus, whether the mode group indicator indicates the MPM group;

determining, by the decoding apparatus, an intra prediction mode specified by the prediction mode index among the three intra prediction modes in the MPM group as the intra prediction mode of the current prediction unit when the mode group indicator indicates the MPM group; and

deriving, by the decoding apparatus, the intra prediction mode of the current prediction unit using the prediction mode index and the three intra prediction modes in the MPM group when the mode group indicator does not indicate the MPM group,

wherein the MPM group includes two non-directional modes and vertical mode when only one of the intra prediction modes of the left and the above blocks is available and the available intra prediction mode is one of the two non-directional modes, and

wherein, when only one of the intra prediction modes of the left and the above blocks is available and the available intra prediction mode is one of directional modes, the MPM group includes two non-directional modes and the available intra prediction mode.

2. The method of claim 1, wherein when the mode group indicator does not indicate the MPM group,

if the prediction mode index is greater than or equal to a first mode in the MPM group, the value of the prediction mode index is increased by one;

if the prediction mode index is greater than or equal to a second mode in the MPM group, the value of the prediction mode index is increased by one; and then

if the prediction mode index is greater than or equal to a third mode in the MPM group, the value of the prediction mode index is increased by one.

3. The method of claim 2, wherein the first mode is an intra prediction mode of a lowest mode number in the MPM group, the second mode is an intra prediction mode of a middle mode number in the MPM group, and the third mode is an intra prediction mode of a highest mode number in the MPM group.

4. The method of claim 2, wherein the three intra prediction modes in the MPM group is sorted in an order of the first mode, the second mode and the third mode.

5. The method of claim 1, wherein the MPM group is constructed using the intra prediction modes of the left and the above blocks.

6. The method of claim 1, wherein the two non-directional modes are planar mode and DC mode.

7. The method of claim 1, wherein the MPM group is comprised of the two non-directional modes and the vertical mode when both of the left intra prediction mode and the above intra prediction mode are unavailable.

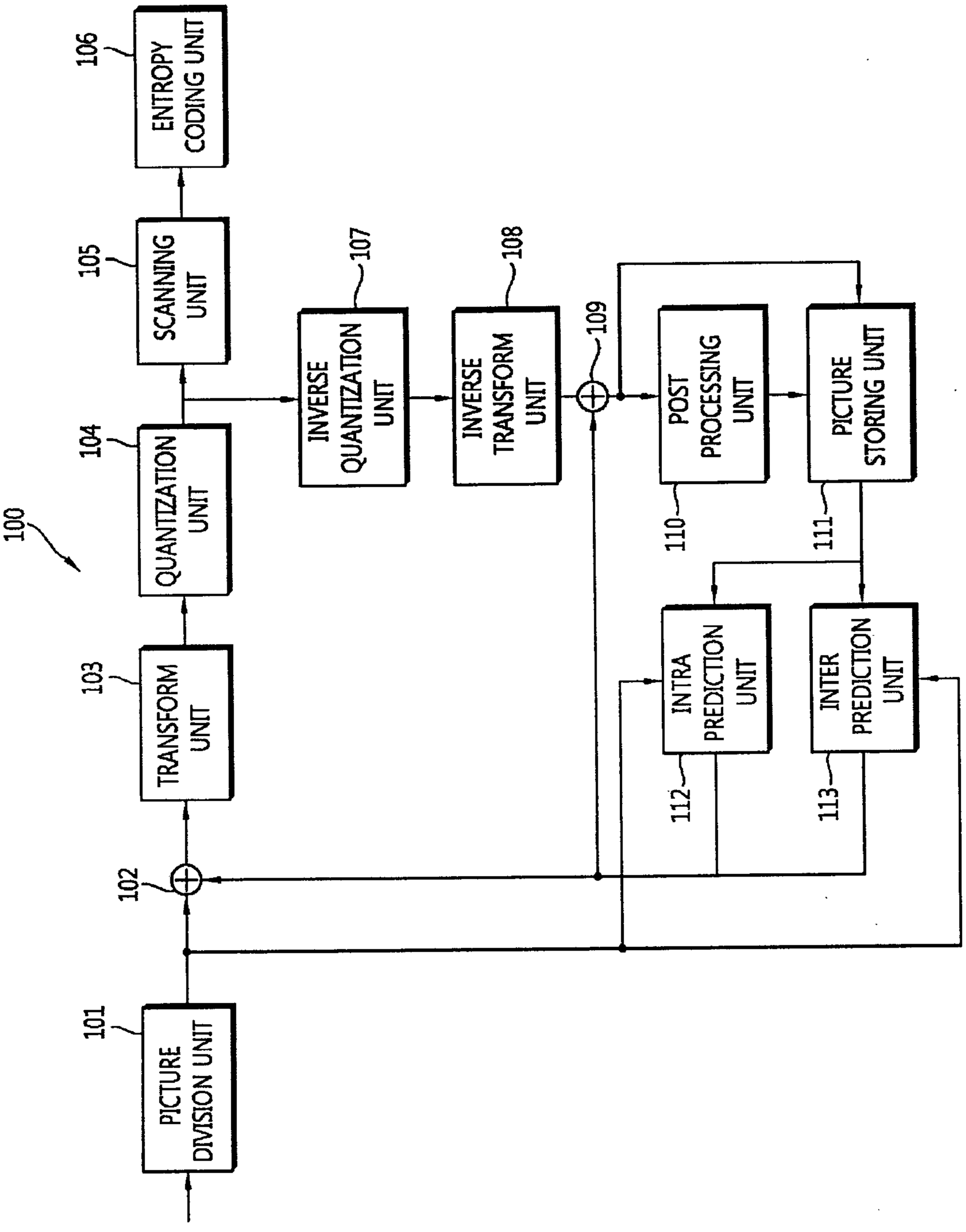

100
101
PICTURE DIVISION UNIT
102
103
TRANSFORM UNIT
104
QUANTIZATION UNIT
105
SCANNING UNIT
106
ENTROPY CODING UNIT
107
INVERSE QUANTIZATION UNIT
108
INVERSE TRANSFORM UNIT
109
110
POST PROCESSING UNIT
111
PICTURE STORING UNIT
112
INTRA PREDICTION UNIT
113
INTER PREDICTION UNIT

