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BDPCM-based image decoding method for luma component and chroma component, and device for same

Abstract

An image decoding method performed by a decoding device according to the present document is characterized by comprising the steps of: acquiring a block-based delta pulse code modulation (BDPCM) available flag about whether a BDPCM is available for a chroma block and a luma block; acquiring, on the basis of the BDPCM available flag, a BDPCM luma flag about whether to apply the BDPCM to the current luma block; and acquiring, on the basis of the BDPCM available flag, a BDPCM chroma flag about whether to apply the BDPCM to the current chroma blocks.

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Background/Summary

(1) This is a Continuation Application of U.S. patent application Ser. No. 17/834,500, filed Jun. 7, 2022, which is a Bypass of PCT Application No. PCT/KR2020/015318, with an international filing date of Nov. 4, 2020, which claims the benefit of U.S. Provisional Application No. 62/959,763, filed on Jan. 10, 2020, all of which are incorporated by reference in their entirety herein.

BACKGROUND OF THE DISCLOSURE
Field of the Disclosure
(1) The present disclosure relates to an image coding technology, and more particularly, to an image decoding method and an apparatus thereof, which perform BDPCM in an image coding system.

Related Art

(2) Recently, demand for high-resolution, high-quality images, such as High Definition (HD) images and Ultra High Definition (UHD) images, has been increasing in various fields. As the image data has high resolution and high quality, the amount of information or bits to be transmitted increases relative to the legacy image data. Therefore, when image data is transmitted using a medium such as a conventional wired/wireless broadband line or image data is stored using an existing storage medium, the transmission cost and the storage cost thereof are increased.

(3) Accordingly, there is a need for a highly efficient image compression technique for effectively transmitting, storing, and reproducing information of high-resolution and high-quality images.

SUMMARY

(4) A technical object of the present disclosure is to provide a method and apparatus for improving image coding efficiency.

(5) Another technical object of the present disclosure is to provide a method and an apparatus for increasing efficiency of BDPCM.

(6) According to an embodiment of the present disclosure, an image decoding method performed by a decoding apparatus is provided. The method includes obtaining a Block-based Delta Pulse Code Modulation (BDPCM) enabled flag for whether BDPCM is enabled for a luma block and a chroma block, obtaining a BDPCM luma flag for whether the BDPCM is applied to a current luma block based on the BDPCM enabled flag, obtaining a BDPCM luma direction flag for a prediction direction of the current luma block based on the BDPCM luma flag, deriving prediction samples of the current luma block based on an intra prediction mode derived based on the BDPCM luma direction flag, obtaining a BDPCM chroma flag for whether the BDPCM is applied to current chroma blocks based on the BDPCM enabled flag, obtaining a BDPCM chroma direction flag for a prediction direction of the current chroma blocks based on the BDPCM chroma flag, deriving prediction samples of the current chroma blocks based on an intra prediction mode derived based on the BDPCM chroma direction flag, and generating a reconstructed picture based on the prediction samples of the current luma block and the prediction samples of the current chroma blocks.

(7) According to another embodiment of the present disclosure, a decoding apparatus performing image decoding is provided. The decoding apparatus includes an entropy decoder configured to obtain a Block-based Delta Pulse Code Modulation (BDPCM) enabled flag for whether BDPCM is enabled for a luma block and a chroma block, obtain a BDPCM luma flag for whether the BDPCM is applied to a current luma block based on the BDPCM enabled flag, obtain a BDPCM luma direction flag for a prediction direction of the current luma block based on the BDPCM luma flag, obtain a BDPCM chroma flag for whether the BDPCM is applied to current chroma blocks based on the BDPCM enabled flag, obtain a BDPCM chroma direction flag for a prediction direction of the current chroma blocks based on the BDPCM chroma flag, a predictor configured to derive prediction samples of the current chroma blocks based on an intra prediction mode derived based on the BDPCM chroma direction flag, and an adder configured to generate a reconstructed picture based on the prediction samples of the current luma block and the prediction samples of the current chroma blocks.

(8) According to still another embodiment of the present disclosure, a video encoding method performed by an encoding apparatus is provided. The method includes determining whether Block-based Delta Pulse Code Modulation (BDPCM) is enabled for a chroma block and a luma block, generating a BDPCM enabled flag for whether the BDPCM is enabled for the chroma block and the luma block based on a result of the determination, generating prediction samples for a current luma block based on the BDPCM, generating prediction samples for current chroma blocks based on the BDPCM, generating BDPCM related information for the current luma block and BDPCM related information for the current chroma blocks, and encoding image information including the BDPCM enabled flag, the BDPCM related information for the current luma block and the BDPCM

related information for the current chroma blocks, wherein the BDPCM related information for the current luma block includes a BDPCM luma flag for whether the BDPCM is applied to the current luma block and a BDPCM luma direction flag for a prediction direction of the current luma block, wherein the BDPCM related information for the current chroma blocks includes a BDPCM chroma flag for whether the BDPCM is applied to the current chroma blocks and a BDPCM chroma direction flag for a prediction direction of the current chroma blocks.

(9) According to still another embodiment of the present disclosure, a video encoding apparatus is provided. The encoding apparatus includes a predictor configured to determine whether Block-based Delta Pulse Code Modulation (BDPCM) is enabled for a chroma block and a luma block, generate prediction samples for a current luma block based on the BDPCM, generate prediction samples for current chroma blocks based on the BDPCM, and an entropy encoder configured to generate a BDPCM enabled flag for whether the BDPCM is enabled for the chroma block and the luma block based on a result of the determination, generate BDPCM related information for the current luma block and BDPCM related information for the current chroma blocks, and encode image information including the BDPCM enabled flag, the BDPCM related information for the current luma block and the BDPCM related information for the current chroma blocks, wherein the BDPCM related information for the current luma block includes a BDPCM luma flag for whether the BDPCM is applied to the current luma block and a BDPCM luma direction flag for a prediction direction of the current luma block, wherein the BDPCM related information for the current chroma blocks includes a BDPCM chroma flag for whether the BDPCM is applied to the current chroma blocks and a BDPCM chroma direction flag for a prediction direction of the current chroma blocks.

(10) According to still another embodiment of the present disclosure, a computer-readable digital storage medium storing a bitstream including image information causing to perform an image decoding method is provided. In the computer-readable digital storage medium, the image decoding method includes obtaining a Block-based Delta Pulse Code Modulation (BDPCM) enabled flag for whether BDPCM is enabled for a luma block and a chroma block, obtaining a BDPCM luma flag for whether the BDPCM is applied to a current luma block based on the BDPCM enabled flag, obtaining a BDPCM luma direction flag for a prediction direction of the current luma block based on the BDPCM luma flag, deriving prediction samples of the current luma block based on an intra prediction mode derived based on the BDPCM luma direction flag, obtaining a BDPCM chroma flag for whether the BDPCM is applied to current chroma blocks based on the BDPCM enabled flag, obtaining a BDPCM chroma direction flag for a prediction direction of the current chroma blocks based on the BDPCM chroma flag, deriving prediction samples of the current chroma blocks based on an intra prediction mode derived based on the BDPCM chroma direction flag, and generating a reconstructed picture based on the prediction samples of the current luma block and the prediction samples of the current chroma blocks.

(11) According to the present disclosure, whether the BDPCM of the luma block and the chroma block in an image is enabled can be determined through one syntax element, and through this, a bit amount for the BDPCM can be reduced, and the overall coding efficiency can be improved.

(12) According to the present disclosure, the BDPCM enabled flag representing whether the BDPCM of the luma block and the chroma block in an image is enabled can be signaled regardless of a chroma format of the image, and through this, complexity for the BDPCM can be reduced, and the overall coding efficiency can be improved.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** briefly illustrates an example of a video/image coding device to which embodiments of

the present disclosure are applicable.

(2) FIG. **2** is a schematic diagram illustrating a configuration of a video/image encoding apparatus to which the embodiment(s) of the present disclosure may be applied.

(3) FIG. **3** is a schematic diagram illustrating a configuration of a video/image decoding apparatus to which the embodiment(s) of the present disclosure may be applied.

(4) FIG. **4** schematically shows a hierarchical structure for a coded image/video.

(5) FIG. **5** schematically shows context-adaptive binary arithmetic coding (CABAC) for encoding a syntax element.

(6) FIG. **6** illustrates an example of an intra prediction-based video/image encoding method.

(7) FIG. **7** illustrates an example of an intra prediction-based video/image encoding method.

(8) FIG. **8** schematically shows an intra prediction procedure.

(9) FIG. **9** schematically shows an image encoding method by an encoding apparatus according to the present document.

(10) FIG. **10** schematically shows an encoding apparatus for performing an image encoding method according to this document.

(11) FIG. **11** schematically shows an image decoding method by a decoding apparatus according to this document.

(12) FIG. **12** schematically shows a decoding apparatus for performing an image decoding method according to this document.

(13) FIG. **13** illustrates a structural diagram of a contents streaming system to which the present disclosure is applied.

DESCRIPTION OF EMBODIMENTS

(14) The present disclosure may be modified in various forms, and specific embodiments thereof will be described and illustrated in the drawings. However, the embodiments are not intended for limiting the disclosure. The terms used in the following description are used to merely describe specific embodiments but are not intended to limit the disclosure. An expression of a singular number includes an expression of the plural number, so long as it is clearly read differently. The terms such as "include" and "have" are intended to indicate that features, numbers, steps, operations, elements, components, or combinations thereof used in the following description exist and it should be thus understood that the possibility of existence or addition of one or more different features, numbers, steps, operations, elements, components, or combinations thereof is not excluded.

(15) Meanwhile, elements in the drawings described in the disclosure are independently drawn for the purpose of convenience for explanation of different specific functions, and do not mean that the elements are embodied by independent hardware or independent software. For example, two or more elements of the elements may be combined to form a single element, or one element may be partitioned into plural elements. The embodiments in which the elements are combined and/or partitioned belong to the disclosure without departing from the concept of the disclosure.

(16) Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. In addition, like reference numerals are used to indicate like elements throughout the drawings, and the same descriptions on the like elements will be omitted.

(17) FIG. **1** briefly illustrates an example of a video/image coding device to which embodiments of the present disclosure are applicable.

(18) Referring to FIG. **1**, a video/image coding system may include a first device (source device) and a second device (receiving device). The source device may deliver encoded video/image information or data in the form of a file or streaming to the receiving device via a digital storage medium or network.

(19) The source device may include a video source, an encoding apparatus, and a transmitter. The receiving device may include a receiver, a decoding apparatus, and a renderer. The encoding apparatus may be called a video/image encoding apparatus, and the decoding apparatus may be

called a video/image decoding apparatus. The transmitter may be included in the encoding apparatus. The receiver may be included in the decoding apparatus. The renderer may include a display, and the display may be configured as a separate device or an external component.

(20) The video source may acquire video/image through a process of capturing, synthesizing, or generating the video/image. The video source may include a video/image capture device and/or a video/image generating device. The video/image capture device may include, for example, one or more cameras, video/image archives including previously captured video/images, and the like. The video/image generating device may include, for example, computers, tablets and smartphones, and may (electronically) generate video/images. For example, a virtual video/image may be generated through a computer or the like. In this case, the video/image capturing process may be replaced by a process of generating related data.

(21) The encoding apparatus may encode input image/image. The encoding apparatus may perform a series of procedures such as prediction, transform, and quantization for compression and coding efficiency. The encoded data (encoded video/image information) may be output in the form of a bitstream.

(22) The transmitter may transmit the encoded image/image information or data output in the form of a bitstream to the receiver of the receiving device through a digital storage medium or a network in the form of a file or streaming. The digital storage medium may include various storage mediums such as USB, SD, CD, DVD, Blu-ray, HDD, SSD, and the like. The transmitter may include an element for generating a media file through a predetermined file format and may include an element for transmission through a broadcast/communication network. The receiver may receive/extract the bitstream and transmit the received bitstream to the decoding apparatus.

(23) The decoding apparatus may decode the video/image by performing a series of procedures such as dequantization, inverse transform, and prediction corresponding to the operation of the encoding apparatus.

(24) The renderer may render the decoded video/image. The rendered video/image may be displayed through the display.

(25) Present disclosure relates to video/image coding. For example, the methods/embodiments disclosed in the present disclosure may be applied to a method disclosed in the versatile video coding (VVC), the EVC (essential video coding) standard, the AOMedia Video 1 (AV1) standard, the 2nd generation of audio video coding standard (AVS2), or the next generation video/image coding standard (ex. H.267 or H.268, etc.).

(26) Present disclosure presents various embodiments of video/image coding, and the embodiments may be performed in combination with each other unless otherwise mentioned.

(27) In the present disclosure, video may refer to a series of images over time. Picture generally refers to a unit representing one image in a specific time zone, and a subpicture/slice/tile is a unit constituting part of a picture in coding. The subpicture/slice/tile may include one or more coding tree units (CTUs). One picture may consist of one or more subpictures/slices/tiles. One picture may consist of one or more tile groups. One tile group may include one or more tiles. A brick may represent a rectangular region of CTU rows within a tile in a picture. A tile may be partitioned into multiple bricks, each of which consisting of one or more CTU rows within the tile. A tile that is not partitioned into multiple bricks may be also referred to as a brick. A brick scan is a specific sequential ordering of CTUs partitioning a picture in which the CTUs are ordered consecutively in CTU raster scan in a brick, bricks within a tile are ordered consecutively in a raster scan of the bricks of the tile, and tiles in a picture are ordered consecutively in a raster scan of the tiles of the picture. In addition, a subpicture may represent a rectangular region of one or more slices within a picture. That is, a subpicture contains one or more slices that collectively cover a rectangular region of a picture. A tile is a rectangular region of CTUs within a particular tile column and a particular tile row in a picture. The tile column is a rectangular region of CTUs having a height equal to the height of the picture and a width specified by syntax elements in the picture parameter set. The tile

row is a rectangular region of CTUs having a height specified by syntax elements in the picture parameter set and a width equal to the width of the picture. A tile scan is a specific sequential ordering of CTUs partitioning a picture in which the CTUs are ordered consecutively in CTU raster scan in a tile whereas tiles in a picture are ordered consecutively in a raster scan of the tiles of the picture. A slice includes an integer number of bricks of a picture that may be exclusively contained in a single NAL unit. A slice may consist of either a number of complete tiles or only a consecutive sequence of complete bricks of one tile. Tile groups and slices may be used interchangeably in the present disclosure. For example, in the present disclosure, a tile group/tile group header may be called a slice/slice header.

(28) A pixel or a pel may mean a smallest unit constituting one picture (or image). Also, 'sample' may be used as a term corresponding to a pixel. A sample may generally represent a pixel or a value of a pixel, and may represent only a pixel/pixel value of a luma component or only a pixel/pixel value of a chroma component.

(29) A unit may represent a basic unit of image processing. The unit may include at least one of a specific region of the picture and information related to the region. One unit may include one luma block and two chroma (ex. cb, cr) blocks. The unit may be used interchangeably with terms such as block or area in some cases. In a general case, an M×N block may include samples (or sample arrays) or a set (or array) of transform coefficients of M columns and N rows.

(30) In the present description, "A or B" may mean "only A", "only B" or "both A and B". In other words, in the present specification, "A or B" may be interpreted as "A and/or B". For example, "A, B or C" herein means "only A", "only B", "only C", or "any and any combination of A, B and C".

(31) A slash (/) or a comma (comma) used in the present description may mean "and/or". For example, "A/B" may mean "A and/or B". Accordingly, "A/B" may mean "only A", "only B", or "both A and B". For example, "A, B, C" may mean "A, B, or C".

(32) In the present description, "at least one of A and B" may mean "only A", "only B", or "both A and B". In addition, in the present description, the expression "at least one of A or B" or "at least one of A and/or B" may be interpreted the same as "at least one of A and B".

(33) In addition, in the present description, "at least one of A, B and C" means "only A", "only B", "only C", or "any combination of A, B and C". Also, "at least one of A, B or C" or "at least one of A, B and/or C" may mean "at least one of A, B and C".

(34) In addition, parentheses used in the present description may mean "for example". Specifically, when "prediction (intra prediction)" is indicated, "intra prediction" may be proposed as an example of "prediction". In other words, "prediction" in the present description is not limited to "intra prediction", and "intra prediction" may be proposed as an example of "prediction". Also, even when "prediction (ie, intra prediction)" is indicated, "intra prediction" may be proposed as an example of "prediction".

(35) In the present description, technical features that are individually described within one drawing may be implemented individually or may be implemented at the same time.

(36) The following drawings were created to explain a specific example of the present description. Since the names of specific devices described in the drawings or the names of specific signals/messages/fields are presented by way of example, the technical features of the present description are not limited to the specific names used in the following drawings.

(37) FIG. **2** is a schematic diagram illustrating a configuration of a video/image encoding apparatus to which the embodiment(s) of the present disclosure may be applied. Hereinafter, the video encoding apparatus may include an image encoding apparatus.

(38) Referring to FIG. **2**, the encoding apparatus **200** includes an image partitioner **210**, a predictor **220**, a residual processor **230**, and an entropy encoder **240**, an adder **250**, a filter **260**, and a memory **270**. The predictor **220** may include an inter predictor **221** and an intra predictor **222**. The residual processor **230** may include a transformer **232**, a quantizer **233**, a dequantizer **234**, and an inverse transformer **235**. The residual processor **230** may further include a subtractor **231**. The

adder **250** may be called a reconstructor or a reconstructed block generator. The image partitioner **210**, the predictor **220**, the residual processor **230**, the entropy encoder **240**, the adder **250**, and the filter **260** may be configured by at least one hardware component (ex. An encoder chipset or processor) according to an embodiment. In addition, the memory **270** may include a decoded picture buffer (DPB) or may be configured by a digital storage medium. The hardware component may further include the memory **270** as an internal/external component.

(39) The image partitioner **210** may partition an input image (or a picture or a frame) input to the encoding apparatus **200** into one or more processors. For example, the processor may be called a coding unit (CU). In this case, the coding unit may be recursively partitioned according to a quad-tree binary-tree ternary-tree (QTBTTT) structure from a coding tree unit (CTU) or a largest coding unit (LCU). For example, one coding unit may be partitioned into a plurality of coding units of a deeper depth based on a quad tree structure, a binary tree structure, and/or a ternary structure. In this case, for example, the quad tree structure may be applied first and the binary tree structure and/or ternary structure may be applied later. Alternatively, the binary tree structure may be applied first. The coding procedure according to the present disclosure may be performed based on the final coding unit that is no longer partitioned. In this case, the largest coding unit may be used as the final coding unit based on coding efficiency according to image characteristics, or if necessary, the coding unit may be recursively partitioned into coding units of deeper depth and a coding unit having an optimal size may be used as the final coding unit. Here, the coding procedure may include a procedure of prediction, transform, and reconstruction, which will be described later. As another example, the processor may further include a prediction unit (PU) or a transform unit (TU). In this case, the prediction unit and the transform unit may be split or partitioned from the aforementioned final coding unit. The prediction unit may be a unit of sample prediction, and the transform unit may be a unit for deriving a transform coefficient and/or a unit for deriving a residual signal from the transform coefficient.

(40) The unit may be used interchangeably with terms such as block or area in some cases. In a general case, an M×N block may represent a set of samples or transform coefficients composed of M columns and N rows. A sample may generally represent a pixel or a value of a pixel, may represent only a pixel/pixel value of a luma component or represent only a pixel/pixel value of a chroma component. A sample may be used as a term corresponding to one picture (or image) for a pixel or a pel.

(41) In the encoding apparatus **200**, a prediction signal (predicted block, prediction sample array) output from the inter predictor **221** or the intra predictor **222** is subtracted from an input image signal (original block, original sample array) to generate a residual signal residual block, residual sample array), and the generated residual signal is transmitted to the transformer **232**. In this case, as shown, a unit for subtracting a prediction signal (predicted block, prediction sample array) from the input image signal (original block, original sample array) in the encoder **200** may be called a subtractor **231**. The predictor may perform prediction on a block to be processed (hereinafter, referred to as a current block) and generate a predicted block including prediction samples for the current block. The predictor may determine whether intra prediction or inter prediction is applied on a current block or CU basis. As described later in the description of each prediction mode, the predictor may generate various information related to prediction, such as prediction mode information, and transmit the generated information to the entropy encoder **240**. The information on the prediction may be encoded in the entropy encoder **240** and output in the form of a bitstream.

(42) The intra predictor **222** may predict the current block by referring to the samples in the current picture. The referred samples may be located in the neighborhood of the current block or may be located apart according to the prediction mode. In the intra prediction, prediction modes may include a plurality of non-directional modes and a plurality of directional modes. The non-directional mode may include, for example, a DC mode and a planar mode. The directional mode may include, for example, 33 directional prediction modes or 65 directional prediction modes

according to the degree of detail of the prediction direction. However, this is merely an example, more or less directional prediction modes may be used depending on a setting. The intra predictor **222** may determine the prediction mode applied to the current block by using a prediction mode applied to a neighboring block.

(43) The inter predictor **221** may derive a predicted block for the current block based on a reference block (reference sample array) specified by a motion vector on a reference picture. Here, in order to reduce the amount of motion information transmitted in the inter prediction mode, the motion information may be predicted in units of blocks, sub-blocks, or samples based on correlation of motion information between the neighboring block and the current block. The motion information may include a motion vector and a reference picture index. The motion information may further include inter prediction direction (L0 prediction, L1 prediction, Bi prediction, etc.) information. In the case of inter prediction, the neighboring block may include a spatial neighboring block present in the current picture and a temporal neighboring block present in the reference picture. The reference picture including the reference block and the reference picture including the temporal neighboring block may be the same or different. The temporal neighboring block may be called a collocated reference block, a co-located CU (colCU), and the like, and the reference picture including the temporal neighboring block may be called a collocated picture (colPic). For example, the inter predictor **221** may configure a motion information candidate list based on neighboring blocks and generate information indicating which candidate is used to derive a motion vector and/or a reference picture index of the current block. Inter prediction may be performed based on various prediction modes. For example, in the case of a skip mode and a merge mode, the inter predictor **221** may use motion information of the neighboring block as motion information of the current block. In the skip mode, unlike the merge mode, the residual signal may not be transmitted. In the case of the motion vector prediction (MVP) mode, the motion vector of the neighboring block may be used as a motion vector predictor and the motion vector of the current block may be indicated by signaling a motion vector difference.

(44) The predictor **220** may generate a prediction signal based on various prediction methods described below. For example, the predictor may not only apply intra prediction or inter prediction to predict one block but also simultaneously apply both intra prediction and inter prediction. This may be called combined inter and intra prediction (CIIP). In addition, the predictor may be based on an intra block copy (IBC) prediction mode or a palette mode for prediction of a block. The IBC prediction mode or palette mode may be used for content image/video coding of a game or the like, for example, screen content coding (SCC). The IBC basically performs prediction in the current picture but may be performed similarly to inter prediction in that a reference block is derived in the current picture. That is, the IBC may use at least one of the inter prediction techniques described in the present disclosure. The palette mode may be considered as an example of intra coding or intra prediction. When the palette mode is applied, a sample value within a picture may be signaled based on information on the palette table and the palette index.

(45) The prediction signal generated by the predictor (including the inter predictor **221** and/or the intra predictor **222**) may be used to generate a reconstructed signal or to generate a residual signal. The transformer **232** may generate transform coefficients by applying a transform technique to the residual signal. For example, the transform technique may include at least one of a discrete cosine transform (DCT), a discrete sine transform (DST), a karhunen-loeve transform (KLT), a graph-based transform (GBT), or a conditionally non-linear transform (CNT). Here, the GBT means transform obtained from a graph when relationship information between pixels is represented by the graph. The CNT refers to transform generated based on a prediction signal generated using all previously reconstructed pixels. In addition, the transform process may be applied to square pixel blocks having the same size or may be applied to blocks having a variable size rather than square.

(46) The quantizer **233** may quantize the transform coefficients and transmit them to the entropy encoder **240** and the entropy encoder **240** may encode the quantized signal (information on the

quantized transform coefficients) and output a bitstream. The information on the quantized transform coefficients may be referred to as residual information. The quantizer **233** may rearrange block type quantized transform coefficients into a one-dimensional vector form based on a coefficient scanning order and generate information on the quantized transform coefficients based on the quantized transform coefficients in the one-dimensional vector form. Information on transform coefficients may be generated. The entropy encoder **240** may perform various encoding methods such as, for example, exponential Golomb, context-adaptive variable length coding (CAVLC), context-adaptive binary arithmetic coding (CABAC), and the like. The entropy encoder **240** may encode information necessary for video/image reconstruction other than quantized transform coefficients (ex. values of syntax elements, etc.) together or separately. Encoded information (ex. encoded video/image information) may be transmitted or stored in units of NALs (network abstraction layer) in the form of a bitstream. The video/image information may further include information on various parameter sets such as an adaptation parameter set (APS), a picture parameter set (PPS), a sequence parameter set (SPS), or a video parameter set (VPS). In addition, the video/image information may further include general constraint information. In the present disclosure, information and/or syntax elements transmitted/signaled from the encoding apparatus to the decoding apparatus may be included in video/picture information. The video/image information may be encoded through the above-described encoding procedure and included in the bitstream. The bitstream may be transmitted over a network or may be stored in a digital storage medium. The network may include a broadcasting network and/or a communication network, and the digital storage medium may include various storage media such as USB, SD, CD, DVD, Blu-ray, HDD, SSD, and the like. A transmitter (not shown) transmitting a signal output from the entropy encoder **240** and/or a storage unit (not shown) storing the signal may be included as internal/external element of the encoding apparatus **200**, and alternatively, the transmitter may be included in the entropy encoder **240**.

(47) The quantized transform coefficients output from the quantizer **233** may be used to generate a prediction signal. For example, the residual signal (residual block or residual samples) may be reconstructed by applying dequantization and inverse transform to the quantized transform coefficients through the dequantizer **234** and the inverse transformer **235**. The adder **250** adds the reconstructed residual signal to the prediction signal output from the inter predictor **221** or the intra predictor **222** to generate a reconstructed signal (reconstructed picture, reconstructed block, reconstructed sample array). If there is no residual for the block to be processed, such as a case where the skip mode is applied, the predicted block may be used as the reconstructed block. The adder **250** may be called a reconstructor or a reconstructed block generator. The generated reconstructed signal may be used for intra prediction of a next block to be processed in the current picture and may be used for inter prediction of a next picture through filtering as described below.

(48) Meanwhile, luma mapping with chroma scaling (LMCS) may be applied during picture encoding and/or reconstruction.

(49) The filter **260** may improve subjective/objective image quality by applying filtering to the reconstructed signal. For example, the filter **260** may generate a modified reconstructed picture by applying various filtering methods to the reconstructed picture and store the modified reconstructed picture in the memory **270**, specifically, a DPB of the memory **270**. The various filtering methods may include, for example, deblocking filtering, a sample adaptive offset, an adaptive loop filter, a bilateral filter, and the like. The filter **260** may generate various information related to the filtering and transmit the generated information to the entropy encoder **240** as described later in the description of each filtering method. The information related to the filtering may be encoded by the entropy encoder **240** and output in the form of a bitstream.

(50) The modified reconstructed picture transmitted to the memory **270** may be used as the reference picture in the inter predictor **221**. When the inter prediction is applied through the encoding apparatus, prediction mismatch between the encoding apparatus **200** and the decoding

apparatus **300** may be avoided and encoding efficiency may be improved.

(51) The DPB of the memory **270** DPB may store the modified reconstructed picture for use as a reference picture in the inter predictor **221**. The memory **270** may store the motion information of the block from which the motion information in the current picture is derived (or encoded) and/or the motion information of the blocks in the picture that have already been reconstructed. The stored motion information may be transmitted to the inter predictor **221** and used as the motion information of the spatial neighboring block or the motion information of the temporal neighboring block. The memory **270** may store reconstructed samples of reconstructed blocks in the current picture and may transfer the reconstructed samples to the intra predictor **222**.

(52) FIG. **3** is a schematic diagram illustrating a configuration of a video/image decoding apparatus to which the embodiment(s) of the present disclosure may be applied.

(53) Referring to FIG. **3**, the decoding apparatus **300** may include an entropy decoder **310**, a residual processor **320**, a predictor **330**, an adder **340**, a filter **350**, a memory **360**. The predictor **330** may include an inter predictor **331** and an intra predictor **332**. The residual processor **320** may include a dequantizer **321** and an inverse transformer **322**. The entropy decoder **310**, the residual processor **320**, the predictor **330**, the adder **340**, and the filter **350** may be configured by a hardware component (ex. A decoder chipset or a processor) according to an embodiment. In addition, the memory **360** may include a decoded picture buffer (DPB) or may be configured by a digital storage medium. The hardware component may further include the memory **360** as an internal/external component.

(54) When a bitstream including video/image information is input, the decoding apparatus **300** may reconstruct an image corresponding to a process in which the video/image information is processed in the encoding apparatus of FIG. **2**. For example, the decoding apparatus **300** may derive units/blocks based on block partition related information obtained from the bitstream. The decoding apparatus **300** may perform decoding using a processor applied in the encoding apparatus. Thus, the processor of decoding may be a coding unit, for example, and the coding unit may be partitioned according to a quad tree structure, binary tree structure and/or ternary tree structure from the coding tree unit or the largest coding unit. One or more transform units may be derived from the coding unit. The reconstructed image signal decoded and output through the decoding apparatus **300** may be reproduced through a reproducing apparatus.

(55) The decoding apparatus **300** may receive a signal output from the encoding apparatus of FIG. **2** in the form of a bitstream, and the received signal may be decoded through the entropy decoder **310**. For example, the entropy decoder **310** may parse the bitstream to derive information (ex. video/image information) necessary for image reconstruction (or picture reconstruction). The video/image information may further include information on various parameter sets such as an adaptation parameter set (APS), a picture parameter set (PPS), a sequence parameter set (SPS), or a video parameter set (VPS). In addition, the video/image information may further include general constraint information. The decoding apparatus may further decode picture based on the information on the parameter set and/or the general constraint information. Signaled/received information and/or syntax elements described later in the present disclosure may be decoded may decode the decoding procedure and obtained from the bitstream. For example, the entropy decoder **310** decodes the information in the bitstream based on a coding method such as exponential Golomb coding, CAVLC, or CABAC, and output syntax elements required for image reconstruction and quantized values of transform coefficients for residual. More specifically, the CABAC entropy decoding method may receive a bin corresponding to each syntax element in the bitstream, determine a context model using a decoding target syntax element information, decoding information of a decoding target block or information of a symbol/bin decoded in a previous stage, and perform an arithmetic decoding on the bin by predicting a probability of occurrence of a bin according to the determined context model, and generate a symbol corresponding to the value of each syntax element. In this case, the CABAC entropy decoding method may update the context

model by using the information of the decoded symbol/bin for a context model of a next symbol/bin after determining the context model. The information related to the prediction among the information decoded by the entropy decoder **310** may be provided to the predictor (the inter predictor **332** and the intra predictor **331**), and the residual value on which the entropy decoding was performed in the entropy decoder **310**, that is, the quantized transform coefficients and related parameter information, may be input to the residual processor **320**. The residual processor **320** may derive the residual signal (the residual block, the residual samples, the residual sample array). In addition, information on filtering among information decoded by the entropy decoder **310** may be provided to the filter **350**. Meanwhile, a receiver (not shown) for receiving a signal output from the encoding apparatus may be further configured as an internal/external element of the decoding apparatus **300**, or the receiver may be a component of the entropy decoder **310**. Meanwhile, the decoding apparatus according to the present disclosure may be referred to as a video/image/picture decoding apparatus, and the decoding apparatus may be classified into an information decoder (video/image/picture information decoder) and a sample decoder (video/image/picture sample decoder). The information decoder may include the entropy decoder **310**, and the sample decoder may include at least one of the dequantizer **321**, the inverse transformer **322**, the adder **340**, the filter **350**, the memory **360**, the inter predictor **332**, and the intra predictor **331**.

(56) The dequantizer **321** may dequantize the quantized transform coefficients and output the transform coefficients. The dequantizer **321** may rearrange the quantized transform coefficients in the form of a two-dimensional block form. In this case, the rearrangement may be performed based on the coefficient scanning order performed in the encoding apparatus. The dequantizer **321** may perform dequantization on the quantized transform coefficients by using a quantization parameter (ex. quantization step size information) and obtain transform coefficients.

(57) The inverse transformer **322** inversely transforms the transform coefficients to obtain a residual signal (residual block, residual sample array).

(58) The predictor may perform prediction on the current block and generate a predicted block including prediction samples for the current block. The predictor may determine whether intra prediction or inter prediction is applied to the current block based on the information on the prediction output from the entropy decoder **310** and may determine a specific intra/inter prediction mode.

(59) The predictor **320** may generate a prediction signal based on various prediction methods described below. For example, the predictor may not only apply intra prediction or inter prediction to predict one block but also simultaneously apply intra prediction and inter prediction. This may be called combined inter and intra prediction (CIIP). In addition, the predictor may be based on an intra block copy (IBC) prediction mode or a palette mode for prediction of a block. The IBC prediction mode or palette mode may be used for content image/video coding of a game or the like, for example, screen content coding (SCC). The IBC basically performs prediction in the current picture but may be performed similarly to inter prediction in that a reference block is derived in the current picture. That is, the IBC may use at least one of the inter prediction techniques described in the present disclosure. The palette mode may be considered as an example of intra coding or intra prediction. When the palette mode is applied, a sample value within a picture may be signaled based on information on the palette table and the palette index.

(60) The intra predictor **331** may predict the current block by referring to the samples in the current picture. The referred samples may be located in the neighborhood of the current block or may be located apart according to the prediction mode. In the intra prediction, prediction modes may include a plurality of non-directional modes and a plurality of directional modes. The intra predictor **331** may determine the prediction mode applied to the current block by using a prediction mode applied to a neighboring block.

(61) The inter predictor **332** may derive a predicted block for the current block based on a reference block (reference sample array) specified by a motion vector on a reference picture. In this case, in

order to reduce the amount of motion information transmitted in the inter prediction mode, motion information may be predicted in units of blocks, sub-blocks, or samples based on correlation of motion information between the neighboring block and the current block. The motion information may include a motion vector and a reference picture index. The motion information may further include inter prediction direction (L0 prediction, L1 prediction, Bi prediction, etc.) information. In the case of inter prediction, the neighboring block may include a spatial neighboring block present in the current picture and a temporal neighboring block present in the reference picture. For example, the inter predictor **332** may configure a motion information candidate list based on neighboring blocks and derive a motion vector of the current block and/or a reference picture index based on the received candidate selection information. Inter prediction may be performed based on various prediction modes, and the information on the prediction may include information indicating a mode of inter prediction for the current block.

(62) The adder **340** may generate a reconstructed signal (reconstructed picture, reconstructed block, reconstructed sample array) by adding the obtained residual signal to the prediction signal (predicted block, predicted sample array) output from the predictor (including the inter predictor **332** and/or the intra predictor **331**). If there is no residual for the block to be processed, such as when the skip mode is applied, the predicted block may be used as the reconstructed block.

(63) The adder **340** may be called reconstructor or a reconstructed block generator. The generated reconstructed signal may be used for intra prediction of a next block to be processed in the current picture, may be output through filtering as described below, or may be used for inter prediction of a next picture.

(64) Meanwhile, luma mapping with chroma scaling (LMCS) may be applied in the picture decoding process.

(65) The filter **350** may improve subjective/objective image quality by applying filtering to the reconstructed signal. For example, the filter **350** may generate a modified reconstructed picture by applying various filtering methods to the reconstructed picture and store the modified reconstructed picture in the memory **360**, specifically, a DPB of the memory **360**. The various filtering methods may include, for example, deblocking filtering, a sample adaptive offset, an adaptive loop filter, a bilateral filter, and the like.

(66) The (modified) reconstructed picture stored in the DPB of the memory **360** may be used as a reference picture in the inter predictor **332**. The memory **360** may store the motion information of the block from which the motion information in the current picture is derived (or decoded) and/or the motion information of the blocks in the picture that have already been reconstructed. The stored motion information may be transmitted to the inter predictor **260** so as to be utilized as the motion information of the spatial neighboring block or the motion information of the temporal neighboring block. The memory **360** may store reconstructed samples of reconstructed blocks in the current picture and transfer the reconstructed samples to the intra predictor **331**.

(67) In the present disclosure, the embodiments described in the filter **260**, the inter predictor **221**, and the intra predictor **222** of the encoding apparatus **200** may be the same as or respectively applied to correspond to the filter **350**, the inter predictor **332**, and the intra predictor **331** of the decoding apparatus **300**. The same may also apply to the unit **332** and the intra predictor **331**.

(68) In the present disclosure, at least one of quantization/inverse quantization and/or transform/inverse transform may be omitted. When the quantization/inverse quantization is omitted, the quantized transform coefficients may be called transform coefficients. When the transform/inverse transform is omitted, the transform coefficients may be called coefficients or residual coefficients, or may still be called transform coefficients for uniformity of expression.

(69) In the present disclosure, a quantized transform coefficient and a transform coefficient may be referred to as a transform coefficient and a scaled transform coefficient, respectively. In this case, the residual information may include information on transform coefficient(s), and the information on the transform coefficient(s) may be signaled through residual coding syntax. Transform

coefficients may be derived based on the residual information (or the information on the transform coefficient(s)), and scaled transform coefficients may be derived by inverse transforming (scaling) on the transform coefficients. Residual samples may be derived based on the inverse transforming (transforming) on the scaled transform coefficients. This may be applied/expressed in other parts of the present disclosure as well.

(70) FIG. **4** schematically shows a hierarchical structure for a coded image/video.

(71) Referring to FIG. **4**, the coded image/video is divided into a video coding layer (VCL) that handles decoding processing of the image/video and itself, a subsystem that transmits and stores coded information, and a network abstraction layer (NAL) that exists between them the VCL and the subsystem and is responsible for network adaptation functions.

(72) In the VCL, VCL data including compressed video data (slice data) may be generated, or a Supplemental Enhancement Information (SEI) message additionally necessary for the video decoding process or a parameter set including information such as a picture parameter set (PPS), a sequence parameter set (SPS), a video parameter set (VPS) may be generated.

(73) In the NAL, a NAL unit may be generated by adding header information (NAL unit header) to a raw byte sequence payload (RBSP) generated in the VCL. In this case, the RBSP refers to slice data, parameter set, SEI message, etc. generated in the VCL. The NAL unit header may include NAL unit type information specified according to RBSP data included in the corresponding NAL unit.

(74) As shown in the figure, the NAL unit may be divided into a VCL NAL unit and a Non-VCL NAL unit according to the RBSP generated in the VCL. The VCL NAL unit may mean a NAL unit including information about an image (slice data), the Non-VCL NAL unit may mean a NAL unit including information (a parameter set or an SEI message) necessary for decoding the image.

(75) The above-described VCL NAL unit and Non-VCL NAL unit may be transmitted through a network by attaching header information according to a data standard of a subsystem. For example, the NAL unit may be transformed into a data form of a predetermined standard such as H.266/VVC file format, Real-time Transport Protocol (RTP), Transport Stream (TS), and transmitted through various networks.

(76) As described above, in the NAL unit, the NAL unit type may be specified according to the RBSP data structure included in the corresponding NAL unit, and information on this NAL unit type may be stored and signaled in the NAL unit header.

(77) For example, the NAL unit may be largely classified into a VCL NAL unit type and a Non-VCL NAL unit type according to whether or not the NAL unit includes image information (slice data). The VCL NAL unit type may be classified according to properties and types of pictures included in the VCL NAL unit, and the Non-VCL NAL unit type may be classified according to a type of a parameter set.

(78) The following is an example of the NAL unit type specified according to the type of parameter set included in the Non-VCL NAL unit type. Adaptation Parameter Set (APS) NAL unit: a type for a NAL unit containing the APS Decoding Parameter Set (DPS) NAL unit: a type for a NAL unit containing the DPS Video Parameter Set (VPS) NAL unit: a type for a NAL unit containing the VPS Sequence Parameter Set (SPS) NAL unit: a type for a NAL unit containing the SPS PPS (Picture Parameter Set) NAL unit: a type for a NAL unit containing the PPS Picture header (PH) NAL unit: a type for a NAL unit containing the PH

(79) The above-described NAL unit types may have syntax information for the NAL unit type, and the syntax information may be stored and signaled in a NAL unit header. For example, the syntax information may be nal_unit_type, and NAL unit types may be specified by a nal_unit_type value.

(80) Meanwhile, as described above, the encoding apparatus may perform various encoding methods such as, for example, exponential Golomb, context-adaptive variable length coding (CAVLC), and context-adaptive binary arithmetic coding (CABAC). In addition, the decoding apparatus may decode information in the bitstream based on a coding method such as the

exponential Golomb coding, the CAVLC or the CABAC, and output a value of a syntax element required for image reconstruction and a quantized value of a transform coefficient related to a residual.

(81) For example, the above-described coding methods may be performed as described below.

(82) FIG. **5** schematically shows context-adaptive binary arithmetic coding (CABAC) for encoding a syntax element. For example, in the CABAC encoding process, when an input signal is a syntax element instead of a binary value, the encoding apparatus may convert the input signal into a binary value by binarizing the value of the input signal. In addition, when the input signal is already a binary value (ie, when a value of the input signal is a binary value), binarization may not be performed and may be bypassed. Here, each binary number 0 or 1 constituting a binary value may be referred to as a bin. For example, if the binary string after binarization is 110, each of 1, 1, and 0 is called one bin. The bin(s) for one syntax element may indicate a value of the syntax element.

(83) Thereafter, the binarized bins of the syntax element may be input to a regular encoding engine or a bypass encoding engine. The regular encoding engine of the encoding apparatus may allocate a context model reflecting a probability value to the corresponding bin, and may encode the corresponding bin based on the allocated context model. The regular encoding engine of the encoding apparatus may update the context model for the corresponding bin after encoding for each bin. The encoded bin as described above may be referred to as a context-coded bin.