Fig. 1

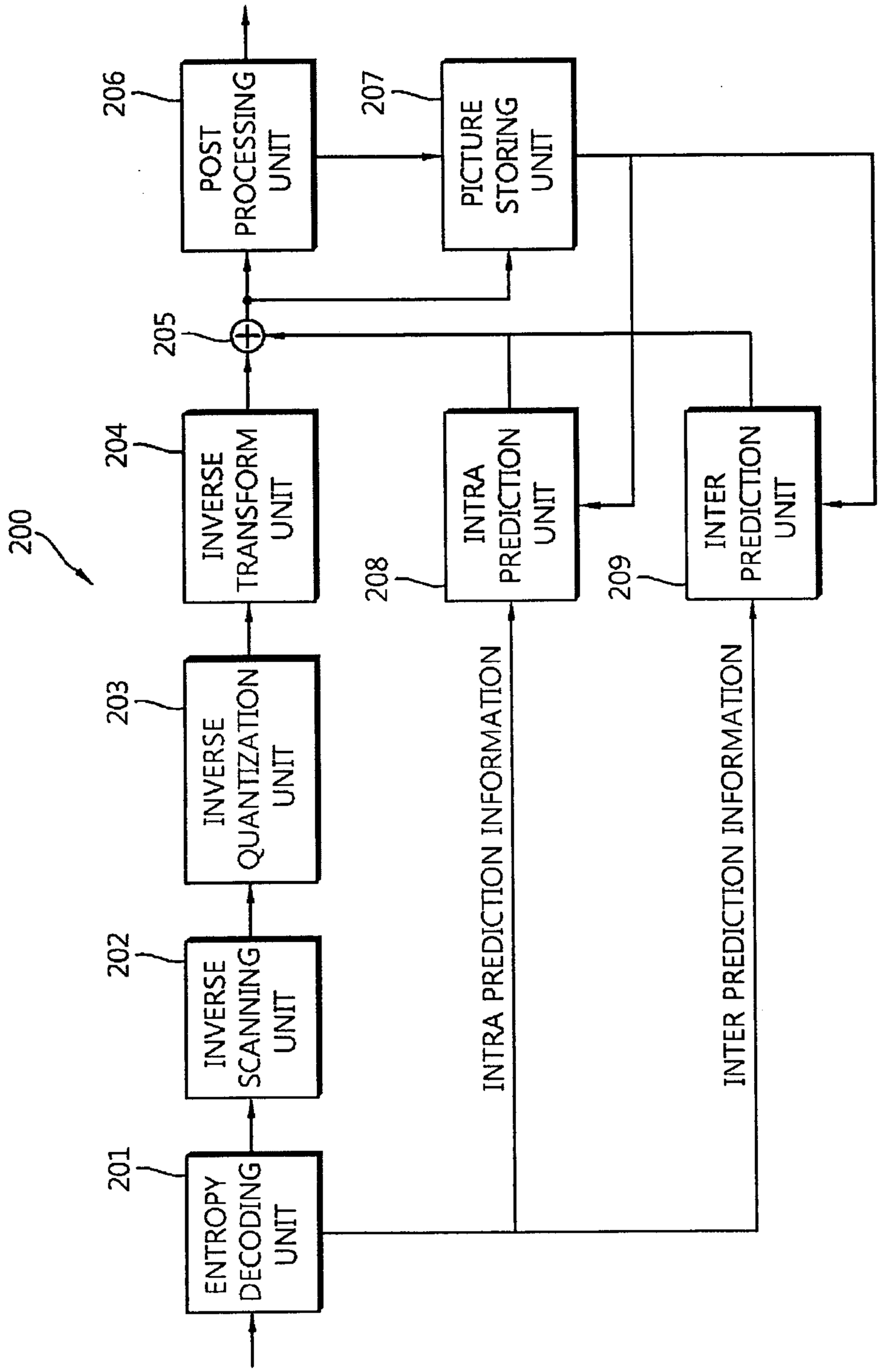

200
201
ENTROPY DECODING UNIT
202
INVERSE SCANNING UNIT
203
INVERSE QUANTIZATION UNIT
204
INVERSE TRANSFORM UNIT
205
206
POST PROCESSING UNIT
207
PICTURE STORING UNIT
208
INTRA PREDICTION UNIT
209
INTER PREDICTION UNIT
INTRA PREDICTION INFORMATION
INTER PREDICTION INFORMATION

Fig. 2

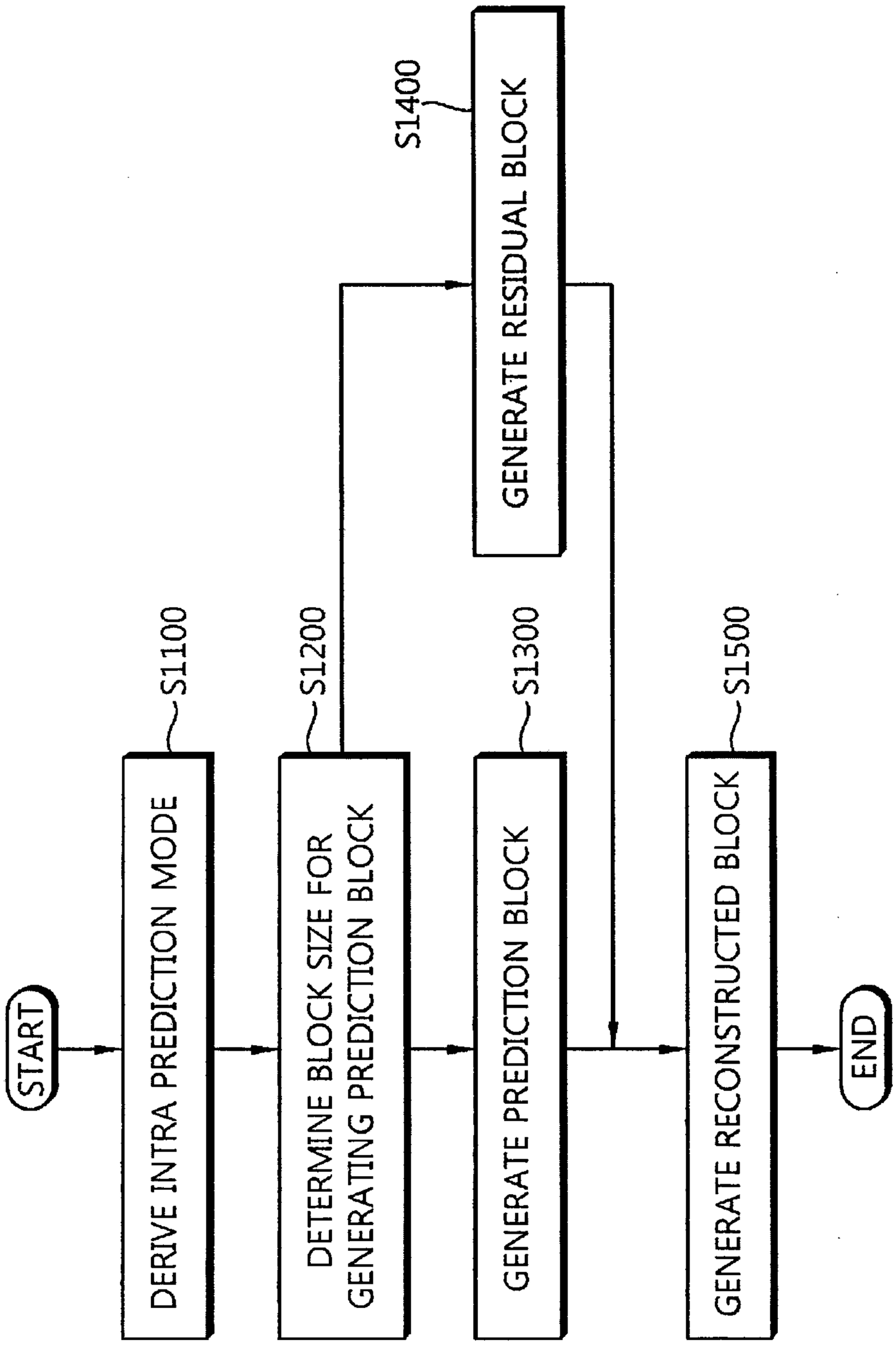

START
DERIVE INTRA PREDICTION MODE
S1100
DETERMINE BLOCK SIZE FOR GENERATING PREDICTION BLOCK
S1200
GENERATE PREDICTION BLOCK
S1300
GENERATE RESIDUAL BLOCK
S1400
GENERATE RECONSTRUCTED BLOCK
S1500
END