(84) Meanwhile, when the binarized bins of the syntax element are input to the bypass encoding engine, they may be coded as follows. For example, the bypass encoding engine of the encoding apparatus omits a procedure of estimating a probability with respect to an input bin and a procedure of updating a probability model applied to the bin after encoding. When bypass encoding is applied, the encoding apparatus may encode the input bin by applying a uniform probability distribution instead of allocating the context model, thereby improving the encoding speed. The encoded bin as described above may be referred to as a bypass bin.

(85) Entropy decoding may represent a process of performing the same process as the above-described entropy encoding in a reverse order.

(86) For example, when a syntax element is decoded based on a context model, the decoding apparatus may receive a bin corresponding to the syntax element through a bitstream, may determine a context model using the syntax element and decoding information of a decoding target block or neighboring blocks, or information of symbols/bins decoded in the previous step, may derive a value of the syntax element by predicting the occurrence probability of the received bin according to the determined context model and performing arithmetic decoding of the bin. Thereafter, a context model of a next decoded bin may be updated with the determined context model.

(87) Also, for example, when a syntax element is bypass decoded, the decoding apparatus may receive a bin corresponding to the syntax element through a bitstream, and may decode the input bin by applying a uniform probability distribution. In this case, the decoding apparatus may omit a procedure for deriving a context model of the syntax element and a procedure for updating a context model applied to the bin after decoding.

(88) Also, as described above, in performing video coding, prediction is performed to improve compression efficiency. Through this, a predicted block including prediction samples for a current block as a block to be coded (i.e., a coding target block) may be generated. Here, the predicted block includes prediction samples in a spatial domain (or pixel domain) The predicted block is derived in the same manner in an encoding apparatus and a decoding apparatus, and the encoding apparatus may signal information (residual information) on residual between the original block and the predicted block, rather than an original sample value of an original block, to the decoding apparatus, thereby increasing image coding efficiency. The decoding apparatus may derive a residual block including residual samples based on the residual information, add the residual block and the predicted block to generate reconstructed blocks including reconstructed samples, and

generate a reconstructed picture including the reconstructed blocks.

(89) The residual information may be generated through a transform and quantization procedure. For example, the encoding apparatus may derive a residual block between the original block and the predicted block, perform a transform procedure on residual samples (residual sample array) included in the residual block to derive transform coefficients, perform a quantization procedure on the transform coefficients to derive quantized transform coefficients, and signal related residual information to the decoding apparatus (through a bit stream). Here, the residual information may include value information of the quantized transform coefficients, location information, a transform technique, a transform kernel, a quantization parameter, and the like. The decoding apparatus may perform dequantization/inverse transform procedure based on the residual information and derive residual samples (or residual blocks). The decoding apparatus may generate a reconstructed picture based on the predicted block and the residual block. Also, for reference for inter prediction of a picture afterward, the encoding apparatus may also dequantize/inverse-transform the quantized transform coefficients to derive a residual block and generate a reconstructed picture based thereon.

(90) Intra prediction may refer to prediction that generates prediction samples for a current block based on reference samples in a picture to which the current block belongs (hereinafter, referred to as a current picture). When the intra prediction is applied to the current block, neighboring reference samples to be used for the intra prediction of the current block may be derived. The neighboring reference samples of the current block may include a sample adjacent to the left boundary of the current block of size $nW \times nH$ and a total of $2 \times nH$ samples adjacent to the bottom-left of the current block, a sample adjacent to the top boundary of the current block and a total of $2 \times nW$ samples adjacent to the top-right and a sample adjacent to the top-left of the current block. Alternatively, the neighboring reference samples of the current block may include a plurality of columns of top neighboring samples and a plurality of rows of left neighboring samples. In addition, the neighboring reference samples of the current block may include a total of nH samples adjacent to the right boundary of the current block of size $nW \times nH$, a total of nW samples adjacent to the bottom boundary of the current block and a sample adjacent to the bottom-right of the current block.

(91) However, some of the neighboring reference samples of the current block have not yet been decoded or may not be available. In this case, the decoder may construct neighboring reference samples to be used for prediction by substituting unavailable samples with available samples. Alternatively, neighboring reference samples to be used for prediction may be configured through interpolation of available samples.

(92) When the neighboring reference samples are derived, (i) a prediction sample may be derived based on the average or interpolation of neighboring reference samples of the current block, or (ii) the prediction sample may be derived based on a reference sample existing in a specific (prediction) direction with respect to a prediction sample among the neighboring reference samples of the current block. The case of (i) may be called a non-directional mode or a non-angular mode, and the case of (ii) may be called a directional mode or an angular mode.

(93) In addition, the prediction sample may be generated through interpolation of a first neighboring sample located in the prediction direction of the intra prediction mode of the current block based on the prediction sample of the current block and a second neighboring sample located in a direction opposite to the prediction direction among the neighboring reference samples. The above-described case may be referred to as linear interpolation intra prediction (LIP). In addition, chroma prediction samples may be generated based on the luma samples using a linear model (LM). This case may be called an LM mode or a chroma component LM (CCLM) mode.

(94) In addition, a temporary prediction sample of the current block is derived based on the filtered neighboring reference samples, and a prediction sample of the current block may also be derived by weighted summing the temporary prediction sample and at least one reference sample derived according to the intra prediction mode among the existing neighboring reference samples, that is,

unfiltered neighboring reference samples. The above-described case may be referred to as position dependent intra prediction (PDPC).

(95) In addition, a reference sample line with the highest prediction accuracy among neighboring multiple reference sample lines of the current block is selected, and a prediction sample is derived using a reference sample located in the prediction direction in the selected line. In this case, intra prediction encoding may be performed by indicating (signaling) the used reference sample line to the decoding apparatus. The above-described case may be referred to as multi-reference line intra prediction or MRL-based intra prediction.

(96) In addition, the current block is divided into vertical or horizontal sub-partitions and intra prediction is performed based on the same intra prediction mode, but neighboring reference samples may be derived and used in units of the sub-partitions. That is, in this case, the intra prediction mode for the current block is equally applied to the sub-partitions, but the intra prediction performance may be improved in some cases by deriving and using the neighboring reference samples in units of the sub-partitions. This prediction method may be called intra-prediction based on intra sub-partitions (ISP).

(97) The above-described intra prediction methods may be called intra prediction types to be distinguished from the intra prediction mode. The intra prediction types may be referred to by various terms such as intra prediction technique or additional intra prediction modes. For example, the intra prediction types (or additional intra prediction modes, etc.) may include at least one of the aforementioned LIP, PDPC, MRL, and ISP. A general intra prediction method excluding a specific intra prediction type such as LIP, PDPC, MRL, and ISP may be referred to as a normal intra prediction type. The normal intra prediction type may be generally applied when the above specific intra prediction type is not applied, and prediction may be performed based on the above-described intra prediction mode. Meanwhile, if necessary, post-processing filtering may be performed on the derived prediction sample.

(98) Specifically, the intra prediction process may include an intra prediction mode/type determination step, neighboring reference samples derivation step, and an intra prediction mode/type based prediction sample derivation step. In addition, if necessary, a post-filtering step may be performed on the derived prediction sample.

(99) FIG. **6** illustrates an example of an intra prediction-based video/image encoding method.

(100) Referring to FIG. **6**, the encoding device performs intra prediction on the current block S**600**. The encoding device derives an intra prediction mode/type for the current block, derives neighboring reference samples of the current block, generates prediction samples in the current block based on the intra prediction mode/type and the neighboring reference samples. Here, the intra prediction mode/type determination, neighboring reference samples derivation, and prediction samples generation procedures may be performed simultaneously, or one procedure may be performed before another procedure. The encoding device may determine a mode/type applied to the current block from among a plurality of intra prediction modes/types. The encoding device may compare RD costs for the intra prediction mode/types and determine an optimal intra prediction mode/type for the current block.

(101) Meanwhile, the encoding device may perform a prediction sample filtering procedure. The prediction sample filtering may be referred to as post filtering. Some or all of the prediction samples may be filtered by the prediction sample filtering procedure. In some cases, the prediction sample filtering procedure may be omitted.

(102) The encoding device generates residual samples for the current block based on the (filtered) prediction samples S**610**. The encoding device may compare the prediction samples in the original samples of the current block based on the phase and derive the residual samples.

(103) The encoding device may encode image information including information on the intra prediction (prediction information) and residual information on the residual samples S**620**. The prediction information may include the intra prediction mode information and the intra prediction

type information. The encoding device may output encoded image information in the form of a bitstream. The output bitstream may be transmitted to the decoding device through a storage medium or a network.

(104) The residual information may include residual coding syntax, which will be described later. The encoding device may transform/quantize the residual samples to derive quantized transform coefficients. The residual information may include information on the quantized transform coefficients.

(105) Meanwhile, as described above, the encoding device may generate a reconstructed picture (including reconstructed samples and reconstructed blocks). To this end, the encoding device may derive (modified) residual samples by performing inverse quantization/inverse transformation on the quantized transform coefficients again. The reason for performing the inverse quantization/inverse transformation again after transforming/quantizing the residual samples in this way is to derive the same residual samples as the residual samples derived in the decoding device as described above. The encoding device may generate a reconstructed block including reconstructed samples for the current block based on the prediction samples and the (modified) residual samples. A reconstructed picture for the current picture may be generated based on the reconstructed block. As described above, an in-loop filtering procedure may be further applied to the reconstructed picture.

(106) FIG. **7** illustrates an example of an intra prediction-based video/image encoding method.

(107) The decoding device may perform an operation corresponding to the operation performed by the encoding apparatus.

(108) Prediction information and residual information may be obtained from a bitstream. Residual samples for the current block may be derived based on the residual information. Specifically, transform coefficients may be derived by performing inverse quantization based on the quantized transform coefficients derived based on the residual information, residual samples for the current block may be derived by performing inverse transform on the transform coefficients.

(109) Specifically, the decoding device may derive the intra prediction mode/type for the current block based on the received prediction information (intra prediction mode/type information) S**700**. The decoding device may derive neighboring reference samples of the current block S**710**. The decoding device generates prediction samples in the current block based on the intra prediction mode/type and the neighboring reference samples S**720**. In this case, the decoding device may perform a prediction sample filtering procedure. The Predictive sample filtering may be referred to as post filtering. Some or all of the prediction samples may be filtered by the prediction sample filtering procedure. In some cases, the prediction sample filtering procedure may be omitted.

(110) The decoding device generates residual samples for the current block based on the received residual information S**730**. The decoding device may generate reconstructed samples for the current block based on the prediction samples and the residual samples, and may derive a reconstructed block including the reconstructed samples S**740**. A reconstructed picture for the current picture may be generated based on the reconstructed block. As described above, an in-loop filtering procedure may be further applied to the reconstructed picture.

(111) The intra prediction mode information may include, for example, flag information (ex. intra_luma_mpm_flag) indicating whether MPM (most probable mode) is applied to the current block or whether a remaining mode is applied, and, when the MPM is applied to the current block, the prediction mode information may further include index information (eg, intra_luma_mpm_idx) indicating one of the intra prediction mode candidates (MPM candidates). The intra prediction mode candidates (MPM candidates) may be constructed of an MPM candidate list or an MPM list. In addition, when the MPM is not applied to the current block, the intra prediction mode information includes remaining mode information (ex. intra_luma_mpm_remainder) indicating one of the remaining intra prediction modes except for the intra prediction mode candidates (MPM candidates). The decoding device may determine the intra prediction mode of the current block

based on the intra prediction mode information.

(112) Also, the intra prediction type information may be implemented in various forms. For example, the intra prediction type information may include intra prediction type index information indicating one of the intra prediction types. As another example, the intra prediction type information may include at least one of reference sample line information (ex. intra_luma_ref_idx) representing whether the MRL is applied to the current block and, if applied, which reference sample line is used, ISP flag information representing whether the ISP is applied to the current block (ex. intra_subpartitions_mode_flag) or ISP type information indicating a split type of subpartitions when the ISP is applied (ex. intra_subpartitions_split_flag). Also, the intra prediction type information may include a MIP flag representing whether matrix-based intra prediction (MIP) is applied to the current block.

(113) The intra prediction mode information and/or the intra prediction type information may be encoded/decoded through a coding method described in the present disclosure. For example, the intra prediction mode information and/or the intra prediction type information may be encoded/decoded through entropy coding (eg, CABAC, CAVLC).

(114) FIG. **8** schematically shows an intra prediction procedure.

(115) Referring to FIG. **8**, as described above, the intra prediction procedure may include a step of determinating an intra prediction mode/type, a step of deriving neighboring reference samples, and a step of performing intra prediction (generating a prediction sample). The intra prediction procedure may be performed by the encoding device and the decoding device as described above. In the present disclosure, a coding device may include the encoding device and/or the decoding device.

(116) Referring to FIG. **8**, the coding device determines an intra prediction mode/type S**800**.

(117) The encoding device may determine an intra prediction mode/type applied to the current block from among the various intra prediction modes/types described above, and may generate prediction related information. The prediction related information may include intra prediction mode information representing an intra prediction mode applied to the current block and/or intra prediction type information representing an intra prediction type applied to the current block. The decoding device may determine an intra prediction mode/type applied to the current block based on the prediction related information.

(118) The intra prediction mode information may include, for example, flag information (ex. intra_luma_mpm_flag) representing whether a most probable mode (MPM) is applied to the current block or a remaining mode is applied, and the When the MPM is applied to the current block, the prediction mode information may further include index information (eg, intra_luma_mpm_idx) indicating one of the intra prediction mode candidates (MPM candidates). The intra prediction mode candidates (MPM candidates) may be constructed of an MPM candidate list or an MPM list. In addition, when the MPM is not applied to the current block, the intra prediction mode information may further include remaining mode information (ex. intra_luma_mpm_remainder) indicating one of the remaining intra prediction modes except for the intra prediction mode candidates (MPM candidates). The decoding device may determine the intra prediction mode of the current block based on the intra prediction mode information.

(119) In addition, the intra prediction type information may be implemented in various forms. For example, the intra prediction type information may include intra prediction type index information indicating one of the intra prediction types. As another example, the intra prediction type information may include at least one of reference sample line information (ex. intra_luma_ref_idx) representing whether the MRL is applied to the current block and, if applied, which reference sample line is used, ISP flag information representing whether the ISP is applied to the current block (ex. intra_subpartitions_mode_flag) or ISP type information indicating a split type of subpartitions when the ISP is applied (ex. intra_subpartitions_split_flag). Also, the intra prediction type information may include a MIP flag representing whether matrix-based intra prediction (MIP)

is applied to the current block.

(120) For example, when intra prediction is applied, an intra prediction mode applied to the current block may be determined using an intra prediction mode of a neighboring block. For example, the coding device may select one of most probable mode (MPM) candidates in the MPM list derived based on additional candidate modes and/or an intra prediction mode of the neighboring block (eg, the left and/or top neighboring block) of the current block, or select one of the remaining intra prediction modes not included in the MPM candidates (and planar mode) based on the MPM remainder information (remaining intra prediction mode information). The MPM list may be configured to include or not include the planner mode as a candidate. For example, when the MPM list includes a planner mode as a candidate, the MPM list may have 6 candidates, and when the MPM list does not include a planner mode as a candidate, the MPM list may have 5 candidates. When the MPM list does not include the planar mode as a candidate, a not planar flag (ex. intra_luma_not_planar_flag) representing whether the intra prediction mode of the current block is not the planar mode may be signaled. For example, the MPM flag may be signaled first, and the MPM index and not planner flag may be signaled when the value of the MPM flag is 1. Also, the MPM index may be signaled when the value of the not planner flag is 1. Here, the fact that the MPM list is configured not to include the planner mode as a candidate is that the planner mode is always considered as MPM rather than that the planner mode is not MPM, thus, the flag (not planar flag) is signaled first to check whether it is the planar mode.

(121) For example, whether the intra prediction mode applied to the current block is among the MPM candidates (and the planar mode) or the remaining modes may be indicated based on the MPM flag (eg, intra_luma_mpm_flag). The MPM flag with a value of 1 may indicate that the intra prediction mode for the current block is within MPM candidates (and planar mode), and The MPM flag with a value of 0 may indicate that the intra prediction mode for the current block is not within MPM candidates (and planar mode). The not planar flag (ex. intra_luma_not_planar_flag) with a value of 0 may indicate that the intra prediction mode for the current block is a planar mode, and the not planar flag with a value of 1 may indicate that the intra prediction mode for the current block is not the planar mode. The MPM index may be signaled in the form of an mpm_idx or intra_luma_mpm_idx syntax element, and the remaining intra prediction mode information may be signaled in the form of a rem_intra_luma_pred_mode or intra_luma_mpm_remainder syntax element. For example, the remaining intra prediction mode information may indicate one of the remaining intra prediction modes not included in the MPM candidates (and planar mode) among all intra prediction modes by indexing in the order of prediction mode number. The intra prediction mode may be an intra prediction mode for a luma component (sample). Hereinafter, the intra prediction mode information may include at least one of the MPM flag (ex. intra_luma_mpm_flag), the not planar flag (ex. intra_luma_not_planar_flag), the MPM index (ex. mpm_idx or intra_luma_mpm_idx), or the remaining intra prediction mode information (rem_intra_luma_luma_mpm_mode or intra_luma_mpminder). In the present disclosure, the MPM list may be referred to by various terms such as an MPM candidate list and candModeList.

(122) When the MIP is applied to the current block, a separate MPM flag (ex. intra_mip_mpm_flag) for the MIP, an MPM index (ex. intra_mip_mpm_idx), and remaining intra prediction mode information (ex. intra_mip_mpm_remainder) may be signaled, and the not planar flag may not be signaled.

(123) In other words, in general, when a block partition for an image is performed, the current block to be coded and a neighboring block have similar image characteristics. Therefore, there is a high probability that the current block and the neighboring block have the same or similar intra prediction mode. Accordingly, the encoder may use the intra prediction mode of the neighboring block to encode the intra prediction mode of the current block.

(124) The coding device may construct a most probable modes (MPM) list for the current block. The MPM list may be referred to as the MPM candidate list. Here, the MPM may refer to modes

used to improve coding efficiency in consideration of the similarity between the current block and the neighboring blocks during intra prediction mode coding. As described above, the MPM list may be constructed to include the planar mode, or may be constructed to exclude the planar mode. For example, when the MPM list includes the planar mode, the number of candidates in the MPM list may be 6. And, when the MPM list does not include the planar mode, the number of candidates in the MPM list may be 5.

(125) The encoding device may perform prediction based on various intra prediction modes, and may determine an optimal intra prediction mode based on rate-distortion optimization (RDO) based thereon. In this case, the encoding device may determine the optimal intra prediction mode by using only the MPM candidates and planar mode configured in the MPM list, or by further using the remaining intra prediction modes as well as the MPM candidates and planar mode configured in the MPM list. Specifically, for example, if the intra prediction type of the current block is a specific type (ex. LIP, MRL, or ISP) other than the normal intra prediction type, the encoding device may determine the optimal intra prediction mode by considering only the MPM candidates and the planar mode as intra prediction mode candidates for the current block. That is, in this case, the intra prediction mode for the current block may be determined only from among the MPM candidates and the planar mode, and in this case, encoding/signaling of the MPM flag may not be performed. In this case, the decoding device may infer that the MPM flag is 1 without separately signaling the MPM flag.

(126) Meanwhile, in general, when the intra prediction mode of the current block is not the planar mode and is one of the MPM candidates in the MPM list, the encoding device generates an MPM index (mpm idx) indicating one of the MPM candidates. when the intra prediction mode of the current block is not included in the MPM list, the encoding device generates MPM reminder information (remaining intra prediction mode information) indicating the same mode as the intra prediction mode of the current block among the remaining intra prediction modes not included in the MPM list (and planar mode). The MPM reminder information may include, for example, an intra_luma_mpm_remainder syntax element.

(127) The decoding device obtains intra prediction mode information from the bitstream. As described above, the intra prediction mode information may include at least one of an MPM flag, a not planner flag, an MPM index, and MPM remaster information (remaining intra prediction mode information). The decoding device may construct the MPM list. The MPM list is constructed the same as the MPM list constructed in the encoding device. That is, the MPM list may include intra prediction modes of neighboring blocks, or may further include specific intra prediction modes according to a predetermined method.

(128) The decoding device may determine the intra prediction mode of the current block based on the MPM list and the intra prediction mode information. For example, when the value of the MPM flag is 1, the decoding device may derive the planar mode as the intra prediction mode of the current block (based on not planar flag) or derive the candidate indicated by the MPM index from among the MPM candidates in the MPM list as the intra prediction mode of the current block. Here, the MPM candidates may represent only candidates included in the MPM list, or may include not only candidates included in the MPM list but also the planar mode applicable when the value of the MPM flag is 1.

(129) As another example, when the value of the MPM flag is 0, the decoding device may derive an intra prediction mode indicated by the remaning intra prediction mode information (which may be referred to as mpm remainder information) among the remaining intra prediction modes not included in the MPM list and the planner mode as the intra prediction mode of the current block. Meanwhile, as another example, when the intra prediction type of the current block is a specific type (ex. LIP, MRL or ISP, etc.), the decoding device may derive a candidate indicated by the MPM flag in the planar mode or the MPM list as the intra prediction mode of the current block without parsing/decoding/checking the MPM flag.