Fig. 3

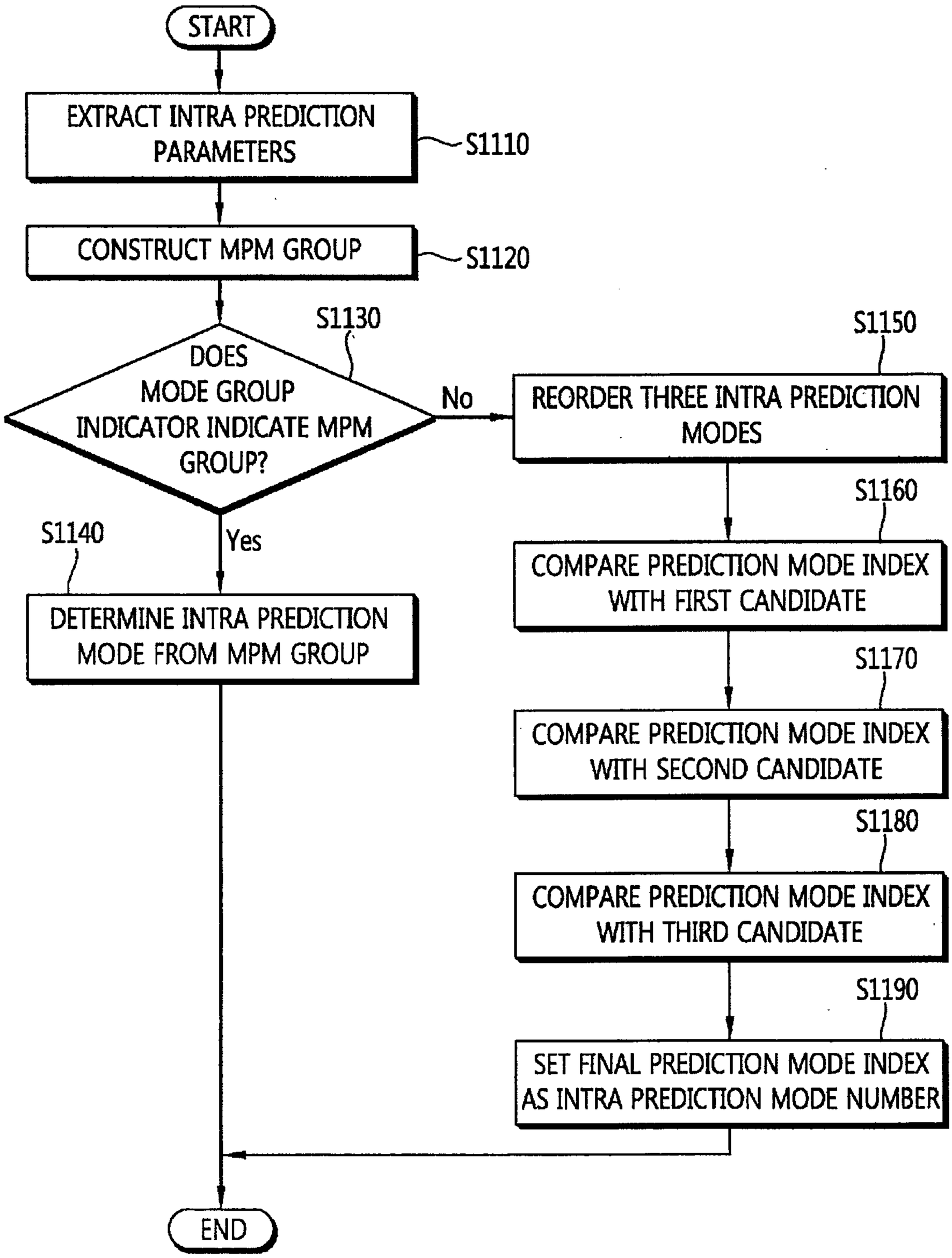

START
EXTRACT INTRA PREDICTION PARAMETERS
S1110
CONSTRUCT MPM GROUP
S1120
S1130
DOES MODE GROUP INDICATOR INDICATE MPM GROUP?
No
Yes
S1140
DETERMINE INTRA PREDICTION MODE FROM MPM GROUP
S1150
REORDER THREE INTRA PREDICTION MODES
S1160
COMPARE PREDICTION MODE INDEX WITH FIRST CANDIDATE
S1170
COMPARE PREDICTION MODE INDEX WITH SECOND CANDIDATE
S1180
COMPARE PREDICTION MODE INDEX WITH THIRD CANDIDATE
S1190
SET FINAL PREDICTION MODE INDEX AS INTRA PREDICTION MODE NUMBER
END

Fig. 4

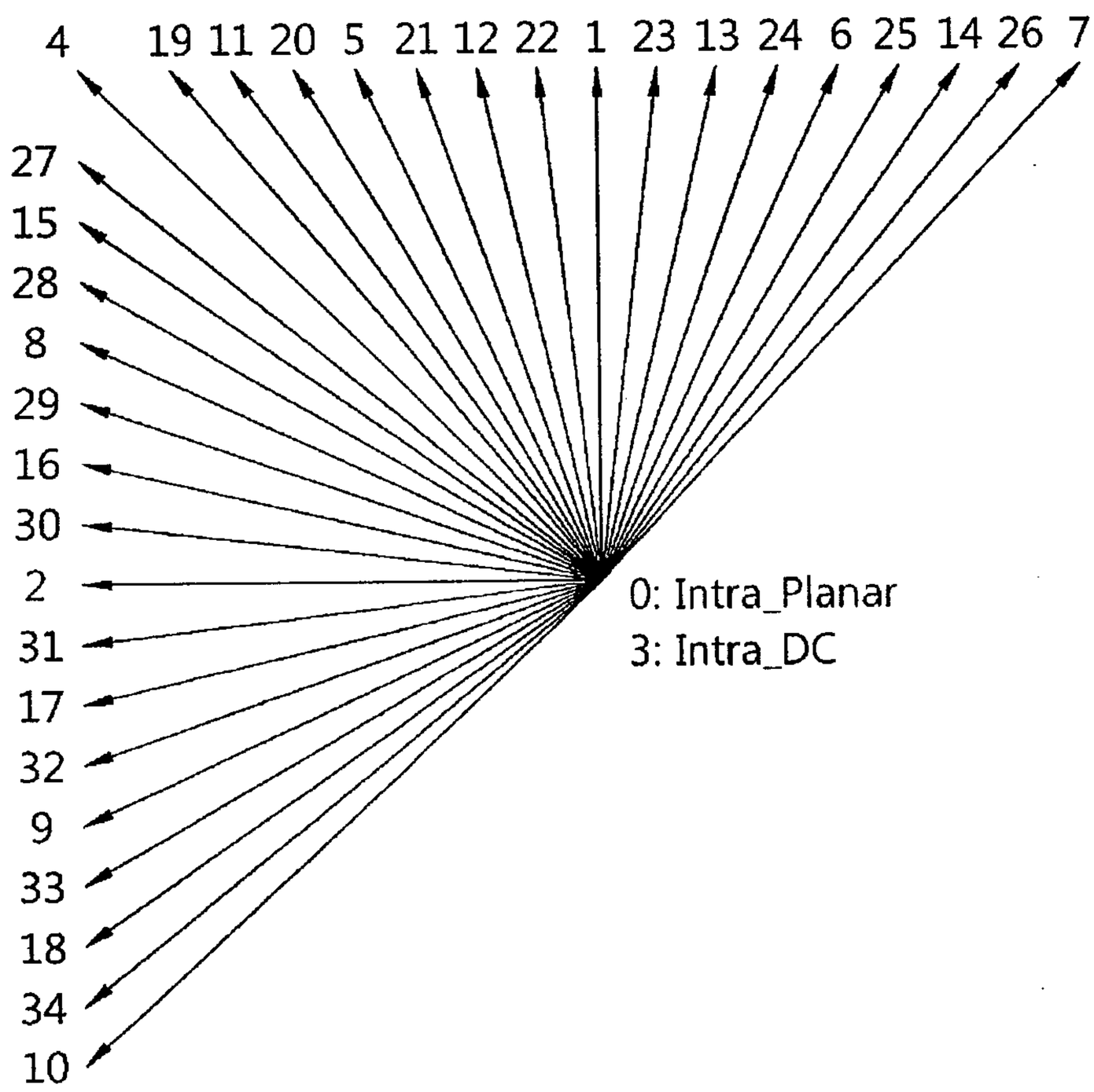

4
19 11 20 5 21 12 22 1 23 13 24 6 25 14 26 7
27
15
28
8
29
16
30
2
31
17
32
9
33
18
34
10
0: Intra_Planar
3: Intra_DC