(130) The coding device derives neighboring reference samples of the current block S**810**. When intra prediction is applied to the current block, the neighboring reference samples to be used for the intra prediction of the current block may be derived. The neighboring reference samples of the current block may include a sample adjacent to the left boundary of the current block of size nW×nH and a total of 2×nH samples adjacent to the bottom-left of the current block, a sample adjacent to the top boundary of the current block and a total of 2×nW samples adjacent to the top-right and a sample adjacent to the top-left of the current block. Alternatively, the neighboring reference samples of the current block may include a plurality of columns of top neighboring samples and a plurality of rows of left neighboring samples. In addition, the neighboring reference samples of the current block may include a total of nH samples adjacent to the right boundary of the current block of size nW×nH, a total of nW samples adjacent to the bottom boundary of the current block and a sample adjacent to the bottom-right of the current block.

(131) On the other hand, when the MRL is applied (that is, when the value of the MRL index is greater than 0), the neighboring reference samples may be located on lines 1 to 2 instead of line 0 adjacent to the current block on the left/top side, and in this case, the number of the neighboring reference samples may be further increased. Meanwhile, when the ISP is applied, the neighboring reference samples may be derived in units of sub-partitions.

(132) The coding device derives prediction samples by performing intra prediction on the current block S**820**. The coding device may derive the prediction samples based on the intra prediction mode/type and the neighboring samples. The coding device may derive a reference sample according to an intra prediction mode of the current block among neighboring reference samples of the current block, and may derive a prediction sample of the current block based on the reference sample.

(133) Meanwhile, according to an embodiment, a block differential pulse coded modulation (BDPCM) technique may be used. The BDPCM may also be called RDPCM (quantized residual Block-based Delta Pulse Code Modulation).

(134) When predicting a block by applying BDPCM, reconstructed samples may be utilized to predict a row or column of the block line-by-line. In this case, the used reference sample may be an unfiltered sample. a BDPCM direction may indicate whether vertical direction or horizontal direction prediction is used. That is, when the BDPCM is applied, a vertical direction or a horizontal direction may be selected as the BDPCM direction, and prediction may be performed in the BDPCM direction. A prediction error may be quantized in the spatial domain, and a sample may be reconstructed by adding the inverse-quantized prediction error to the prediction (i.e. the prediction sample). The prediction error may mean a residual. As an alternative to this BDPCM, a quantized residual domain BDPCM may be proposed, and the prediction direction or signaling may be the same as the BDPCM applied to the spatial domain. That is, the quantization coefficient itself may be accumulated like DPCM (Delta Pulse Code Modulation) through the quantized residual domain BDPCM, and then the residual may be reconstructed through inverse quantization. Accordingly, the quantized residual domain BDPCM may be used in the sense of applying DPCM in the residual coding state. The quantized residual domain used below is the one in which the derived residual based on the prediction is quantized without transform, which means the domain for quantized residual samples. For example, the quantized residual domain may include quantized residuals (or quantized residual coefficients) to which transform skip is applied, ie, transform is skipped but quantization is applied for the residual samples. Or, for example, the quantized residual domain may include quantized transform coefficients.

(135) For a block of M×N size, It may be assumed that the residual derived using a prediction value derived by performing intra prediction in the horizontal direction using unfiltered samples among left or top boundary samples (i.e., left neighboring samples or top neighboring samples) (copy the left neighboring sample line to the prediction block line-by-line) or obtained by performing intra prediction in the vertical direction (copy the top neighboring sample line to the

prediction block line-by-line) is r(i,j)(0≤i≤M−1, 0≤j≤N−1). Here, M may represent a row or height, and N may represent a column or width. And, it may be assumed that the quantized value of the residual r(i,j) is Q(r(i,j))(0≤i≤M−1, 0≤j≤N−1). Here, the residual means a difference value between the original block and the predicted block value.

(136) Then, if the BDPCM is applied to the quantized residual samples, a modified array {tilde over (R)} of M×N having {tilde over (r)}.sub.i,j as the configuration can be derived.

(137) For example, when vertical BDPCM is signaled (i.e., when vertical BDPCM is applied), {tilde over (r)}.sub.i,j may be derived as in the following equation.

(138) $\tilde{r}_{i,j} = \begin{cases} Q(r_{i,j}), & i = 0, \ 0 \le j \le (N-1) \\ Q(r_{i,j}) - Q(r_{(i-1),j}), & 1 \le i \le (M-1), \ 0 \le j \le (N-1) \end{cases}$. [Equation1]

(139) That is, for example, when vertical BDPCM is applied, the encoding device may perform vertical intra prediction based on top neighboring samples, and quantized residual samples for the current block may be derived as in Equation 1 above. Referring to Equation 1 above, a quantized residual sample of rows other than the first row of the current block may be derive as a difference between the quantized value for the corresponding position and the quantized value for the position of the previous row of the corresponding position (i.e., the top neighboring position of the corresponding position).

(140) In addition, when similarly applied to horizontal prediction (that is, when BDPCM in the horizontal direction is applied), the residual quantized samples may be derived as in the following equation.

(141) $\tilde{r}_{i,j} = \begin{cases} Q(r_{i,j}), & 0 \le i \le (M-1), \ j = 0 \\ Q(r_{i,j}) - Q(r_{i,(j-1)}), & 0 \le i \le (M-1), \ 1 \le j \le (N-1) \end{cases}$ [Equation2]

(142) That is, for example, when horizontal BDPCM is applied, the encoding device may perform horizontal intra prediction based on left neighboring samples, and quantized residual samples for the current block may be derived as in Equation 2 above. Referring to Equation 2 above, a quantized residual sample of columns other than the first column of the current block may be derive as a difference between the quantized value for the corresponding position and the quantized value for the position of the previous column of the corresponding position (i.e., the left neighboring position of the corresponding position).

(143) The quantized residual sample ({tilde over (r)}.sub.i,j) may be transmitted to the decoding device.

(144) In the decoding apparatus, the above operation may be performed inversely to derive Q(r(i,j)) (0≤i≤M−1, 0≤j≤N−1).

(145) The following equation may be applied for the vertical prediction.

$Q(r.sub.i,j)=Σ.sub.k=0.sup.i r.sub.k,j, 0≤i≤(M−1), 0≤j≤(N−1)$ custom characterEquation 3 custom character

(146) In addition, the following equation may be applied for the horizontal prediction.

$Q(r.sub.i,j)=Σ.sub.k=0.sup.j r.sub.i,k, 0≤i≤(M−1), 0≤j≤(N−1)$ custom characterEquation 4 custom character

(147) The dequantized quantized residual (Q.sup.−1(Q(r.sub.i,j))) is summed with the intra block prediction value to derive a reconstructed sample value.

(148) The main advantage of this technique is that the inverse BDPCM may be performed by simply adding predictors at parsing the coefficients or even after parsing.

(149) As described above, the BDPCM may be applied to a quantized residual domain, and the quantized residual domain may include a quantized residual (or quantized residual coefficients), in which case transform skip is applied to the residual. That is, when BDPCM is applied, transform may be skipped and quantization may be applied to the residual samples. Alternatively, the

quantized residual domain may include quantized transform coefficients. A flag for whether BDPCM is available may be signaled at a sequence level (SPS), and this flag may be signaled only when it is signaled that a transform skip mode is enable in the SPS. The flag may be called a BDPCM enabled flag or an SPS BDPCM enabled flag.

(150) When BDPCM is applied, intra prediction may be performed on the entire block by sample copy according to a prediction direction (ex. vertical prediction or horizontal prediction) similar to the intra prediction direction. The residual, which is the difference value between the original and the prediction block, is quantized by skipping the transform, and a delta value, that is, a difference value ($\{$tilde over (r)$\}$.sub.i,j) between the quantized residual and a predictor in the horizontal or vertical direction (i.e., the quantized residual in the horizontal or vertical direction) may be coded.

(151) If BDPCM is applicable, when the CU size is less than or equal to MaxTsSize (maximum transform skip block size) for luma samples, and the CU is coded with intra prediction, flag information may be transmitted at the CU level. The flag information may be referred to as a BDPCM flag. Here, MaxTsSize may mean the maximum block size for allowing the transform skip mode. The flag information may indicate whether conventional intra coding or BDPCM is applied. When BDPCM is applied, a BDPCM prediction direction flag indicating whether the prediction direction is a horizontal direction or a vertical direction may be transmitted. The BDPCM prediction direction flag may be referred to as a BDPCM direction flag. Thereafter, the block may be predicted through a conventional horizontal or vertical intra prediction process using an unfiltered reference sample. In addition, the residuals may be quantized, and a difference value between each quantized residual and its predictor, for example, between the already quantized residuals in the horizontal or vertical direction according to the BDPCM prediction direction, may be coded.

(152) Meanwhile, the above-described BDPCM may be described in a standard document format as described later.

(153) For example, a syntax element for the above-described BDPCM enabled flag and semantics for the syntax element may be represented as shown in the following tables.

(154) TABLE-US-00001 TABLE 1 Descriptor seq parameter set rbsp( ) { (...) sps_transform_skip_enabled_flag u(1) if(sps transform skip enabled flag) sps bdpcm enabled flag u(1) if(sps bdpcm enabled flag && chroma format idc = = 3) sps bdpcm chroma enabled flag u(1) (....) }

(155) TABLE-US-00002 TABLE 2 7.4.3.4 Sequence parameter set RBSP semantics (...) sps_bdpcm_enabled_flag equal to 1 specifies that intra_bdpcm_luma_flag may be present in the coding unit syntax for intra coding units. sps_bdpcm_enabled_flag equal to 0 specifies that intra_bdpcm_luma_flag is not present in the coding unit syntax for intra coding units. When not present, the value of sps_bdpcm_enabled_flag is inferred to be equal to 0. sps_bdpcm_chroma_enabled_flag equal to 1 specifies that intra_bdpcm_chroma_flag may be present in the coding unit syntax for intra coding units. sps_bdpcm_chroma_enabled_flag equal to 0 specifies that intra_bdpcm_chroma_flag is not present in the coding unit syntax for intra coding units. When not present, the value of sps_bdpcm_chroma_enabled flag is inferred to be equal to 0. (...)

(156) Table 1 represents sps_bdpcm_enabled_flag and sps_bdpcm_chroma_enabled_flag being signaled in a sequence parameter set (SPS), and when the syntax element sps_bdpcm_enabled_flag is 1, it may represent that flag information representing whether BDPCM is applied to a coding luma unit in which intra prediction is performed, that is, "intra_bdpcm_luma_flag", is present in the coding luma unit, whereas when the syntax element sps_bdpcm_chroma_enabled_flag is 1, it may represent that flag information representing whether BDPCM is applied to a coding chroma unit in which intra prediction is performed, that is, "intra_bdpcm_chroma_flag", is present in the coding chroma unit. The syntax elements sps_bdpcm_enabled_flag and sps_bdpcm_chroma_enabled_flag may be syntax elements for the BDPCM enabled flag. Further,

when the syntax element "sps_bdpcm_enabled_flag" is not present, the value thereof may be considered as 0. Further, when the syntax element "sps_bdpcm_chroma_enabled_flag" is not present, the value thereof may be considered as 0.

(157) Further, for example, the syntax elements for the BDPCM flag and the BDPCM direction flag as described above may be separately signaled for a luma component and a chroma component. For example, a coding unit syntax including the syntax elements and semantics for the syntax elements may be represented as in the following tables.

(158) TABLE-US-00003 TABLE 3 Descriptor coding unit(x0, y0, cbWidth, cbHeight, cqtDepth, tree Type, mode Type) {   chType = treeType = = DUAL TREE CHROMA ? 1 : 0   if(slice type != ‖ sps ibc enabled flag) {   if(treeType != DUAL_TREE_CHROMA &&   ((!(cbWidth = = 4 && cbHeight = = 4) && modeType != MOD E_TYPE_INTRA)   ‖ (sps_ibc_enabled_flag && cbWidth <= 64 && cbHeight <= 6 4)))   cu skip flag[x0][y0] ae(v)   if(cu_skip_flag[x0][y0] = = 0 && slice_type != I   && !(cbWidth = = 4 && cbHeight = = 4) && modeType = = MOD E TYPE ALL)   pred mode flag ae(v)   if(((slice_type = = I && cu_skip_flag[x0][y0] = = 0) ‖   (slice_type != I && (CuPredMode[chType][x0][y0] != MODE.sub.— INTRA ‖   (((cbWidth = = 4 && cbHeight = = 4) ‖ modeType = = MOD E_TYPE_INTRA)   && cu_skip_flag[x0][y0] = = 0)))) &&   cbWidth <= 64 && cbHeight <= 64 && modeType != MODE_TY PE_INTER &&   sps ibc enabled flag && treeType != DUAL TREE CHROMA)   pred mode ibc flag ae(v)   }   if(CuPredMode[chType][x0][y0] = = MODE_INTRA && sps_palette_e nabled_flag &&   cbWidth <= 64 && cbHeight <= 64 && cu_skip_flag[x0][y0] = = 0 &&   mode Type != MODE TYPE INTER)   pred mode plt flag ae(v)   }   if(CuPredMode[chType][x0][y0] = = MODE_INTRA && sps_act_cnab led_flag &&   treeType = = SINGLE TREE)   cu act enabled flag ae(v)   if(CuPredMode[chType][x0][y0] = = MODE_INTRA ‖   CuPredMode[chType][x0][y0] = = MODE PLT) {   if(treeType = = SINGLE_TREE ‖ treeType = = DUAL_TREE_LUMA) {   if(pred mode plt flag) {   palette coding(x0, y0, cbWidth, cbHeight, treeType)   } else {   if(sps_bdpcm_enabled_flag &&   cbWidth <= MaxTsSize && cbHeight <= MaxTsSize)   intra bdpcm luma flag ae(v)   if(intra bdpcm luma flag)   intra bdpcm luma dir flag ae(v)   else {   if(sps mip enabled flag)   intra mip flag[x0][y0] ae(v)   if(intra mip flag[x0][y0]) {   intra mip transposed[x0][y0] ae(v)   intra mip mode[x0][y0] ae(v)   } else {   if(sps mrl enabled flag && ((y0 % CtbSizeY) > 0))   intra luma ref idx[x0][y0] ae(v)   if(sps_isp_enabled_flag && intra_luma_ref_idx[x0][y0] = = 0 &&   (cbWidth <= MaxTbSizeY && cbHeight <= MaxTbSizeY) &&   (cbWidth * cbHeight > MinTbSizeY * MinTbSizeY) && !cu act enabled flag)   intra subpartitions mode flag[x0][y0] ae(v)   if(intra subpartitions mode flag[x0][y0] = = 1)   intra subpartitions split flag[x0][y0] ae(v)   if(intra luma ref idx[x0][y0] = = 0)   intra luma mpm flag[x0][y0] ae(v)   if(intra luma mpm flag[x0][y0]) {   if(intra luma ref idx[x0][y0] = = 0)   intra luma not planar flag[x0][y0] ae(v)   if(intra luma not planar flag[x0][y0])   intra luma mpm idx[x0][y0] ae(v)   } else   intra luma mpm remainder[x0][y0] ae(v)   }   }   }   }   if((tree Type = = SINGLE_TREE ‖ treeType = = DUAL_TREE_CHR OMA) &&   ChromaArray Type != 0) {   if(pred mode plt flag && treeType = = DUAL TREE CHROMA)   palette_coding(x0, y0, cbWidth / SubWidthC, cbHeight / SubHeightC, treeType)   else {   if(!cu act enabled flag) {   if(cbWidth <= MaxTsSize && cbHeight <= MaxTsSize &&   sps bdpcm chroma enabled flag) {   intra_bdpcm_chroma_flag ae(v)   if(intra

bdpcm chroma flag)   intra_bdpcm_chroma_dir_flag ae(v)   } else {
                if(CclmEnabled)   cclm_mode_flag ae(v)   if(cclm
mode flag)   cclm_mode_idx ae(v)   else
intra_chroma_pred_mode ae(v)   }   }   }   }   } else if(treeType !=
DUAL_TREE_CHROMA) { /* MODE_INTER or MO DE IBC */   if(cu skip flag[x0][y0]
= = 0)   general_merge_flag[x0][y0] ae(v)   if(general merge flag[x0][y0])
merge data(x0, y0, cbWidth, cbHeight, chType)   else if(CuPredMode[chType][x0][y0] =
= MODE IBC) {   mvd coding(x0, y0, 0, 0)   if(MaxNumIbcMergeCand > 1)
          mvp 10 flag[x0][y0] ae(v)   if(sps_amvr_enabled_flag &&   (
MvdL0[x0][y0][0] != 0 ‖ MvdL0[x0][y0][1] != 0))   amvr precision idx[x0][y0
] ae(v)   } else {   if(slice type = = B)   inter_pred_idc[x0][y0] ae(v)
if(sps_affine_enabled_flag && cbWidth >= 16 && cbHeight >= 16) {
inter_affine_flag[x0][y0] ae(v)   if(sps affine type flag && inter affine flag[x0][y0])
          cu_affine_type_flag[x0][y0] ae(v)   }   if(sps_smvd_enabled_flag &&
!mvd_l1_zero_flag &&   inter_pred_idc[x0][y0] = = PRED_BI &&
          !inter_affine_flag[x0][y0] && RefIdxSymL0 > −1 && RefIdxS ymL1 > −1)
          sym_mvd_flag[x0 ‖[y0] ae(v)   if(inter_pred_idc[x0][y0] !=
PRED L1) {   if(NumRefIdxA ctive[0] > 1 && !sym mvd flag[x0][
y0])   ref_idx_10[x0][y0] ae(v)   mvd coding(x0, y0, 0, 0)   if(
MotionModelIdc[x0][y0] > 0)   mvd coding(x0, y0, 0, 1)
if(MotionModelIdc[x0][y0] > 1)   mvd coding(x0, y0, 0, 2)   mvp_10_flag[
x0][y0] ae(v)   } else {   MvdL0[x0][y0][0] = 0   MvdL0[x0][y0][1
] = 0   }   if(inter pred idc[x0][y0] != PRED L0) {   if(NumRefIdxActive[
1] > 1 && !sym mvd flag[x0][y0])   ref_idx_l1[x0][y0] ae(v)   if(mvd l1
zero flag && inter pred idc[x0][y0] = = PRED BI) {   MvdL1[x0][y0][0] = 0
          MvdL1[x0][y0][1] = 0   MvdCpL1[x0][y0][0][0] = 0
MvdCpL1[x0][y0][0][1] = 0   MvdCpL1[x0][y0][1][0] = 0
MvdCpL1[x0][y0][1][1] = 0   MvdCpL1[x0][y0][2][0] = 0
MvdCpL1[x0]] y0][2][1] = 0   } else {   if(sym mvd flag[x0][y0]) {
          MvdL1[x0][y0][0] = −MvdL0[x0][y0][0]   MvdL1[x0][y0][
1] = −MvdL0[x0][y0][1]   } else   mvd coding(x0, y0, 1, 0)
          if(MotionModelIdc[x0][y0] > 0)   mvd coding(x0, y0, 1, 1)
          if(MotionModelIdc[x0][y0] > 1)   mvd coding(x0, y0, 1, 2)
          mvp_l1_flag[x0][y0] ae(v)   }   } else {   MvdL1[x0][y0][
0] = 0   MvdL1[x0][y0][1] = 0   }   if((sps_amvr_enabled_flag &&
inter_affine_flag[x0][y0] = = 0 &&   (MvdL0[x0][y0][0] != 0 ‖ MvdL0[x0][y0][
1] != 0 ‖   MvdL1[x0][y0][0] != 0 ‖ MvdL1[x0][y0][1] != 0)) ‖   (
sps_affine_amvr_enabled_flag && inter_affine_flag[x0][y0] = = 1 &&   (MvdCpL0[
x0][y0][0][0] != 0 ‖ MvdCpL0[x0][y0][0][1] != 0 ‖   MvdCpL1[x0][y0][0]
[0] != 0 ‖ MvdCpL1[x0][y0][0][1] != 0 ‖   MvdCpL0[x0][y0][1][0] != 0 ‖
MvdCpL0[x0][y0][1][1] != 0 ‖   MvdCpL1[x0][y0][1][0] != 0 ‖ MvdCpL1 [
x0][y0][1][1] != 0 ‖   MvdCpL0[x0][y0][2][0] != 0 ‖ MvdCpL0[x0][y0][2]
[1] != 0 ‖   MvdCpL1[x0 TT y0][2][1] != 0)) {   amvr flag[x0][y0]
ae(v)   if(amvr flag[x0][y0])   amvr precision idx| x0 | y0 | ae(v)   }
     if(sps_bcw_enabled_flag && inter_pred_idc[x0][y0] = = PRED_BI &&
luma_weight_10_flag[ref_idx_10 [x0][y0]] = = 0 &&   luma_weight_11_flag[
ref_idx_11 [x0][y0]] = = 0 &&   chroma_weight_10_flag[ref_idx 10 [x0][y0]] = =
0 &&   chroma_weight_11_flag[ref_idx 11 [x0][y0]] = = 0 &&   cbWidth *
cbHeight >= 256)   bcw_idx[x0][y0] ae(v)   }   }   if(CuPredMode[chType][x0

][y0] != MODE_INTRA && !pred_mode_p lt_flag && general merge flag[x0][y0] = = 0)
cu_cbf ae(v)   if(cu cbf) {   if(CuPredMode[chType][x0][y0] = = MODE_INTER && sps_sbt_e nabled_flag   && !ciip_flag[x0][y0] && !MergeTriangleFlag[x0][y0]   && cbWidth <= MaxTbSizeY && cbHeight <= MaxTbSizeY) {   allowSbtVerH = cbWidth >= 8   allowSbtVerQ = cbWidth >= 16   allowSbtHorH = cbHeight >= 8   allowSbtHorQ = cbHeight >= 16   if(allowSbtVerH ‖ allowSbtHorH)   cu sbt flag ae(v)   if(cu sbt flag) {   if((allowSbtVerH ‖ allowSbtHorH) && (allowSbtVerQ ‖ allowSbt HorQ))   cu sbt quad flag ae(v)   if((cu_sbt_quad_flag && allowSbtVerQ && allowSbtHorQ) ‖   (!cu sbt quad flag && allowSbtVerH && allowSbtHorH))   cu sbt horizontal flag ae(v)   cu sbt pos flag ae(v)   }   }   if(sps_act_enabled_flag && CuPredMode[chType][x0][y0] != MOD E_INTRA &&   treeType = = SINGLE TREE)   cu act enabled flag ae(v)
LfnstDcOnly = 1   LfnstZeroOutSigCoeffFlag = 1   MtsZeroOutSigCoeffFlag = 1
transform tree(x0, y0, cbWidth, cbHeight, treeType, chType)   lfnstWidth = (treeType = = DUAL_TREE_CHROMA) ? cbWidth / SubW idthC   : ((IntraSubPartitionsSplitType = = ISP_VER_SPLIT) ? c bWidth / NumIntraSubPartitions : cbWidth)   lfnstHeight = (treeType = = DUAL_TREE_CHROMA) ? cbHeight / Sub HeightC   : ((IntraSubPartitionsSplitType = = ISP_HOR_SPLIT) ? c bHeight /   NumIntraSubPartitions : cbHeight)   if(Min(lfnstWidth, lfnstHeight) >= 4 && sps_lfnst_enabled_flag = = 1 &&   CuPredMode[chType][x0][y0] = = MODE_INTRA &&   (!intra_mip_flag[x0][y0] ‖ Min(lfnstWidth, lfnstHeight) >= 16) &&   Max(cbWidth, cbHeight) <= MaxTbSizeY) {   if((IntraSubPartitionsSplitType != ISP_NO_SPLIT ‖ LfnstDcOnly = = 0) &&
LfnstZeroOutSigCoeffFlag = = 1)   lfnst_idx ae(v)   }   if(treeType != DUAL_TREE_CHROMA && lfnst_idx = = 0 &&   transform_skip_flag[x0][y0][0] = = 0 && Max(cbWidth, cbHeight) <= 32 &&   IntraSubPartitionsSplit[x0][y0] = = ISP_NO_SPLIT && cu_sbt_flag = = 0 &&   MtsZeroOutSigCoeffFlag = = 1 && tu cbf luma[x0][y0]) {   if(((CuPredMode[chType][x0][y0] = = MODE_INTER &&   sps_explicit_mts_inter_enabled_flag) ‖   (CuPredMode[chType][x0][y0] = = MODE_INTRA &&   sps explicit mts intra enabled flag)))   mts_idx ae(v)
}   }

(159) TABLE-US-00004 TABLE 4 7.4.11.5 Coding unit semantics (...) intra_bdpcm_luma_flag equal to 1 specifies that BDPCM is applied to the current luma coding block at the location (x0, y0), i.e. the transform is skipped, the intra luma prediction mode is specified by intra_bdpcm_luma_dir_flag. intra_bdpcm_luma_flag equal to 0 specifies that BDPCM is not applied to the current luma coding block at the location (x0, y0). When intra_bdpcm_luma_flag is not present it is inferred to be equal to 0. The variable BdpcmFlag[x][y][cIdx] is set equal to intra_bdpcm_luma_flag for x = x0..x0 + cbWidth − 1, y = y0..y0 + cbHeight − 1 and cIdx = 0. intra_bdpcm_luma_dir_flag equal to 0 specifies that the BDPCM prediction direction is horizontal. intra_bdpcm_luma_dir_flag equal to 1 specifies that the BDPCM prediction direction is vertical. The variable BdpcmDir[x][y][cIdx] is set equal to intra_bdpcm_luma_dir flag for x = x0..x0 + cbWidth − 1, y = y0..y0 + cbHeight − 1 and cIdx = 0. (...) intra_bdpcm_chroma_flag equal to 1 specifies that BDPCM is applied to the current chroma coding blocks at the location (x0, y0), i.e. the transform is skipped, the intra chroma prediction mode is specified by intra_bdpcm_chroma_dir_flag. intra_bdpcm_chroma_flag equal to 0 specifies that BDPCM is not applied to the current chroma coding blocks at the location (x0, y0). When intra_bdpcm_chroma_flag is not present it is inferred to be equal to 0. The variable BdpcmFlag[x][y][cIdx] is set equal to intra_bdpcm_chroma_flag for x = x0..x0 + cbWidth − 1, y = y0..y0 + cbHeight − 1 and cIdx = 1..2. intra_bdpcm_chroma_dir_flag equal to 0 specifies that the BDPCM

prediction direction is horizontal. intra_bdpcm_chroma_dir_flag equal to 1 specifies that the BDPCM prediction direction is vertical. The variable BdpcmDir[x][y][cIdx] is set equal to intra_bdpcm_chroma_dir_flag for x = x0..x0 + cbWidth − 1, y = y0..y0 + cbHeight − 1 and cIdx = 1..2. (...)

(160) As described above, the syntax element intra_bdpcm_luma_flag of the Table 3 may represent whether the BDPCM is applied to the current luma block, and the intra_bdpcm_chroma_flag may represent whether the BDPCM is applied to the current luma block or the current chroma block. For example, when a value of the intra_bdpcm_luma_flag or the intra_bdpcm_chroma_flag is 1, transformation for the corresponding coding block may be skipped, and the prediction mode for the coding block may be set in the horizontal or vertical direction by the intra_bdpcm_luma_dir_flag or the intra_bdpcm_chroma_dir_flag representing the prediction direction. When the intra_bdpcm_luma_flag or the intra_bdpcm_chroma_flag is not present, a value of the intra_bdpcm_luma_flag or the intra_bdpcm_chroma_flag may be inferred to be equal to 0.

(161) Also, for example, when the value of the intra_bdpcm_luma_dir_flag or the intra_bdpcm_chroma_dir_flag representing the prediction direction is 0, the intra_bdpcm_luma_dir_flag or the intra_bdpcm_chroma_dir_flag may represent that the BDPCM prediction direction is a horizontal direction, and when the value of the intra_bdpcm_luma_dir_flag or the intra_bdpcm_chroma_dir_flag is 1, the intra_bdpcm_luma_dir_flag or the intra_bdpcm_chroma_dir_flag may represent that the BDPCM prediction direction is a vertical direction.

(162) Meanwhile, the intra_bdpcm_luma_flag may represent a syntax element of a BDPCM luma flag for the current luma block, the intra_bdpcm_chroma_flag may represent a syntax element of a BDPCM chroma flag for the current chroma block, the intra_bdpcm_luma_dir_flag may represent a syntax element of a BDPCM luma direction flag for the current luma block, and the intra_bdpcm_chroma_dir_flag may represent a syntax element of a BDPCM chroma direction flag for the current chroma block.

(163) Further, in case that the BDPCM is applied, an example of a dequantization process may be represented as in the following table.

(164) TABLE-US-00005 TABLE 5 8.7.3   Scaling process for transform coefficients Inputs to this process are: - a luma location (xTbY, yTbY) specifying the top-left sample of the current luma transform block relative to the top-left luma sample of the current picture, - a variable nTbW specifying the transform block width, - a variable nTbH specifying the transform block height, - a variable cIdx specifying the colour component of the current block, - a variable bitDepth specifying the bit depth of the current colour component. Output of this process is the (nTbW)x(nTbH) array d of scaled transform coefficients with   elements d[x][y]. The quantization parameter qP is derived as follows: - If cIdx is equal to 0, the following applies: $qP = Qp'_Y$ (8-1018) - Otherwise, if cIdx is equal to 1, the following applies: $qP = Qp'_{Cb}$ (8-1019) - Otherwise (cIdx is equal to 2), the following applies: $qP = Qp'_{Cr}$ (8-1020) The variable rectNonTsFlag is derived as follows: (8-1021) rectNonTsFlag = (((Log2(nTbW) + Log2(nTbH)) & 1) = = 1 &&   transform_skip_flag[xTbY][yTbY] = = 0) The variables bdShift, rectNorm and bdOffset are derived as follows: bdShift = bitDepth + ((rectNonTsFlag ? 8 : 0) + (8-1022)   (Log2(nTbW) + Log2(nTbH)) /2) − 5 + dep_quant_enabled_flag rectNorm = rectNonTsFlag ? 181 : 1 (8-1023) bdOffset = (1 << bdShift) >> 1   (8-1024) The list levelScale[ ] is specified as levelScale[k] = { 40, 45, 51, 57, 64, 72 } with k = 0..5. For the derivation of the scaled transform coefficients d[x][y] with x = 0..nTbW − 1, y = 0..nTbH − 1, the following applies: - The intermediate scaling factor m[x][y] is set equal to 16. - The scaling factor ls[x][y] is derived as follows: - If dep_quant_enabled_flag is equal to 1, the following applies: ls[x][y] = (m[x][y] * levelScale[(qP + 1) % 6]) << ((qP + 1) / 6)   (8-1025)   - Otherwise (dep_quant_enabled_flag is equal to 0), the following applies: ls[x][y] = (m[x][y] * levelScale[qP % 6]) << (qP / 6)   (8-1026) - The value

dz[x][y] is derived as follows: - if bdpcm_flag[xTbY][yTbY]=1, dz] x][y] = bdpcm_dir_flag[x0][y0]==0 ? (x== 0 ? TransCoeffLevel[xTbY][yTbY][cIdx][x][y]:dz[x−1][y] + TransCoeffLevel[xTbY][yTbY][cIdx][x][y]):(y==0 ? TransCoeffLevel[xTbY][yTbY][cIdx][x][y]:dz[x][y−1] + TransCoeffLevel[xTbY][yTbY][cIdx][x][y]) - other wise dz[x][y] = TransCoeffLevel[xTbY][yTbY][cIdx][x][y]) - The value dne[x][y] is derived as follows: dnc[x][y] = (8-1027) (dz[x][y] * ls[x][y] * rectNorm +bdOffset) >> bdShift - The scaled transform coefficient d[x][y] is derived as follows: d[x][y] = Clip3(CoeffMin, CoeffMax, dnc[x][y]) (8-1028)

(165) Further, in case that the BDPCM is applied, an example of a dequantization process may be represented as in the following table.

(166) TABLE-US-00006 TABLE 6 8.7.3 Scaling process for transform coefficients Inputs to this process are: - a luma location (xTbY, yTbY) specifying the top-left sample of the current luma transform block relative to the top-left luma sample of the current picture, - a variable nTbW specifying the transform block width, - a variable nTbH specifying the transform block height, - a variable predMode specifying the prediction mode of the coding unit, - a variable cIdx specifying the colour component of the current block. Output of this process is the (nTbW)x(nTbH) array d of scaled transform coefficients with elements d[x][y]. The quantization parameter qP and the variable QpActOffset are derived as follows: - If cIdx is equal to 0, the following applies: qP = Qp{acute over ( )}.sub.Y (1141) QpActOffset = cu_act_enabled_flag[xTbY][yTbY] ? −5 : 0 (1142) Otherwise, if TuCResMode[xTbY][yTbY] is equal to 2, the following applies: qP = Qp{acute over ( )}.sub.CbCr (1143) QpActOffset = cu_act_enabled_flag[xTbY][yTbY] ? 1 : 0 (1144) - Otherwise, if cIdx is equal to 1, the following applies: qP = Qp{acute over ( )}.sub.Cb (1145) QpActOffset = cu_act_enabled_flag[xTbY][yTbY] ? 1 : 0 (1146) - Otherwise (cIdx is equal to 2), the following applies: qP = Qp{acute over ( )}.sub.Cr (1147) QpActOffset = cu_act_enabled_flag[xTbY][yTbY] ? 3 : 0 (1148) The quantization parameter qP is modified and the variables rectNonTsFlag and bdShift are derived as follows: - If transform_skip_flag[xTbY][yTbY][cIdx] is equal to 0, the following applies: qP = Clip3(0, 63 + QpBdOffset, qP + QpActOffset) (1149) rectNonTsFlag = (((Log2(nTbW) + Log2(nTbH)) & 1) = = 1) ? 1 : 0 (1150) bdShift = BitDepth + rectNonTsFlag + (1151) ((Log2(nTbW) + Log2(nTbH)) / 2) − 5 + sh_dep_quant_used_flag - Otherwise (transform_skip_flag[xTbY][yTbY][cIdx] is equal to 1), the following applies: qP = Clip3(QpPrimeTsMin, 63 + QpBdOffset, qP + QpActOffset) (1152) rectNonTsFlag = 0 (1153) bdShift = 10 (1154) The variable bdOffset is derived as follows: bdOffset = (1 << bdShift) >> 1 (1155) The list levelScale[ ][ ] is specified as levelScale[j][k] = { { 40, 45, 51, 57, 64, 72 }, { 57, 64, 72, 80, 90, 102 } } with j = 0..1, k = 0..5. The (nTbW)x(nTbH) array dz is set equal to the (nTbW)x(nTbH) array TransCoeffLevel[xTbY][yTbY][cIdx]. For the derivation of the scaled transform coefficients d[x][y] with x = 0..nTbW − 1, y = 0..nTbH − 1, the following applies: - The intermediate scaling factor m[x][y] is derived as follows: - If one or more of the following conditions are true, m[x][y] is set equal to 16: - sh_explicit_scaling_list_used_flag is equal to 0. - transform_skip_flag[xTbY][yTbY][cIdx] is equal to 1. - sps_scaling_matrix_for_lfnst_disabled_flag is equal to 1 and ApplyLfnstFlag is equal to 1. - sps_scaling_matrix_for_alternative_colour_space_disabled_flag is equal to 1 and sps_scaling_matrix_designated_colour_space_flag is equal to cu_act_enabled_flag[xTbY][yTbY]. - Otherwise, the following applies: - The variable id is derived based on predMode, cIdx, nTbW, and nTbH as specified in Table 38 and the variable log2MatrixSize is derived as follows: log2MatrixSize = (id < 2) ? 1 : (id < 8) ? 2 : 3 (1156) - The scaling factor m[x][y] is derived as follows: m[x][y] = ScalingMatrixRec[id][i][j] with i = (x << log2MatrixSize) >> Log2(nTbW), j = (y << log2MatrixSize) >> Log2(nTbH) (1157) - If id is greater than 13 and both x and y are equal to 0, m[0][0] is further modified as follows: m[0][0] = ScalingMatrixDCRec[id − 14] (1158) NOTE - A quantization

matrix element m[x][y] can be zeroed out when any of the following conditions is true - x is greater than 31 - y is greater than 31 - The decoded tu is not coded by default transform mode (i.e. transform type is not equal to 0) and x is greater than 15 - The decoded tu is not coded by default transform mode (i.e. transform type is not equal to 0) and y is greater than 15 - The scaling factor ls[x][y] is derived as follows: - If sh_dep_quant_used_flag is equal to 1 and transform_skip_flag[xTbY][yTbY][cIdx] is equal to 0, the following applies: ls[x][y] = (m[x][y] * levelScale[rectNonTsFlag][(qP + 1) % 6])   << ((qP+ 1) / 6) (1159) - Otherwise (sh_dep_quant_used_flag is equal to 0 or transform_skip_flag[xTbY][yTbY][cIdx] is equal to 1), the following applies: ls[x][y] = (m[x][y] * levelScale[rectNonTsFlag][qP% 6]) << (qP /   6)   (1160) - When BdpcmFlag[xTbY][yYbY][cIdx] is equal to 1, dz[x][y] is modified as follows: - If BdpcmDir[xTbY][yYbY][cIdx] is equal to 0 and x is greater than 0, the following applies: dz[x][y] = Clip3(CoeffMin, CoeffMax, dz[x − 1][y] + dz[x][y])   (1161) - Otherwise, if BdpcmDir[xTbY][yTbY][cIdx] is equal to 1 and y is greater than 0, the following applies: dz[x][y] = Clip3(CoeffMin, CoeffMax, dz[x][y − 1] + dz[x][y])   (1162) - The value dnc[x][y] is derived as follows: dnc[x][y] = (dz[x][y] * ls[x] [y] +bdOffset) >> bdShift   (1163) - The scaled transform coefficient d[x][y] is derived as follows: d[x][y] = Clip3(CoeffMin, CoeffMax, dnc[x][y])   (1164)

(167) Referring to Table 5 or 6, when the value of the bdpcm_flag is 1, the inverse quantized residual value d[x][y] may be derived based on the intermediate variable dz[x][y]. Here, x is a horizontal coordinate that increases from left to right, y is a vertical coordinate that increases from top to bottom, and a position in a two-dimensional block may be expressed as (x, y). In addition, the position in the two-dimensional block indicates the (x, y) position when a top left position of the block is set to (0, 0).

(168) For example, when the value of the bdpcm_dir_flag is 0, that is, when the horizontal BDPCM is applied, the variable dz[x][y] may be TransCoeffLevel[xTbY][yTbY][cIdx][x][y] when x is 0, dz[x][y] may be derived based on dz[x−1][y]+dz[x][y] when x is not 0. That is, when the horizontal BDPCM is applied (the value of bdpcm_dir_flag is 0), the variable dz[x][y] of a sample located in a first column where x is 0 is derived as TransCoeffLevel[xTbY][yTbY][cIdx][x][y] derived based on residual information of the sample, and the variable dz[x][y] of a sample located in a column other than the first column where x is not 0 is derived as the sum of dz[x−1][y] of a left neighboring sample of the sample and dz[x][y] of the sample. Here, dz[x][y] for the sample that is added to the dz[x−1][y] may be derived based on the signaled residual information for the sample.

(169) In addition, for example, when the value of the bdpcm_dir_flag is 1, that is, the vertical BDPCM is applied, the variable dz[x][y] is derived based on dz[x][y−1]+dz[x][y]. That is, when the vertical BDPCM is applied (the value of bdpcm_dir_flag is 1), the variable dz[x][y] of a sample located in a first row where y is 0 is derived as TransCoeffLevel[xTbY][yTbY][cIdx][x][y] derived based on residual information of the sample, and the variable dz[x][y] of a sample located in a row other than the first row where y is not 0 is derived as the sum of dz[x][y−1] of a top neighboring sample of the sample and dz[x][y] of the sample. Here, dz[x][y] for the sample that is added to the dz[x][y−1] may be derived based on the signaled residual information for the sample.

(170) As described above, a residual of a specific location may be derived based on the sum of a residual of the previous location (i.e., left or top) in the horizontal or vertical direction and a value received as residual information of the specific location. This is because, when the BDPCM is applied, a difference value between a residual sample value of the specific position (x, y) and a residual sample value of the previous position (i.e., (x−1, y) or (x, y−1)) in the horizontal or vertical direction is signaled as residual information.

(171) As the above-described contents, information on the BDPCM may be signaled, but in the present disclosure, other embodiments for signaling the information on the BDPCM are proposed. For example, according to the existing video standards, since only the BDPCM for the luma block can be performed in YUV 420, and the BDPCM for the luma block and the chroma block can be

performed in YUV 444, as illustrated in Table as described above, the sps_bdpcm_enabled_flag that is a syntax element of the BDPCM enabled flag for the luma block and the sps_bdpcm_chroma_enabled_flag that is a syntax element of the BDPCM enabled flag for the chroma block may be respectively transmitted in the sequence parameter set (SPS) syntax. In particular, the BDPCM enabled flag for the chroma block may be transmitted only in case that the BDPCM is enabled for the luma block, and the chroma format of the image is YUV 444 (i.e., in case that chroma_format_idc=3).

(172) Unlike the above-described contents, the present disclosure proposes an embodiment for controlling whether the BDPCM for both the luma block and the chroma block is enabled based on one flag. For example, in the proposed embodiment, as in Table 7 to be described later, only one syntax element sps_bdpcm_enabled_flag for whether the BDPCM is enabled may be transmitted in the SPS syntax, and through this, whether the BDPCM is enabled/disabled for both the luma block and the chroma block may be derived. According to the present embodiment, whether the BDPCM of the luma block and the chroma block in the image is enabled can be determined through one syntax element, and through this, the bit amount for the BDPCM can be reduced, and the overall coding efficiency can be improved.