Fig. 5

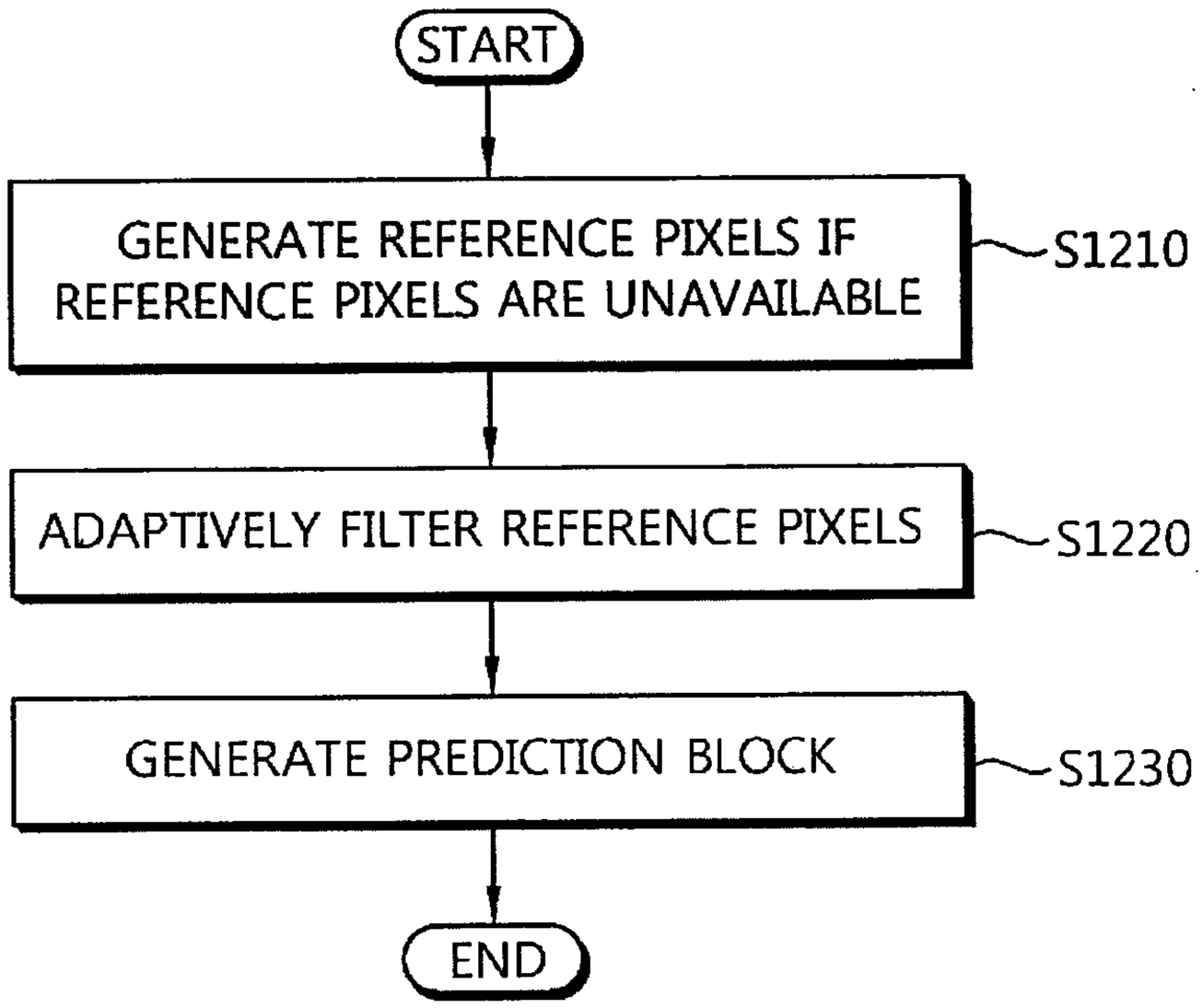

START
GENERATE REFERENCE PIXELS IF REFERENCE PIXELS ARE UNAVAILABLE
S1210
ADAPTIVELY FILTER REFERENCE PIXELS
S1220
GENERATE PREDICTION BLOCK
S1230
END