(173) TABLE-US-00007 TABLE 7 Descriptor seq parameter set rbsp( ) {   (...) sps_transform_skip_enabled_flag u(1)   if(sps transform skip enabled flag)   sps bdpcm enabled flag u(1)   (...) }

(174) TABLE-US-00008 TABLE 8 sps_bdpcm_enabled_flag equal to 1 specifies that intra_bdpcm_flag may be present in the coding unit syntax for intra coding units. sps_bdpcm_enabled_flag equal to 0 specifies that intra_bdpcm_flag is not present in the coding unit syntax for intra coding units. When not present, the value of sps bdpcm enabled flag is inferred to be equal to 0.

(175) For example, referring to Table 8, when the sps_bdpcm_enabled_flag is 1, it may mean that the BDPCM is enabled for both the luma block and the chroma block, whereas when the sps_bdpcm_enabled_flag is 0, it may mean that the BDPCM is not enabled for both the luma block and the chroma block. That is, for example, when the syntax element sps_bdpcm_enabled_flag is 1, it may represent that the BDPCM is enabled in a coding unit (including a luma component and a chroma component) in which intra prediction is performed, whereas when the syntax element sps_bdpcm_enabled_flag is 0, it may represent that the BDPCM is not enabled in the coding unit in which the intra prediction is performed. That is, for example, when the syntax element sps_bdpcm_enabled_flag is 1, it may represent that an intra_bdpcm_luma_flag and an intra_bdpcm_chroma_flag are present in the coding unit, whereas when the syntax element sps_bdpcm_enabled_flag is 0, it may represent that the intra_bdpcm_luma_flag and the intra_bdpcm_chroma_flag are not present in the coding unit. The intra_bdpcm_luma_flag and the intra_bdpcm_chroma_flag may be represented as intra_bdpcm_flags.

(176) Meanwhile, the flag for whether the BDPCM is enabled may be transmitted from not only an SPS syntax as exemplified above but also an adaptation parameter set (APS) syntax, a picture parameter set (PPS) syntax, a video parameter set (VPS) syntax, a decoding parameter set (DPS) syntax, a picture header syntax, or a slice header syntax.

(177) Further, in the proposed embodiment, semantics for the syntax element sps_bdpcm_enabled_flag may be changed as in Table 8.

(178) Further, in the present embodiment, since whether the BDPCM for the luma block and the chroma block is enabled is controlled at once by the syntax element sps_bdpcm_enabled_flag, the coding unit syntax according to the present embodiment may be as in the following table.

(179) TABLE-US-00009 TABLE 9 Descriptor coding unit(x0, y0, cbWidth, cbHeight, cqtDepth, treeType, modeType) {   if(sh slice type = = I && (cbWidth > 64 || cbHeight > 64))   mode Type = MODE TYPE INTRA   chType = treeType = = DUAL TREE CHROMA ? 1 : 0   if(sh slice type != I || sps ibc enabled flag) {   if(treeType != DUAL_TREE_CHROMA &&

```
                    ( ( !( cbWidth = = 4 && cbHeight = = 4 ) &&                    modeType !=
MODE_TYPE_INTRA ) ||                    ( sps_ibc_enabled flag && cbWidth <= 64 && cbHeight <=
64 ) ) )            cu_skip_flag[ x0 ][ y0 ] ae(v)        if( cu_skip_flag[ x0 ][ y0 ] = = 0 &&
sh_slice_type != I &&                    !( cbWidth = = 4 && cbHeight = = 4) && modeType = = MOD E
TYPE ALL )            pred mode flag ae(v)        if( ( ( sh_slice_type = = I && cu_skip_flag[ x0 ][
y0 ] = =0 ) ||                    ( sh_slice_type != I && ( CuPredMode[ chType ][ x0 ][ y0 ] != MO
DE_INTRA ||                    ( ( ( cbWidth = = 4 && cbHeight = = 4 ) || modeType = = MODE
_TYPE_INTRA )                    && cu_skip_flag[ x0 ][ y0 ] = = 0 ) ) ) ) &&                    cbWidth <=
64 && chHeight <= 64 && modeType != MODE_T YPE_INTER &&            sps ibc enabled
flag && treeType != DUAL TREE CHROMA )            pred_mode_ibc_flag ae(v)      }    if(
CuPredMode[ chType ][ x0 ][ y0 ] = = MODE_INTRA && sps_palette_e nabled_flag &&
cbWidth <= 64 && cbHeight <= 64 && cu_skip_flag[ x0 ][ y0 ] = = 0 &&            modeType !=
MODE_TYPE_INTER && ( ( cbWidth * cbHeight ) >          ( treeType !=
DUAL_TREE_CHROMA ? 16 : 16 * SubWidthC * SubHe ightC ) ) &&            ( modeType !=
MODE_TYPE_INTRA || treeType != DUAL_TREE.sub.— CHROMA ) )        pred mode plt flag
ae(v)    if( CuPredMode[ chType ][ x0 ][ y0 ] = = MODE_INTRA && sps_act_enab led_flag &&
      treeType = = SINGLE TREE )        cu act enabled flag ae(v)    if( CuPredMode[ chType ][
x0 ][ y0 ] = = MODE_INTRA ||            CuPredMode[ chType ][ x0 ]] y0 ] = = MODE PLT ) {
      if( treeType = = SINGLE_TREE || treeType = = DUAL_TREE_LUMA ) {            if( pred
mode plt flag )            palette coding( x0, y0, cbWidth, cbHeight, treeType )            else {
            if( sps_bdpcm_enabled_flag &&                    cbWidth <= MaxTsSize && cbHeight
<= MaxTsSize )                    intra_bdpcm_luma_flag ae(v)            if( intra bdpcm luma flag )
            intra bdpcm luma dir flag ae(v)            else {                    if( sps mip enabled flag )
            intra_mip_flag[ x0 ][ y0 ] ae(v)            if( intra mip flag[ x0 ][ y0 ] ) {
            intra_mip_transposed_flag[ x0 ][ y0 ] ae(v)                    intra_mip_mode[ x0 ][
y0] ae(v)            } else {                    if( sps mrl enabled flag && ( ( y0 % CtbSizeY ) > 0 )
)            intra_luma_ref_idx[ x0 ][ y0 ] ae(v)                    if( sps_isp_enabled_flag &&
intra_luma_ref_idx[ x0 ][ y0 ] = = 0 &&                    ( cbWidth <= MaxTbSizeY &&
cbHeight <= MaxTbSize Y ) &&                    ( cbWidth * cbHeight > MinTbSizeY * Min
TbSizeY ) &&                    !cu act enabled flag )
intra_subpartitions_mode_flag[ x0 ][ y0 ] ae(v)                    if( intra subpartitions mode flag[ x0
][ y0 ] = = 1 )                    intra subpartitions split flag[ x0 ][ y0 ] ae(v)                    if( intra
luma ref idx[ x0 ][ y0 ] = = 0 )                    intra luma mpm flag[ x0][ y0 ] ae(v)
            if( intra luma mpm flag[ x0 ][ y0 ] ) {                    if( intra luma ref idx[ x0 ][
y0 ] = = 0 )                    intra luma not planar flag[ x0 ][ y0 ] ae(v)                    if( intra
luma not planar flag[ x0 ][ y0 ] )                    intra_luma_mpm_idx[ x0 ][ y0 ] ae(v)
            } else                    intra luma mpm remainder[ x0 ][ y0 ] ae(v)                    }
      }            }        }        if( ( treeType = = SINGLE_TREE || treeType = =
DUAL_TREE_CHR OMA ) &&            sps chroma format idc != 0 ) {        if( pred mode plt
flag && treeType = = DUAL TREE CHROMA )            palette_coding( x0, y0, cbWidth /
SubWidthC, cbHeight / SubHeightC, treeType )        else if( !pred mode plt flag ) {            if(
!cu act enabled flag ) {            if( cbWidth / SubWidthC <= MaxTsSize && cbHeight /
SubHeigh tC <= MaxTsSize                    && sps bdpcm enabled flag )
intra_bdpcm_chroma_flag ae(v)            if( intra bdpcm chroma flag )
intra_bdpcm_chroma_dir_flag ae(v)                    else {                    if( CclmEnabled )
            cclm_mode_flag ae(v)                    if( cclm mode flag )                    cclm
mode idx ae(v)                    else                    intra_chroma_pred_mode ae(v)                    }
      }        }        }        } else if( treeType != DUAL_TREE_CHROMA ) { /*
MODE_INTER or MO DE IBC */        if( cu skip flag[ x0 ][ y0 ] = = 0 )            general merge
```

flag[x0][y0] ae(v)   if(general merge flag[x0][y0])   merge data(x0, y0, cbWidth, cbHeight, chType)   else if(CuPredMode[chType][x0][y0] = = MODE IBC) {   mvd coding(x0, y0, 0, 0)   if(MaxNumIbcMergeCand > 1)   mvp l0 flag[x0][y0] ae(v)   if(sps_amvr_enabled_flag &&   (MvdL0[x0][y0][0] != 0 ‖ MvdL0[x0][y0][1] != 0))   amvr precision idx[x0][y0] ae(v)   } else {   if(sh slice type = = B)   inter pred idc[x0][y0] ae(v)   if(sps_affine_enabled_flag && cbWidth >= 16 && cbHeight >= 16) {   inter affine flag[x0][y0] ae(v)   if(sps 6param affine enabled flag && inter affine flag[x0][y0])   cu affine type flag[x0][y0] ae(v)   }   if(sps_smvd_enabled_flag && !ph_mvd_l1_zero_flag &&   inter_pred_idc[x0][y0] = = PRED_BI &&   !inter_affine_flag[x0][y0] && RefIdxSymL0 > −1 && RefIdxS ymL1 > −1)   sym_mvd_flag[x0][y0] ae(v)   if(inter pred idc[x0][y0] != PRED L1) {   if(NumRefIdxActive[0] > 1 && !sym mvd flag[x0][y0])   ref_idx_l0[x0][y0] ae(v)   mvd coding(x0, y0, 0, 0)   if(MotionModelIdc[x0][y0] > 0)   mvd coding(x0, y0, 0, 1)   if(MotionModelIdc[x0][y0] > 1)   mvd coding(x0, y0, 0, 2)   mvp_l0_flag[x0][y0] ae(v)   } else {   MvdL0[x0][y0][0] = 0   MvdL0[x0][y0][1] = 0   }   if(inter pred idc[x0][y0] != PRED L0) {   if(NumRefIdxActive[1] > 1 && !sym mvd flag[x0][y0])   ref_idx_l1[x0][y0] ae(v)   if(ph_mvd_l1_zero_flag && inter_pred_idc[x0][y0] = = PRED_B I) {   MvdL1[x0][y0][0] = 0   MvdL1[x0][y0][1] = 0   MvdCpL1[x0][y0][0][0] = 0   MvdCpL1[x0][y0][0][1] = 0   MvdCpL1[x0][y0][1][0] = 0   MvdCpL1[x0][y0][1][1] = 0   MvdCpL1[x0][y0][2][0] = 0   MvdCpL1[x0][y0][2][1] = 0   } else {   if(sym mvd flag[x0][y0]) {   MvdL1[x0][y0][0] = −MvdL0[x0][y0][0]   MvdL1[x0][y0][1] = −MvdL0[x0][y0][1]   } else   mvd coding(x0, y0, 1, 0)   if(MotionModelIdc[x0][y0] > 0)   mvd coding(x0, y0, 1, 1)   if(MotionModelIdc[x0][y0] > 1)   mvd coding(x0, y0, 1, 2)   }   mvp l1 flag[x0][y0] ae(v)   } else {   MvdL1[x0][y0][0] = 0   MvdL1[x0][y0][1] = 0   }   if((sps_amvr_enabled_flag && inter_affine_flag[x0 [y0] = = 0 &&   (MvdL0[x0][y0][0] != 0 ‖ MvdL0[x0][y0][1] != 0 ‖   MvdL1[x0][y0][0] != 0 ‖ MvdL1[x0][y0][1] != 0)) ‖   (sps_affine_amvr_enabled_flag && inter_affine_flag[x0][y0] = = 1 &&   (MvdCpL0[x0][y0][0][0] != 0 ‖ MvdCpL0[x0][y0][0] [1] != 0 ‖   MvdCpL1[x0][y0][0][0] != 0 ‖ MvdCpL1[x0][y0][0][1] != 0 ‖   MvdCpL0[x0][y0][1][0] != 0 ‖ MvdCpL0[x0][y0][1] [1] != 0 ‖   MvdCpL1[x0][y0][1][0] != 0 ‖ MvdCpL1[x0][y0][1][1] != 0 ‖   MvdCpL0[x0][y0][2][0] != 0 ‖ MvdCpL0[x0][y0][2][1] != 0 ‖   MvdCpL1[x0][y0][2][0] != 0 ‖ MvdCpL1[x0][y0][2][1] != 0)) {   amvr flag[x0][y0] ae(v)   if(amvr flag[x0][y0])   amvr precision idx[x0][y0] ae(v)   }   if(sps_bcw_enabled_flag && inter_pred_idc[x0][y0] = = PRED_BI &&   luma_weight_l0_flag[ref_idx_l0 [x0][y0]] = = 0 &&   luma_weight_l1_flag[ref_idx_l1 [x0][y0]] = = 0 &&   chroma_weight_l0_flag[ref_idx_l0 [x0][y0]] = = 0 &&   chroma_weight_l1_flag[ref_idx_l1 [x0][y0]] = = 0 &&   cbWidth * cbHeight >= 256)   bcw idx[x0][y0] ae(v)   }   }   if(CuPredMode[chType][x0][y0] != MODE_INTRA && !pred_mode_pl t_flag && general merge flag[x0][y0] = = 0)   cu coded flag ae(v)   if(cu coded flag) {   if(CuPredMode[chType][x0][y0] = = MODE_INTER && sps_sbt_en abled_flag &&   !ciip_flag[x0][y0] && cbWidth <= MaxTbSizeY && cbHeight < = MaxTbSizeY) {   allowSbtVerH = cbWidth >= 8   allowSbtVerQ = cbWidth >= 16

allowSbtHorH = cbHeight >= 8   allowSbtHorQ = cbHeight >= 16   if(allowSbtVerH
|| allowSbtHorH)   cu sbt flag ae(v)   if(cu sbt flag) {   if((allow SbtVerH
|| allow SbtHorH) && (allowSbtVerQ || allowS btHorQ))   cu sbt quad flag ae(v)
          if((cu_sbt_quad_flag && allowSbtVerQ && allowSbtHorQ) || (!cu sbt
quad flag && allowSbtVerH && allowSbtHorH))   cu sbt horizontal flag ae(v)
          cu sbt pos flag ae(v)   }   }   if(sps_act_enabled_flag && CuPredMode[
chType][x0][y0] != MOD E_INTRA &&   treeType = = SINGLE TREE)   cu act
enabled flag ae(v)   LfnstDcOnly = 1   LfnstZeroOutSigCoeffFlag = 1   MtsDcOnly = 1
     MtsZeroOutSigCoeffFlag = 1   transform tree(x0, y0, cbWidth, cbHeight, treeType,
chType)   lfnstWidth = (treeType = = DUAL_TREE_CHROMA) ? cbWidth / SubWi dthC :
               ((IntraSubPartitionsSplitType = = ISP_VER_SPLIT) ?
cbWidth / NumIntraSubPartitions : cbWidth)   lfnstHeight = (treeType = =
DUAL_TREE_CHROMA) ? cbHeight / SubH eightC :   ((
IntraSubPartitionsSplitType = = ISP_HOR_SPLIT) ?   cbHeight /
NumIntraSubPartitions : cbHeight)   lfnstNotTsFlag = (treeType = =
DUAL_TREE_CHROMA   !tu_y_coded_flag[x0][y0] ||
          transform_skip_flag[x0][y0][0] = = 0) &&   (
treeType = = DUAL_TREE_LUMA || ((!tu_cb_coded_flag[x0][y0] ||
          transform_skip_flag[x0][y0][1] = = 0) &&   (
!tu_cr_coded_flag[x0][y0] || transform skip flag[x0][y0][2] = = 0))
)   if(Min(lfnstWidth, lfnstHeight) >= 4 && sps_lfnst_enabled_flag = = 1 &&
CuPredMode[chType][x0][y0] = = MODE_INTRA && lfnstNot TsFlag = = 1 &&   (
treeType = = DUAL_TREE_CHROMA || !intra_mip_flag[x0][y 0] || Min(
lfnstWidth, lfnstHeight) >= 16) &&   Max(cbWidth, cbHeight) <= MaxTbSizeY) {
          if((IntraSubPartitionsSplitType != ISP_NO_SPLIT || LfnstDcOnly = = 0) &&
          LfnstZeroOutSigCoeffFlag = = 1)   lfnst idx ae(v)   }   if(treeType !=
DUAL_TREE_CHROMA && lfnst_idx = = 0 &&   transform_skip_flag[x0][y0][0] =
= 0 && Max(cbWidth, cbHeig ht) <= 32 &&   IntraSubPartitionsSplitType = =
ISP_NO_SPLIT && cu_sbt_flag = = 0 &&   MtsZeroOutSigCoeffFlag = = 1 &&
MtsDcOnly = = 0) {   if(((CuPredMode[chType][x0][y0] = = MODE_INTER &&
          sps_explicit_mts_inter_enabled_flag) || (CuPredMode[chType][x0][
y0] = = MODE_INTRA &&   sps explicit mts intra enabled flag)))   mts idx
ae(v)   }   } }

(180) Further, the present disclosure proposes another embodiment for signaling information on the
BDPCM. For example, the present disclosure proposes an embodiment for controlling whether the
BDPCM for both the luma block and the chroma block is enabled regardless of the chroma format
of the image. According to the present embodiment, information on whether the BDPCM of the
luma block is enabled and information on whether the BDPCM of the chroma block is enabled may
be respectively transmitted regardless of the chroma format of the image. According to the present
embodiment, the BDPCM chroma enabled flag representing whether the BDPCM of the chroma
block in the image is enabled can be signaled regardless of the chroma format of the image, and
through this, complexity for the BDPCM can be reduced, and the overall coding efficiency can be
improved.

(181) For example, in the proposed embodiment, if a transform skip mode is enabled (i.e., if an
sps_transform_skip_enabled_flag is 1) as in Table 10 to be described later, the syntax element
sps_bdpcm_enabled_flag for whether the BDPCM of the luma block is enabled and the syntax
element sps_bdpcm_chroma_enabled_flag for whether the BDPCM of the chroma block is enabled
may be transmitted from the SPS syntax.

(182) TABLE-US-00010 TABLE 10 Descriptor seq parameter set rbsp( ) {   (...)

sps_transform_skip_enabled_flag u(1)   if(sps transform skip enabled flag)
sps_bdpcm_enabled_flag u(1)   sps_bdpcm_chroma_enabled_flag u(1)   (...) }
(183) TABLE-US-00011 TABLE 11 sps_bdpcm_enabled_flag equal to 1 specifies that intra_bdpcm_luma_flag may be present in the coding unit syntax for intra coding units. sps_bdpcm_enabled_flag equal to 0 specifies that intra_bdpcm_luma_flag is not present in the coding unit syntax for intra coding units. When not present, the value of sps_bdpcm_enabled_flag is inferred to be equal to 0. sps_bdpcm_chroma_enabled_flag equal to 1 specifies that intra_bdpcm_chroma_flag may be present in the coding unit syntax for intra coding units. sps_bdpcm_chroma_enabled_flag equal to 0 specifies that intra_bdpcm_chroma_flag is not present in the coding unit syntax for intra coding units. When not present, the value of sps_bdpcm_chroma_enabled_flag is inferred to be equal to 0.

(184) For example, if the sps_bdpcm_enabled_flag is 1, it may mean that the BDPCM is enabled for the luma block, whereas if the sps_bdpcm_enabled_flag is 0, it may mean that the BDPCM is not enabled for the luma block. That is, for example, if the syntax element sps_bdpcm_enabled_flag is 1, it may represent that the BDPCM is enabled in the luma coding unit in which intra prediction is performed, and if the syntax element sps_bdpcm_enabled_flag is 0, it may represent that the BDPCM is not enabled in the luma coding unit in which the intra prediction is performed. That is, for example, if the syntax element sps_bdpcm_enabled_flag is 1, it may represent that the intra_bdpcm_luma_flag is present in the coding unit, whereas if the syntax element sps_bdpcm_enabled_flag is 0, it may represent that the intra_bdpcm_luma_flag is not present in the coding unit.

(185) Further, for example, if the sps_bdpcm_chroma_enabled_flag is 1, it may mean that the BDPCM is enabled for the chroma block, whereas if the sps_bdpcm_chroma_enabled_flag is 0, it may mean that the BDPCM is not enabled for the chroma block. That is, for example, if the syntax element sps_bdpcm_chroma_enabled_flag is 1, it may represent that the BDPCM is enabled in the chroma coding unit in which intra prediction is performed, whereas if the syntax element sps_bdpcm_chroma_enabled_flag is 0, it may represent that the BDPCM is not enabled in the chroma coding unit in which the intra prediction is performed. That is, for example, if the syntax element sps_bdpcm_chroma_enabled_flag is 1, it may represent that the intra_bdpcm_chroma_flag is present in the coding unit, whereas if the syntax element sps_bdpcm_enabled_flag is 0, it may represent that the intra_bdpcm_chroma_flag is not present in the coding unit.