Fig. 6

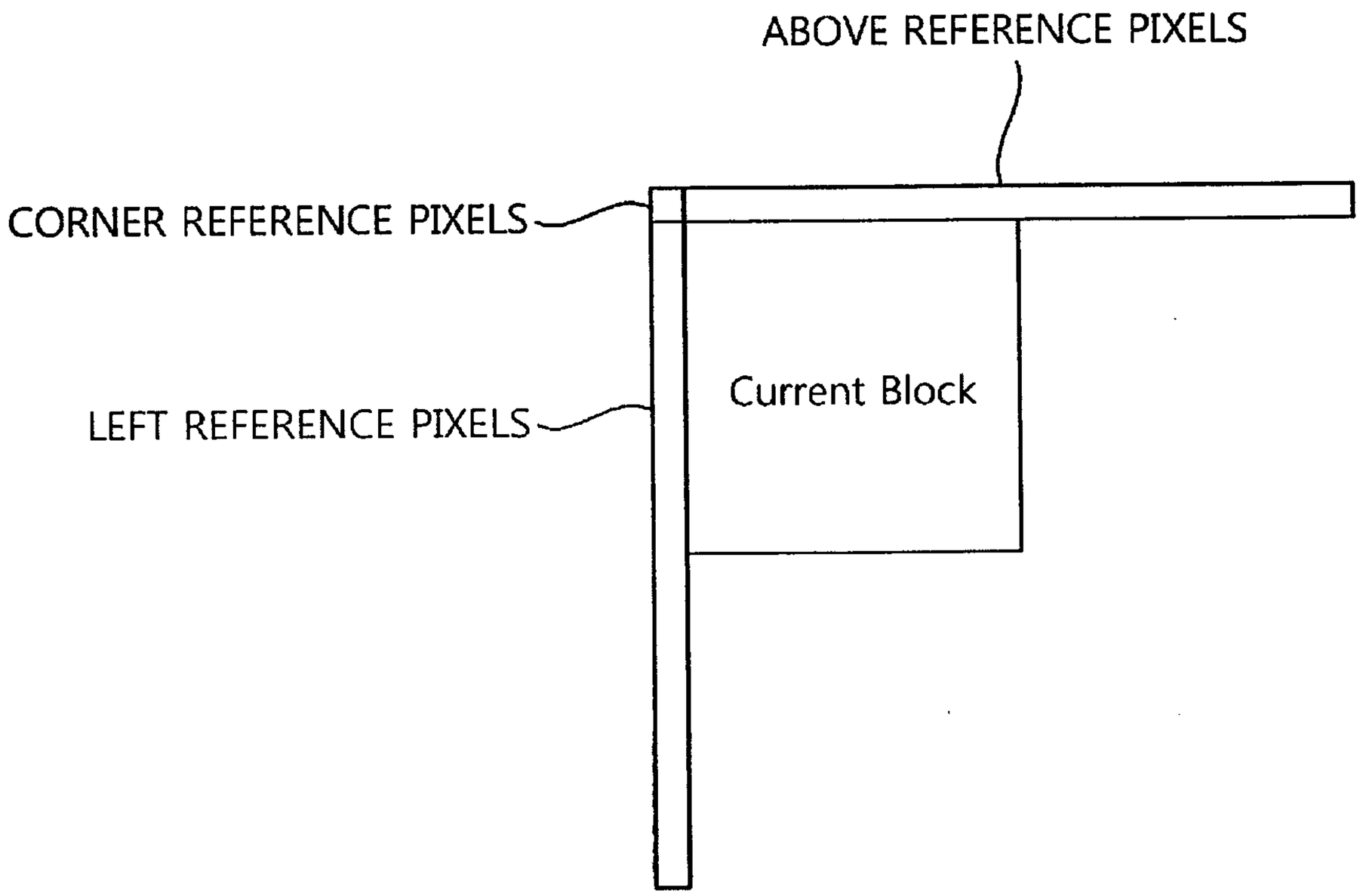

ABOVE REFERENCE PIXELS
CORNER REFERENCE PIXELS
LEFT REFERENCE PIXELS
Current Block

Fig. 7

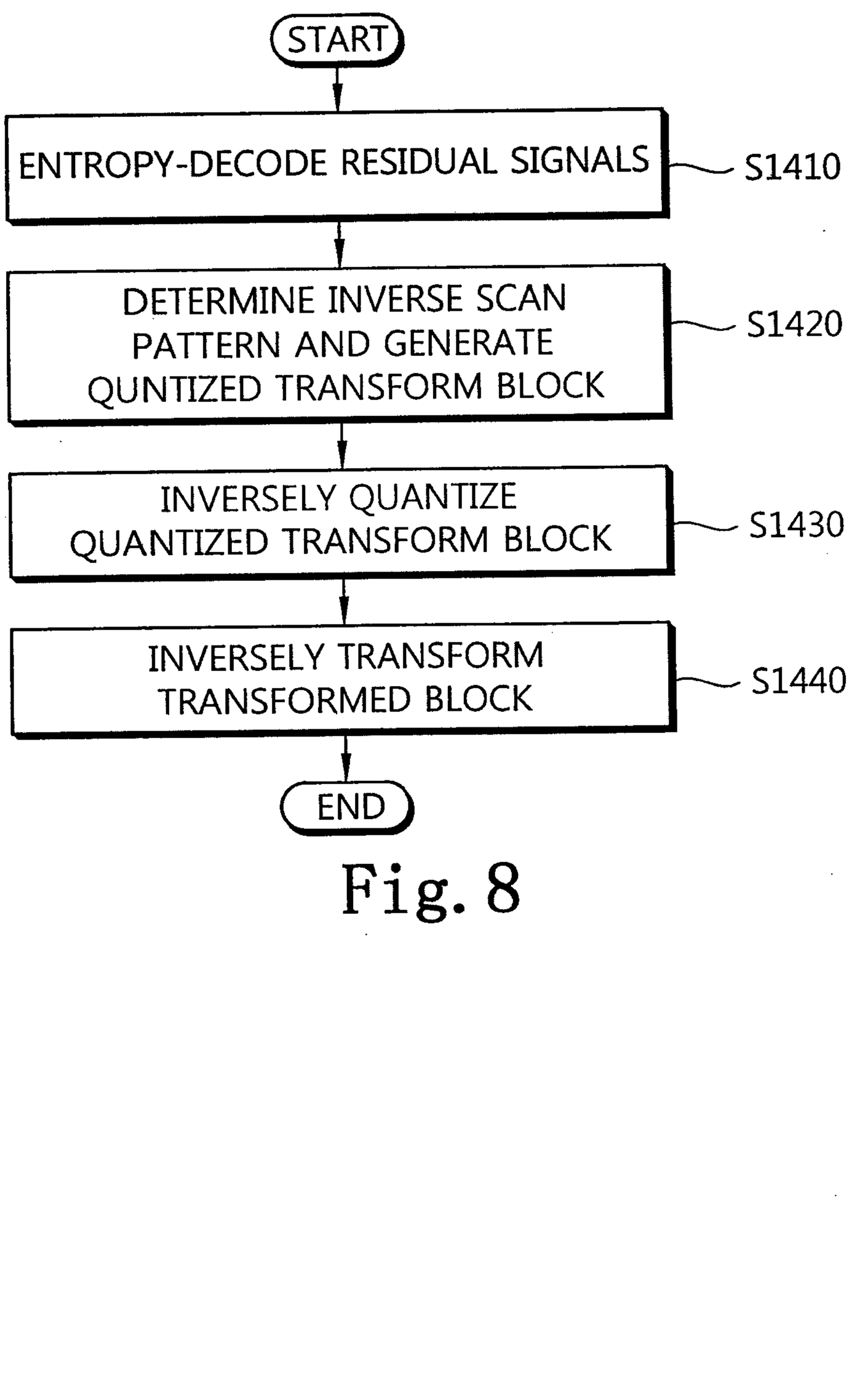

START
ENTROPY-DECODE RESIDUAL SIGNALS
S1410
DETERMINE INVERSE SCAN PATTERN AND GENERATE QUNTIZED TRANSFORM BLOCK
S1420
INVERSELY QUANTIZE QUANTIZED TRANSFORM BLOCK
S1430
INVERSELY TRANSFORM TRANSFORMED BLOCK
S1440
END