(186) Meanwhile, the flags for whether the BDPCM is enabled may be transmitted from not only an SPS syntax as exemplified above but also an adaptation parameter set (APS) syntax, a picture parameter set (PPS) syntax, a video parameter set (VPS) syntax, a decoding parameter set (DPS) syntax, a picture header syntax, or a slice header syntax.

(187) Further, in the proposed embodiment, semantics for the syntax element sps_bdpcm_enabled_flag and the syntax element sps_bdpcm_chroma_enabled_flag may be changed as in Table 11.

(188) Further, the present disclosure proposes another embodiment for signaling information on the BDPCM. For example, the present disclosure proposes an embodiment for controlling whether the BDPCM for both the luma block and the chroma block is enabled regardless of the chroma format of the image. According to the present embodiment, information on whether the BDPCM of the luma block is enabled and information on whether the BDPCM of the chroma block is enabled may be respectively transmitted regardless of the chroma format of the image, and information on whether the BDPCM of the chroma block is enabled may be transmitted only in case that the BDPCM is enabled for the luma block. According to the present embodiment, the BDPCM enabled flags representing whether the BDPCM of the luma block and the chroma block in the image is enabled can be signaled regardless of the chroma format of the image, and through this, complexity for the BDPCM can be reduced, and the overall coding efficiency can be improved.

(189) For example, in the proposed embodiment, if the transform skip mode is enabled (i.e., if an

sps_transform_skip_enabled_flag is 1) as in Table 12 to be described later, the syntax element sps_bdpcm_enabled_flag for whether the BDPCM of the luma block is enabled may be transmitted, and if the BDPCM is enabled for the luma block (i.e., if the sps_bdpcm_enabled_flag is 1), the syntax element sps_bdpcm_chroma_enabled_flag for whether the BDPCM of the chroma block is enabled may be transmitted from the SPS syntax.

(190) TABLE-US-00012 TABLE 12 Descriptor seq parameter set rbsp( ) {   (...) sps_transform_skip_enabled_flag u(1)   if(sps transform skip enabled flag)   sps bdpcm enabled flag u(1)   if(sps bdpcm enabled flag)   sps bdpcm chroma enabled flag u(1) (...) }

(191) TABLE-US-00013 TABLE 13 sps_bdpcm_enabled_flag equal to 1 specifies that intra_bdpcm_luma_flag may be present in the coding unit syntax for intra coding units. sps_bdpcm_enabled_flag equal to 0 specifies that intra_bdpcm_luma_flag is not present in the coding unit syntax for intra coding units. When not present, the value of sps_bdpcm_enabled_flag is inferred to be equal to 0. sps_bdpcm_chroma_enabled_flag equal to 1 specifies that intra_bdpcm_chroma_flag may be present in the coding unit syntax for intra coding units. sps_bdpcm_chroma_enabled_flag equal to 0 specifies that intra_bdpcm_chroma_flag is not present in the coding unit syntax for intra coding units. When not present, the value of sps_bdpcm_chroma_enabled_flag is inferred to be equal to 0.

(192) For example, if the sps_bdpcm_enabled_flag is 1, it may mean that the BDPCM is enabled for the luma block, whereas if the sps_bdpcm_enabled_flag is 0, it may mean that the BDPCM is not enabled for the luma block. That is, for example, if the syntax element sps_bdpcm_enabled_flag is 1, it may represent that the BDPCM is enabled in the luma coding unit in which intra prediction is performed, and if the syntax element sps_bdpcm_enabled_flag is 0, it may represent that the BDPCM is not enabled in the luma coding unit in which the intra prediction is performed. That is, for example, if the syntax element sps_bdpcm_enabled_flag is 1, it may represent that the intra_bdpcm_luma_flag is present in the coding unit, whereas if the syntax element sps_bdpcm_enabled_flag is 0, it may represent that the intra_bdpcm_luma_flag is not present in the coding unit.

(193) Further, for example, if the sps_bdpcm_chroma_enabled_flag is 1, it may mean that the BDPCM is enabled for the chroma block, whereas if the sps_bdpcm_chroma_enabled_flag is 0, it may mean that the BDPCM is not enabled for the chroma block. That is, for example, if the syntax element sps_bdpcm_chroma_enabled_flag is 1, it may represent that the BDPCM is enabled in the chroma coding unit in which intra prediction is performed, whereas if the syntax element sps_bdpcm_chroma_enabled_flag is 0, it may represent that the BDPCM is not enabled in the chroma coding unit in which the intra prediction is performed. That is, for example, if the syntax element sps_bdpcm_chroma_enabled_flag is 1, it may represent that the intra_bdpcm_chroma_flag is present in the coding unit, whereas if the syntax element sps_bdpcm_enabled_flag is 0, it may represent that the intra_bdpcm_chroma_flag is not present in the coding unit.

(194) Meanwhile, the flags for whether the BDPCM is enabled may be transmitted from not only an SPS syntax as exemplified above but also an adaptation parameter set (APS) syntax, a picture parameter set (PPS) syntax, a video parameter set (VPS) syntax, a decoding parameter set (DPS) syntax, a picture header syntax, or a slice header syntax.

(195) Further, the present disclosure proposes another embodiment for signaling information on the BDPCM. For example, the present disclosure proposes an embodiment for performing a process to be described later in addition to the above-described embodiments. For example, according to the present embodiment, the BDPCM may be enabled for both the luma block and the chroma block in the SPS syntax, VPS syntax, DPS syntax, picture header syntax, or slice header syntax, and if a specific condition that the BDPCM can be performed is satisfied, the intra_bdpcm_chroma_flag and intra_bdpcm_chroma_dir_flag are not transmitted in a CU syntax or TU syntax, and the value of the intra_bdpcm_chroma_flag may be derived as the value of a infra_bdpcm_luma_flag, and the

value of the intra_bdpcm_chroma_dir_flag may be derived as the value of an intra_bdpcm_luma_dir_flag. Here, for example, the specific condition may be a case that the tree type is a dual tree and/or a width and a height of the current block are all smaller than the maximum size of the defined transform skip block (i.e., in case that cbWidth<=MaxTsSize && cbHeight<=MaxTsSize).

(196) Further, for example, according to the present embodiment, if the specific condition that the BDPCM can be performed is satisfied, the intra_bdpcm_chroma_flag may not be transmitted, and the value of the intra_bdpcm_chroma_flag may be derived as the value of the intra_bdpcm_luma_flag. This means that the chroma block of the current block is coded in the BDPCM mode without transmission of an additional syntax element (i.e., intra_bdpcm_chroma_flag) in case that the luma block of the current block is coded in the BDPCM mode. However, in the above-described embodiment, the intra_bdpcm_chroma_dir_flag may have a different value independently of the intra_bdpcm_luma_dir_flag. That is, in the above-described embodiment, the intra_bdpcm_chroma_dir_flag for the current block may be transmitted.

(197) As another example, if the intra_bdpcm_luma_flag and the intdra_bdpcm_chroma_flag for the current block are all 1 in case that the specific condition in which the BDPCM can be performed is satisfied, the intra_bdpcm_chroma_dir_flag may not be transmitted, and the value of the intra_bdpcm_chroma_dir_flag may be derived as the value of the intra_bdpcm_luma_dir_flag.

(198) Further, the present disclosure proposes another embodiment for signaling information on the BDPCM. For example, the present disclosure proposes an embodiment for performing a process to be described later in addition to one of the embodiments as described above in the present disclosure.

(199) For example, according to the present embodiment, in case that the DBPCM for the chroma block is enabled based on the intra_bdpcm_enabled_flag or the intra_bdpcm_chroma_enabled_flag in a high level syntax (e.g., SPS syntax, VPS syntax, DPS syntax, picture header syntax, or slice header syntax), and the tree type is a single tree, the intra_bdpcm_chroma_flag and the intra_bdpcm_chroma_dir_flag for the respective chroma blocks (Cb chroma block and Cr chroma block) are not separately transmitted in the CU syntax or the TU syntax, and the intra_bdpcm_chroma_flag and the intra_bdpcm_chroma_dir_flag for the Cb chroma block and the Cr chroma block may be transmitted. That is, if the value of the transmitted intra_bdpcm_chroma_flag is 1, it means that both the Cb chroma block and the Cr chroma block of the current block are all coded in the BDPCM mode, whereas if the value of the transmitted intra_bdpcm_chroma_flag is 0, it means that both the Cb chroma block and the Cr chroma block of the current block are not coded in the BDPCM mode. Further, if the value of the intra_bdpcm_chroma_dir_flag is 0, it means that the BDPCM prediction direction for the Cb chroma block and the Cr chroma block of the current block is a horizontal direction, whereas if the value of the intra_bdpcm_chroma_dir_flag is 1, it means that the BDPCM prediction direction for the Cb chroma block and the Cr chroma block of the current block is a vertical direction.

(200) Alternatively, for example, according to the present embodiment, in case that the DBPCM for the chroma block is enabled based on the intra_bdpcm_enabled_flag or the intra_bdpcm_chroma_enabled_flag in the high level syntax (e.g., SPS syntax, VPS syntax, DPS syntax, picture header syntax, or slice header syntax), and the tree type is a single tree, the intra_bdpcm_chroma_flag for each of the chroma blocks (Cb chroma block and Cr chroma block) may not be separately transmitted in the CU syntax or the TU syntax, and the intra_bdpcm_chroma_flag for the Cb chroma block and the Cr chroma block may be transmitted. That is, if the value of the transmitted intra_bdpcm_chroma_flag is 1, it means that both the Cb chroma block and the Cr chroma block of the current block are all coded in the BDPCM mode, whereas if the value of the transmitted intra_bdpcm_chroma_flag is 0, it means that both the Cb chroma block and the Cr chroma block of the current block are not coded in the BDPCM mode. Here, the intra_bdpcm_chroma_dir_flag for each of the chroma blocks may be transmitted, and the

intra_bdpcm_chroma_dir_flag for each of the chroma blocks may have a different value.

(201) For example, according to the present embodiment, in case that the DBPCM for the chroma block is enabled based on the intra_bdpcm_enabled_flag or the intra_bdpcm_chroma_enabled_flag in the high level syntax (e.g., SPS syntax, VPS syntax, DPS syntax, picture header syntax, or slice header syntax), and the tree type is a single tree, the intra_bdpcm_chroma_flag for each of the chroma blocks (Cb chroma block and Cr chroma block) is transmitted in the CU syntax or the TU syntax, and the intra_bdpcm_chroma_dir_flag for the Cb chroma block and the Cr chroma block may be transmitted.

(202) That is, if the intra_bdpcm_chroma_flag values transmitted for the chroma blocks are all 1, the intra_bdpcm_chroma_dir_flag for the chroma block being later coded between the two chroma blocks may not be coded, and the intra_bdpcm_chroma_dir_flag for the chroma color difference block being earlier coded between the two Chroma blocks may be derived as the intra_bdpcm_chroma_dir_flag for the chroma block being later coded. For example, if the value of the intra_bdpcm_chroma_dir_flag is 0, it may mean that the BDPCM prediction direction for the Cb chroma block and the Cr chroma block of the current block is the horizontal direction, whereas if the value of the intra_bdpcm_chroma_dir_flag is 1, it may mean that the BDPCM prediction direction for the Cb chroma block and the Cr chroma block of the current block is the vertical direction.

(203) FIG. **9** schematically shows an image encoding method by an encoding apparatus according to the present disclosure. The method disclosed in FIG. **9** may be performed by the encoding apparatus disclosed in FIG. **2**. Specifically, for example, S**900** and S**920** to S**930** of FIG. **9** may be performed by the predictor of the encoding apparatus, S**910** and S**940** to S**950** of FIG. **9** may be performed by the entropy encoder of the encoding apparatus. Further, although not illustrated, a process of deriving residual samples may be performed by the residual processor of the encoding apparatus, and a process of generating reconstructed samples and a reconstructed picture based on the residual samples and prediction samples may be performed by the adder of the encoding apparatus.

(204) The encoding apparatus determines whether Block-based Delta Pulse Code Modulation (BDPCM) is enabled for a chroma block and a luma block (S**900**). For example, the encoding apparatus may determine whether the BDPCM is enabled for a chroma block and a luma block in an image.

(205) The encoding apparatus generates a BDPCM enabled flag for whether the BDPCM is enabled for the chroma block and the luma block based on a result of the determination (S**910**). The encoding apparatus may generate a BDPCM enabled flag for whether the BDPCM is enabled for the chroma block and the luma block based on a result of the determination. For example, image information may include the BDPCM enabled flag for whether the BDPCM is enabled for the chroma block and the luma block. For example, the BDPCM enabled flag may represent whether the Block-based Delta Pulse Code Modulation (BDPCM) is enabled for the chroma block and the luma block. For example, if the value of the BDPCM enabled flag is 1, the BDPCM enabled flag may represent that the Block-based Delta Pulse Code Modulation (BDPCM) is enabled for the chroma block and the luma block, whereas if the value of the BDPCM enabled flag is 0, the BDPCM enabled flag may represent that the Block-based Delta Pulse Code Modulation (BDPCM) is not enabled for the chroma block and the luma block. That is, for example, the BDPCM enabled flag may represent whether the BDPCM flag for the chroma block and the luma block is present. For example, if the value of the BDPCM enabled flag is 1, the BDPCM enabled flag may represent that the BDPCM flag for the chroma block and the luma block is present, whereas if the value of the BDPCM enabled flag is 0, the BDPCM enabled flag may represent that the BDPCM flag for the chroma block and the luma block is not present. Further, for example, the chroma block may include a block of a chroma Cb component (chroma Cb block) and/or a block of a chroma Cr component (chroma Cr block).

(206) Further for example, the BDPCM enabled flag may be signaled regardless of a chroma format of an image. For example, the BDPCM enabled flag may be signaled in case that the chroma format of the image is YUV 444, YUV 420, or YUV 422. That is, for example, even in case that the chroma format of the image is YUV 444, the BDPCM enabled flag may be signaled.

(207) Further, for example, the BDPCM enabled flag may be signaled through a high level syntax. For example, the BDPCM enabled flag may be signaled through a sequence parameter set (SPS). Further, for example, the BEPCM enabled flag may be signaled through an adaptation parameter set (APS) syntax, a picture parameter set (PPS) syntax, a video parameter set (VPS) syntax, a decoding parameter set (DPS) syntax, a picture header syntax (PH syntax), or a slice header syntax. For example, the syntax element of the BDPCM enabled flag may be the sps_bdpcm_enabled_flag as described above.

(208) The encoding apparatus generates prediction samples for a current luma block based on the BDPCM (S**920**). For example, the encoding apparatus may determine whether the BDPCM is applied to a current luma block, and may determine a direction in which the BDPCM is performed.

(209) The encoding apparatus may derive prediction samples by performing intra prediction for the current luma block based on a prediction direction in which the BDPCM for the current luma block is performed. For example, the prediction direction may be a vertical direction or a horizontal direction, and the prediction sample for the current luma block may be generated in accordance with the consequent intra prediction mode.

(210) For example, if the prediction direction for the current luma block is derived as the horizontal direction, the encoding apparatus may derive the prediction samples of the current luma block based on the horizontal intra prediction mode. In other words, for example, if the prediction direction for the current luma block is derived as the horizontal direction, the encoding apparatus may derive the prediction samples of the current luma block by performing intra prediction based on left neighboring samples of the current luma block. For example, if the prediction direction for the current luma block is derived as the horizontal direction, the encoding apparatus may derive a sample value of the left neighboring sample in the same row as the row of the prediction sample as a sample value of the prediction sample.

(211) Further, for example, if the prediction direction for the current luma block is derived as the vertical direction, the encoding apparatus may derive the prediction samples of the current luma block based on the vertical intra prediction mode. In other words, for example, if the prediction direction for the current luma block is derived as the vertical direction, the encoding apparatus may derive the prediction samples of the current luma block based on top neighboring samples of the current luma block. For example, if the prediction direction for the current luma block is derived as the vertical direction, the encoding apparatus may derive a sample value of the top neighboring sample in the same column as the column of the prediction sample as a sample value of the prediction sample.

(212) The encoding apparatus generates prediction samples for current chroma blocks based on the BDPCM (S**930**). For example, the encoding apparatus may determine whether the BDPCM is applied to current chroma blocks, and may determine a direction in which the BDPCM is performed.

(213) The encoding apparatus may derive the prediction samples by performing intra prediction for the current chroma blocks based on the prediction direction in which the BDPCM for the current chroma blocks is performed. For example, the prediction direction may be a vertical direction or a horizontal direction, and the prediction samples for the current chroma blocks may be generated in accordance with the consequent intra prediction mode.

(214) For example, if the prediction direction for the current chroma blocks is derived as the horizontal direction, the encoding apparatus may derive the prediction samples of the current chroma blocks based on the horizontal intra prediction mode. In other words, for example, if the prediction direction for the current chroma blocks is derived as the horizontal direction, the

encoding apparatus may derive the prediction samples of the current chroma blocks by performing intra prediction based on left neighboring samples of the current chroma blocks. For example, if the prediction direction for the current chroma blocks is derived as the horizontal direction, the encoding apparatus may derive a sample value of the left neighboring sample in the same row as the row of the prediction sample as a sample value of the prediction sample.

(215) Further, for example, if the prediction direction for the current chroma blocks is derived as the vertical direction, the encoding apparatus may derive the prediction samples of the current chroma blocks based on the vertical intra prediction mode. In other words, for example, if the prediction direction for the current chroma blocks is derived as the vertical direction, the encoding apparatus may derive the prediction samples of the current chroma blocks based on top neighboring samples of the current chroma blocks. For example, if the prediction direction for the current chroma blocks is derived as the vertical direction, the encoding apparatus may derive a sample value of the top neighboring sample in the same column as the column of the prediction sample as a sample value of the prediction sample.

(216) The encoding apparatus generates BDPCM related information for the current luma block and BDPCM related information for the current chroma blocks (S**940**).

(217) For example, if the value of the BDPCM enabled flag is 1 (i.e., if it is determined that the BDPCM is enabled for the chroma block and the luma block), the encoding apparatus may generate the BDPCM-related information for the current luma block and the BDPCM-related information for the current chroma blocks. The image information may include the BDPCM-related information for the current luma block and the BDPCM-related information for the current chroma blocks.

(218) For example, the BDPCM-related information for the current luma block may inlude a BDPCM luma flag and/or a BDPCM luma direction flag for the current luma block.

(219) For example, the encoding apparatus may determine whether the BDPCM is applied to the current luma block, and may generate a BDPCM luma flag for whether the BDPCM is applied to the current luma block.

(220) For example, the BDPCM luma flag may represent whether the BDPCM is applied to the current luma block and whether the BDPCM luma direction flag for the current luma block is present. For example, if the value of the BDPCM luma flag is 1, the BDPCM luma flag may represent that the BDPCM is applied to the current luma block, and the BDPCM luma direction flag for the current luma block is present, whereas if the value of the BDPCM luma flag is 0, the BDPCM luma flag may represent that the BDPCM is not applied to the current luma block, and the BDPCM luma direction flag for the current luma block is not present. For example, the syntax element of the BDPCM luma flag may be the bdpcm_flag or the intra_bdpcm_luma_flag as described above. Further, for example, the BDPCM luma flag may be signaled in the unit of a coding unit (CU).

(221) Further, for example, the encoding apparatus may determine whether the BDPCM is applied to the current luma block, and may determine a direction in which the BDPCM is performed. For example, if the BDPCM luma flag represents that the BDPCM is applied to the current luma block, the encoding apparatus may generate and encode the BDPCM luma direction flag. For example, the BDPCM luma direction flag may represent a vertical direction or a horizontal direction as a prediction direction for the current luma block. For example, if the value of the BDPCM luma direction flag is 0, the BDPCM luma direction flag may represent that the prediction direction for the current luma block is the horizontal direction, whereas if the value of the BDPCM luma direction flag is 1, the BDPCM luma direction flag may represent that the prediction direction for the current luma block is the vertical direction. For example, the syntax element of the BDPCM luma direction flag may be the bdpcm_dir_flag or the intra_bdpcm_luma_dir_flag as described above. Further, for example, the BDPCM luma direction flag may be signaled in the unit of a coding unit (CU).

(222) For example, the BDPCM-related information for the current chroma blocks may include a BDPCM chroma flag and/or a BDPCM chroma direction flag for the current chroma blocks. Further, for example, the BDPCM-related information for the current chroma blocks (i.e., for all the current chroma blocks) may be signaled in case that the tree type of the image is a single tree, and the value of the BDPCM enabled flag is 1. That is, for example, the BDPCM-related information for the current chroma blocks (i.e., for all the current chroma blocks) may be signaled in case that the tree type of the image is the single tree, and the BDPCM is enabled for the current chroma blocks. Meanwhile, the tree type of the current block may be divided into a signal tree (SINGLE_TREE) or a dual tree (DUAL_TREE) depending on whether the current chroma blocks corresponding to the current luma block have individual divided structures. For example, if the current chroma blocks have the same divided structure as that of the current luma block, it may be represented as the single tree, whereas if the current chroma blocks have the divided structure different from that of the current luma block, it may be represented as the dual tree.