Fig. 8

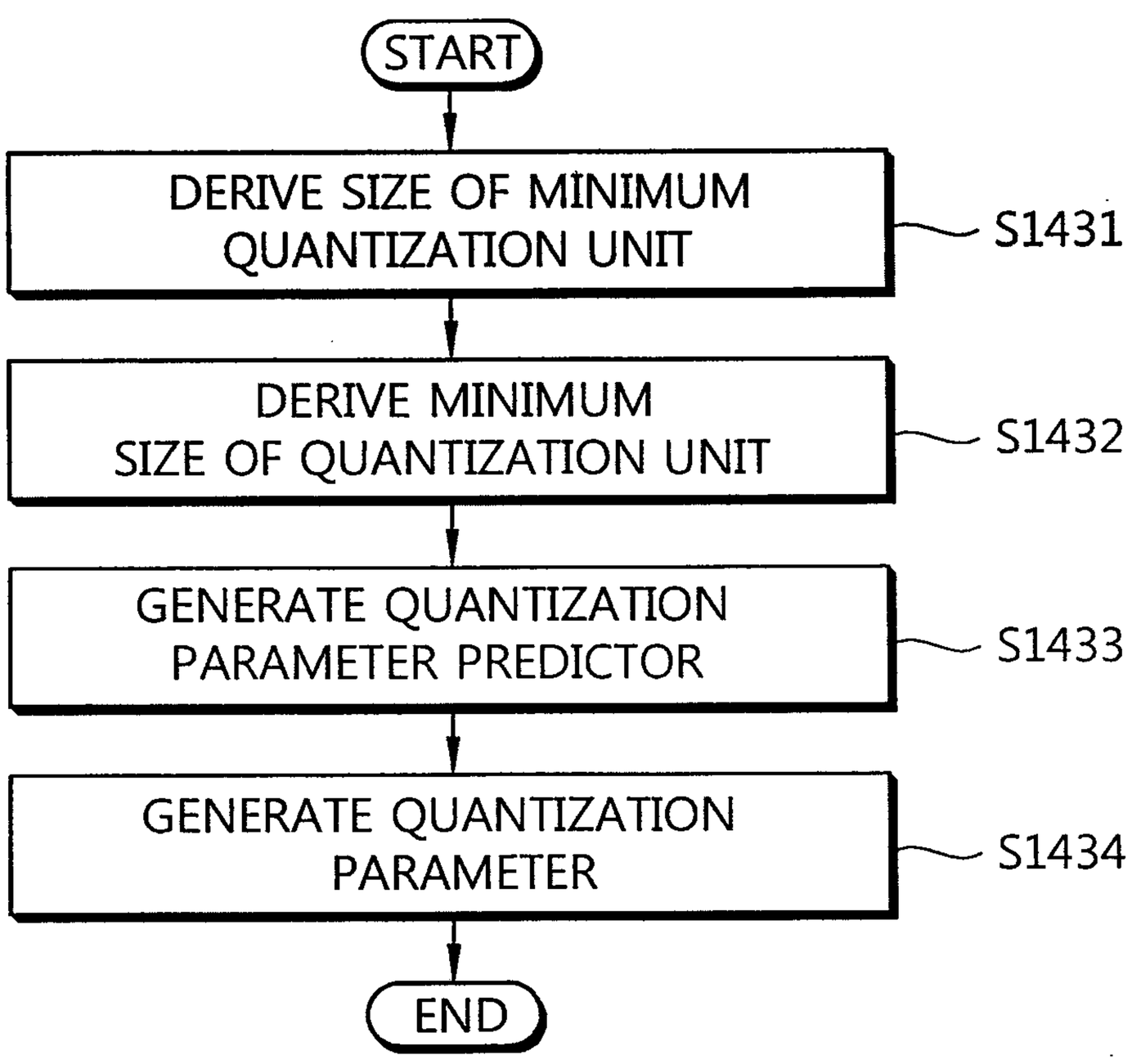

START
DERIVE SIZE OF MINIMUM QUANTIZATION UNIT
S1431
DERIVE MINIMUM SIZE OF QUANTIZATION UNIT
S1432
GENERATE QUANTIZATION PARAMETER PREDICTOR
S1433
GENERATE QUANTIZATION PARAMETER
S1434
END

Fig. 9

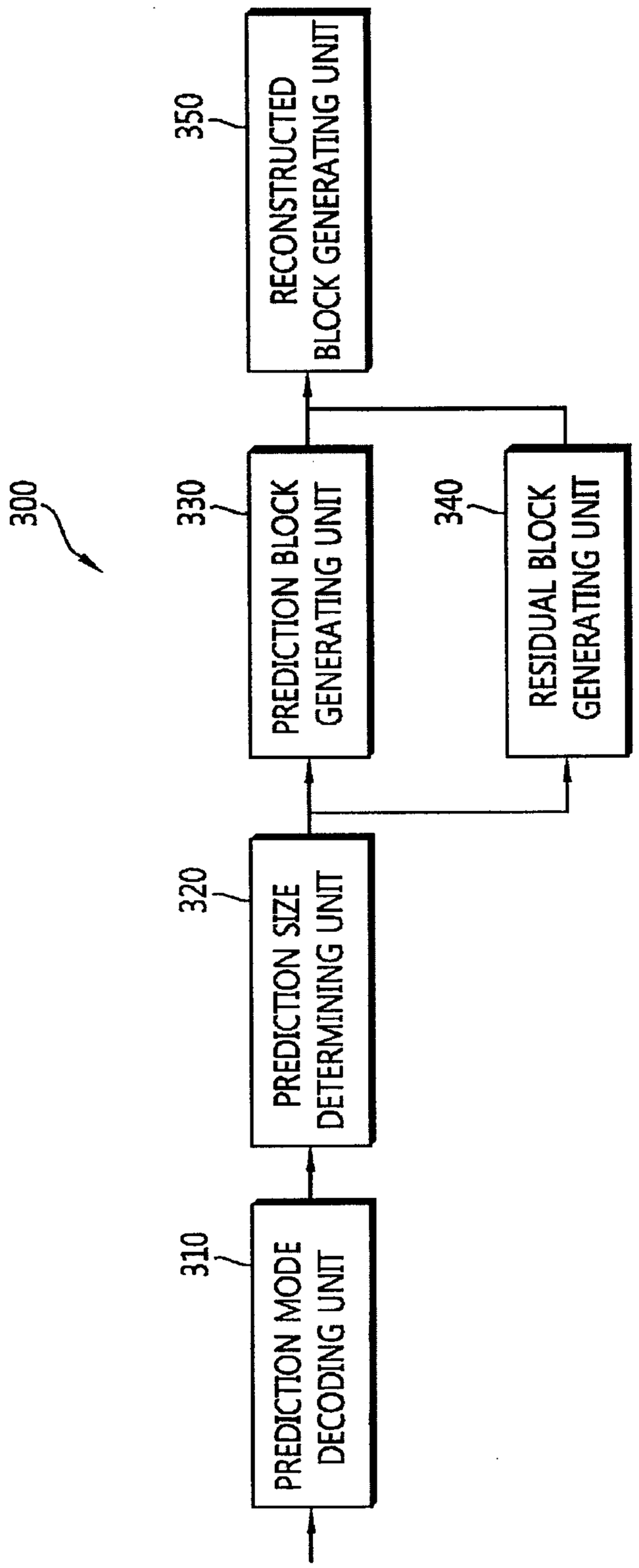
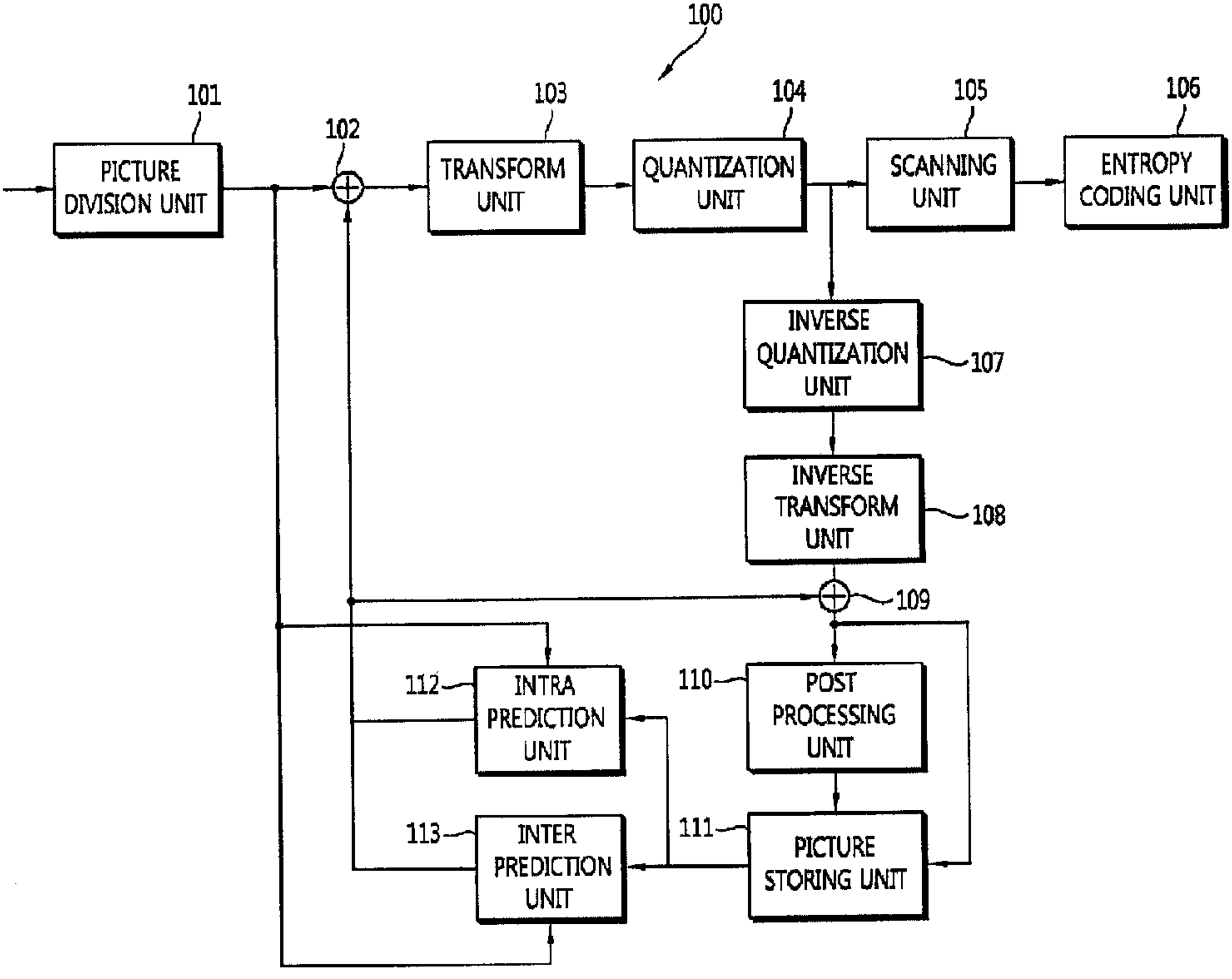

300
310
PREDICTION MODE DECODING UNIT
320
PREDICTION SIZE DETERMINING UNIT
330
PREDICTION BLOCK GENERATING UNIT
340
RESIDUAL BLOCK GENERATING UNIT
350
RECONSTRUCTED BLOCK GENERATING UNIT

Fig. 10


100
101
PICTURE DIVISION UNIT
102
103
TRANSFORM UNIT
104
QUANTIZATION UNIT
105
SCANNING UNIT
106
ENTROPY CODING UNIT
INVERSE QUANTIZATION UNIT
107
INVERSE TRANSFORM UNIT
108
109
110
POST PROCESSING UNIT
111
PICTURE STORING UNIT
112
INTRA PREDICTION UNIT
113
INTER PREDICTION UNIT