(223) For example, the encoding apparatus may determine whether the BDPCM is applied to the current chroma blocks, and may generate a BDPCM chroma flag for whether the Block-based Delta Pulse Code Modulation (BDPCM) is applied to the current chroma blocks. For example, the BDPCM chroma flag may represent whether the BDPCM is applied to the current chroma blocks and whether the BDPCM chroma direction flag for the current chroma blocks is present. For example, if the value of the BDPCM chroma flag is 1, the BDPCM chroma flag may represent that the BDPCM is applied to the current chroma blocks, and the BDPCM chroma direction flag for the current chroma blocks is present, whereas if the value of the BDPCM chroma flag is 0, the BDPCM chroma flag may represent that the BDPCM is not applied to the current chroma blocks, and the BDPCM chroma direction flag for the current chroma blocks is not present. That is, for example, if the value of the BDPCM chroma flag is 1, the BDPCM chroma flag may represent that the BDPCM is applied to all of the current chroma blocks, and the BDPCM chroma direction flag for all of the current chroma blocks is present, whereas if the value of the BDPCM chroma flag is 0, the BDPCM chroma flag may represent that the BDPCM is not applied to all of the current chroma blocks, and the BDPCM chroma direction flag for all of the current chroma blocks is not present. Here, for example, the current chroma blocks may include a current chroma Cb block and a current chroma Cr block. For example, the syntax element of the BDPCM chroma flag may be the bdpcm_flag or the intra_bdpcm_chroma_flag as described above. Further, for example, the BDPCM chroma flag may be signaled in the unit of a coding unit (CU).

(224) Further, for example, the encoding apparatus may determine whether the BDPCM is applied to the current chroma blocks, and may determine a direction in which the BDPCM is performed. For example, if the BDPCM chroma flag represents that the BDPCM is applied to the current chroma blocks, the encoding apparatus may generate and encode the BDPCM chroma direction flag. For example, the BDPCM chroma direction flag may represent a vertical direction or a horizontal direction as a prediction direction for the current chroma blocks. For example, if the value of the BDPCM chroma direction flag is 0, the BDPCM chroma direction flag may represent that the prediction direction for the current chroma blocks is the horizontal direction, whereas if the value of the BDPCM chroma direction flag is 1, the BDPCM chroma direction flag may represent that the prediction direction for the current chroma blocks is the vertical direction. For example, the syntax element of the BDPCM chroma direction flag may be the bdpcm_dir_flag or the intra_bdpcm_chroma_dir_flag as described above. Further, for example, the BDPCM chroma direction flag may be signaled in the unit of a coding unit (CU).

(225) Meanwhile, for example, the encoding apparatus may derive residual samples of the current luma block based on prediction samples of the current luma block. For example, the encoding apparatus may derive the residual sample through subtraction of the prediction sample from the original sample for the current luma block. Further, for example, the encoding apparatus may derive the residual samples of the current chroma blocks based on the prediction samples of the

current chroma blocks. For example, the encoding apparatus may derive the residual sample through subtraction of the prediction sample from the original sample for each of the current chroma blocks.

(226) The encoding apparatus encodes image information including the BDPCM enabled flag, the BDPCM related information for the current luma block and the BDPCM related information for the current chroma blocks (S**950**). The ecoding apparatus may encode image information including the BDPCM enabled flag, the BDPCM related information for the current luma block and the BDPCM related information for the current chroma blocks. For example, the BDPCM related information for the current luma block may include a BDPCM luma flag for whether the BDPCM is applied to the current luma block and/or a BDPCM luma direction flag for a prediction direction of the current luma block, the BDPCM related information for the current chroma blocks may include a BDPCM chroma flag for whether the BDPCM is applied to the current chroma blocks and/or a BDPCM chroma direction flag for a prediction direction of the current chroma blocks.

(227) Meanwhile, for example, the image information may include residual information. For example, the encoding apparatus may derive residual coefficients of the current luma block or the current chroma blocks based on the residual samples of the current luma block or the current chroma blocks. For example, if the BDPCM is applied to the current luma block or the current chroma blocks, the encoding apparatus may determine that transform is not applied to the current luma block or the current chroma blocks. In this case, for example, the encoding apparatus may derive the residual coefficients by performing quantization for the current luma block or the current chroma blocks. Here, for example, the block to which the transform is not applied may be represented as a transform skip block. That is, for example, the current luma block or the current chroma blocks may be transform skip blocks.

(228) Thereafter, for example, the encoding apparatus may encode residual information for the residual coefficients. For example, the residual information may include residual information for the residual coefficients of the residual samples.

(229) For example, the residual information may include syntax elements for residual samples of the current luma block or the current chroma blocks, and based on the syntax elements for a target residual sample, a difference between a residual coefficient value of the target residual sample and a residual coefficient value of a left neighboring residual sample or a top neighboring residual sample of the target residual sample may be derived. For example, if the prediction direction of the current luma block or the current chroma blocks is the horizontal direction, the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample. That is, for example, if the prediction direction of the current luma block or the current chroma blocks is the horizontal direction, the syntax elements for the target residual sample may represent the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample of the target residual sample. Further, for example, if the prediction direction of the current luma block or the current chroma blocks is the vertical direction, the syntax elements for the target residual sample may represent the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the top neighboring residual sample of the target residual sample. That is, for example, if the prediction direction of the current luma block or the current chroma blocks is the vertical direction, the syntax elements for the target residual sample may represent the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the top neighboring residual sample of the target residual sample. Further, if the target residual sample is located in the first row or column of the current luma block or the current chroma block, the residual coefficient value of the target residual sample may be derived based on the syntax elements for the target residual sample. That is, if the target residual sample is located in the first row or column of the current luma block or the current

chroma block, the syntax elements for the target residual sample may represent the residual coefficient value of the target residual sample.

(230) Meanwhile, a bitstream including the image information may be transmitted to the decoding apparatus through a network or a (digital) storage medium. Here, the network may include a broadcast network and/or a communication network, and the digital storage medium may include various types of storage media such as an USB disk, an SD, a CD, a DVD, a Blu-ray disk, an HDD, and an SSD.

(231) FIG. **10** schematically shows an encoding apparatus for performing an image encoding method according to this disclosure. The method disclosed in FIG. **9** may be performed by the encoding apparatus disclosed in FIG. **10**. Specifically, for example, a predictor of the encoding apparatus of FIG. **10** may perform S**900** and S**920** to S**930** of FIG. **9**, and an entropy encoder of the encoding apparatus may perform S**910** and S**940** to S**950** of FIG. **9**. Further, although not illustrated, a process of deriving residual samples may be performed by a residual processor of the encoding apparatus, and a process of generating reconstructed samples and a reconstructed picture based on the residual samples and prediction samples may be performed by an adder of the encoding apparatus.

(232) FIG. **11** schematically shows an image decoding method by a decoding apparatus according to this disclosure. The method disclosed in FIG. **11** may be performed by the decoding apparatus disclosed in FIG. **3**. Specifically, for example, S**1100** to S**1120** and S**1140** to S**1150** of FIG. **11** may be performed by the entropy decoder of the decoding apparatus, S**1130** and S**1160** of FIG. **11** may be performed by the predictor of the decoding apparatus, and S**1170** of FIG. **11** may be performed by the adder of the decoding apparatus.

(233) The decoding apparatus obtains a Block-based Delta Pulse Code Modulation (BDPCM) enabled flag for whether BDPCM is enabled for a luma block and a chroma block (S**1100**). The decoding apparatus may obtain a BDPCM enabled flag for whether BDPCM is enabled for a luma block and a chroma block. The decoding apparatus may obtain image information through a bitstream. For example, the image information may include a BDPCM enabled flag for whether BDPCM is enabled for a luma block and a chroma block. For example, the BDPCM enabled flag may represent whether the Block-based Delta Pulse Code Modulation (BDPCM) is enabled for the chroma block and the luma block. For example, if the value of the BDPCM enabled flag is 1, the BDPCM enabled flag may represent that the Block-based Delta Pulse Code Modulation (BDPCM) is enabled for the chroma block and the luma block, whereas if the value of the BDPCM enabled flag is 0, the BDPCM enabled flag may represent that the Block-based Delta Pulse Code Modulation (BDPCM) is not enabled for the chroma block and the luma block. That is, for example, the BDPCM enabled flag may represent whether the BDPCM flag for the chroma block and the luma block is present. For example, if the value of the BDPCM enabled flag is 1, the BDPCM enabled flag may represent that the BDPCM flag for the chroma block and the luma block is present, whereas if the value of the BDPCM enabled flag is 0, the BDPCM enabled flag may represent that the BDPCM flag for the chroma block and the luma block is not present. Further, for example, the chroma block may include a block of a chroma Cb component (chroma Cb block) and/or a block of a chroma Cr component (chroma Cr block).

(234) Further, for example, the BDPCM enabled flag may be signaled regardless of a chroma format of an image. For example, the BDPCM enabled flag may be signaled in case that the chroma format of the image is YUV 444, YUV 420, or YUV 422. That is, for example, even in case that the chroma format of the image is YUV 444, the BDPCM enabled flag may be signaled.

(235) Further, for example, the BDPCM enabled flag may be signaled through a high level syntax. For example, the BDPCM enabled flag may be signaled through a sequence parameter set (SPS). Further, for example, the BEPCM enabled flag may be signaled through an adaptation parameter set (APS) syntax, a picture parameter set (PPS) syntax, a video parameter set (VPS) syntax, a decoding parameter set (DPS) syntax, a picture header syntax (PH syntax), or a slice header syntax.

For example, the syntax element of the BDPCM enabled flag may be the sps_bdpcm_enabled_flag as described above.

(236) The decoding apparatus obtains a BDPCM luma flag for whether the BDPCM is applied to a current luma block based on the BDPCM enabled flag (S**1110**). The decoding apparatus may obtain BDPCM related information for a current luma block based on the BDPCM enabled flag. For example, the BDPCM related information for the current luma block may include a BDPCM luma flag for the current luma block. The decoding apparatus may obtain a BDPCM luma flag for the current luma block based on the BDPCM enabled flag.

(237) For example, if the value of the BDPCM enabled flag is 1 (i.e., if it is represented that the BDPCM is enabled for the chroma block and the luma block), the decoding apparatus may obtain a BDPCM luma flag for whether the BDPCM is applied to the current luma block. For example, the BDPCM luma flag may represent whether the BDPCM is applied to the current luma block and whether the BDPCM luma direction flag for the current luma block is present. For example, if the value of the BDPCM luma flag is 1, the BDPCM luma flag may represent that the BDPCM is applied to the current luma block, and the BDPCM luma direction flag for the current luma block is present, whereas if the value of the BDPCM luma flag is 0, the BDPCM luma flag may represent that the BDPCM is not applied to the current luma block, and the BDPCM luma direction flag for the current luma block is not present. For example, the syntax element of the BDPCM luma flag may be the bdpcm_flag or the intra_bdpcm_luma_flag as described above. Further, for example, the BDPCM luma flag may be signaled in the unit of a coding unit (CU).

(238) The decoding apparatus obtains a BDPCM luma direction flag for a prediction direction of the current luma block based on the BDPCM luma flag (S**1120**). For example, the BDPCM related information for the current luma block may include a BDPCM luma flag for the current luma block and/or a BDPCM luma direction flag.

(239) For example, the decoding apparatus may obtain a BDPCM luma direction flag for a prediction direction of the current luma block based on the BDPCM luma flag. For example, if the BDPCM luma flag represents that the BDPCM is applied to the current luma block, the decoding apparatus may obtain the BDPCM luma direction flag. That is, for example, if the value of the BDPCM luma flag is 1, the decoding apparatus may obtain the BDPCM luma direction flag. For example, the BDPCM luma direction flag may represent a vertical direction or a horizontal direction as a prediction direction for the current luma block. For example, if the value of the BDPCM luma direction flag is 0, the BDPCM luma direction flag may represent that the prediction direction for the current luma block is the horizontal direction, whereas if the value of the BDPCM luma direction flag is 1, the BDPCM luma direction flag may represent that the prediction direction for the current luma block is the vertical direction. For example, the syntax element of the BDPCM luma direction flag may be the bdpcm_dir_flag or the intra_bdpcm_luma_dir_flag as described above. Further, for example, the BDPCM luma direction flag may be signaled in the unit of a coding unit (CU).

(240) The decoding apparatus derives prediction samples of the current luma block based on an intra prediction mode derived based on the BDPCM luma direction flag (S**1130**).

(241) For example, the decoding apparatus may derive prediction samples of the current luma block based on an intra prediction mode derived based on the BDPCM luma direction flag.

(242) For example, if the value of the BDPCM luma direction flag is 0, that is, for example, if the BDPCM luma direction flag represents that the prediction direction for the current luma block is the horizontal direction, the decoding apparatus may derive the horizontal intra prediction mode as the intra prediction mode of the current luma block. For example, if the value of the BDPCM luma direction flag is 0, that is, for example, if the BDPCM luma direction flag represents that the prediction direction for the current luma block is the horizontal direction, the decoding apparatus may derive the prediction samples of the current luma block based on the horizontal intra prediction mode. In other words, for example, if the value of the BDPCM luma direction flag is 0,

that is, for example, if the BDPCM luma direction flag represents that the prediction direction for the current luma block is the horizontal direction, the decoding apparatus may derive the prediction samples of the current luma block by performing the intra prediction based on left neighboring samples of the current luma block. For example, if the prediction direction for the current luma block is derived as the horizontal direction, the decoding apparatus may derive the sample value of the left neighboring sample in the same row as the row of the prediction sample as the sample value of the prediction sample.

(243) Further, for example, if the value of the BDPCM luma direction flag is 1, that is, for example, if the BDPCM luma direction flag represents that the prediction direction for the current luma block is the vertical direction, the decoding apparatus may derive the vertical intra prediction mode as the intra prediction mode of the current luma block. For example, if the value of the BDPCM luma direction flag is 1, that is, for example, if the BDPCM luma direction flag represents that the prediction direction for the current luma block is the vertical direction, the decoding apparatus may derive the prediction samples of the current luma block based on the vertical intra prediction mode. In other words, for example, if the value of the BDPCM luma direction flag is 1, that is, for example, if the BDPCM luma direction flag represents that the prediction direction for the current luma block is the vertical direction, the decoding apparatus may derive the prediction samples of the current luma block by performing the intra prediction based on top neighboring samples of the current luma block. For example, if the prediction direction for the current luma block is derived as the vertical direction, the decoding apparatus may derive the sample value of the top neighboring sample in the same column as the column of the prediction sample as the sample value of the prediction sample.

(244) The decoding apparatus obtains a BDPCM chroma flag for whether the BDPCM is applied to current chroma blocks based on the BDPCM enabled flag (S**1140**). The decoding apparatus may obtain BDPCM related information for the current chroma blocks based on the BDPCM enabled flag. For example, the BDPCM related information for the current chroma blocks may include a BDPCM chroma flag for the current chroma blocks. The decoding apparatus may obtain the BDPCM chroma flag for the current chroma blocks based on the BDPCM enabled flag.

(245) Further, for example, the BDPCM-related information for the current chroma blocks (i.e., for all the current chroma blocks) may be signaled in case that the tree type of the image is a single tree, and the value of the BDPCM enabled flag is 1. That is, for example, the BDPCM-related information for the current chroma blocks (i.e., for all the current chroma blocks) may be signaled in case that the tree type of the image is the single tree, and the BDPCM is enabled for the current chroma blocks. Meanwhile, the tree type of the current block may be divided into a signal tree (SINGLE_TREE) or a dual tree (DUAL_TREE) depending on whether the current chroma blocks corresponding to the current luma block have individual divided structures. For example, if the current chroma blocks have the same divided structure as that of the current luma block, it may be represented as the single tree, whereas if the current chroma blocks have the divided structure different from that of the current luma block, it may be represented as the dual tree.

(246) For example, the BDPCM luma flag may represent whether the BDPCM is applied to the current luma block and whether the BDPCM luma direction flag for the current luma block is present. For example, if the value of the BDPCM luma flag is 1, the BDPCM luma flag may represent that the BDPCM is applied to the current luma block, and the BDPCM luma direction flag for the current luma block is present, whereas if the value of the BDPCM luma flag is 0, the BDPCM luma flag may represent that the BDPCM is not applied to the current luma block, and the BDPCM luma direction flag for the current luma block is not present. For example, the syntax element of the BDPCM luma flag may be the bdpcm_flag or the intra_bdpcm_luma_flag as described above. Further, for example, the BDPCM luma flag may be signaled in the unit of a coding unit (CU).

(247) The decoding apparatus obtains a BDPCM chroma direction flag for a prediction direction of

the current chroma blocks based on the BDPCM chroma flag (S**1150**). For example, BDPCM related information for the current chroma blocks may include a BDPCM chroma flag for the current chroma blocks and/or a BDPCM chroma direction flag.

(248) For example, the decoding apparatus may obtain a BDPCM chroma direction flag for a prediction direction of the current chroma blocks based on the BDPCM chroma flag. For example, if the BDPCM chroma flag represents that the BDPCM is applied to the current chroma blocks, the decoding apparatus may obtain the BDPCM chroma direction flag. That is, for example, if the value of the BDPCM chroma flag is 1, the decoding apparatus may obtain the BDPCM chroma direction flag. For example, the BDPCM chroma direction flag may represent the vertical direction or the horizontal direction as the prediction direction for the current chroma blocks. For example, if the value of the BDPCM chroma direction flag is 0, the BDPCM chroma direction flag may represent that the prediction direction for the current chroma blocks is the horizontal direction, whereas if the value of the BDPCM chroma direction flag is 1, the BDPCM chroma direction flag may represent that the prediction direction for the current chroma blocks is the vertical direction. For example, the syntax element of the BDPCM chroma direction flag may be the bdpcm_dir_flag or the intra_bdpcm_chroma_dir_flag as described above. Further, for example, the BDPCM chroma direction flag may be signaled in the unit of a coding unit (CU).

(249) The decoding apparatus derives prediction samples of the current chroma blocks based on an intra prediction mode derived based on the BDPCM chroma direction flag (S**1160**). For example, the decoding apparatus may derive prediction samples of the current chroma blocks based on an intra prediction mode derived based on the BDPCM chroma direction flag.

(250) For example, if the value of the BDPCM chroma direction flag is 0, that is, for example, if the BDPCM chroma direction flag represents that the prediction direction for the current chroma blocks is the horizontal direction, the decoding apparatus may derive the horizontal intra prediction mode as the intra prediction mode of the current chroma blocks. For example, if the value of the BDPCM chroma direction flag is 0, that is, for example, if the BDPCM chroma direction flag represents that the prediction direction for the current chroma blocks is the horizontal direction, the decoding apparatus may derive the prediction samples of the current chroma blocks based on the horizontal intra prediction mode. In other words, for example, if the value of the BDPCM chroma direction flag is 0, that is, for example, if the BDPCM chroma direction flag represents that the prediction direction for the current chroma blocks is the horizontal direction, the decoding apparatus may derive the prediction samples of the current chroma blocks by performing the intra prediction based on left neighboring samples of the current chroma blocks. For example, if the prediction direction for the current chroma blocks is derived as the horizontal direction, the decoding apparatus may derive the sample value of the left neighboring sample in the same row as the row of the prediction sample as the sample value of the prediction sample.

(251) Further, for example, if the value of the BDPCM chroma direction flag is 1, that is, for example, if the BDPCM chroma direction flag represents that the prediction direction for the current chroma blocks is the vertical direction, the decoding apparatus may derive the vertical intra prediction mode as the intra prediction mode of the current chroma blocks. For example, if the value of the BDPCM chroma direction flag is 1, that is, for example, if the BDPCM chroma direction flag represents that the prediction direction for the current chroma blocks is the vertical direction, the decoding apparatus may derive the prediction samples of the current chroma blocks based on the vertical intra prediction mode. In other words, for example, if the value of the BDPCM chroma direction flag is 1, that is, for example, if the BDPCM chroma direction flag represents that the prediction direction for the current chroma blocks is the vertical direction, the decoding apparatus may derive the prediction samples of the current chroma blocks by performing the intra prediction based on top neighboring samples of the current chroma blocks. For example, if the prediction direction for the current chroma blocks is derived as the vertical direction, the decoding apparatus may derive the sample value of the top neighboring sample in the same column

as the column of the prediction sample as the sample value of the prediction sample.

(252) The decoding apparatus generates a reconstructed picture based on the prediction samples of the current luma block and the prediction samples of the current chroma blocks (S**1170**).

(253) The decoding apparatus may derive reconstructed samples and/or a reconstructed picture for the current luma block and the current chroma blocks based on the prediction samples of the current luma block and the prediction samples of the current chroma blocks. For example, the decoding apparatus may derive the reconstructed samples of the current luma block through addition of the prediction samples of the current luma block and the residual samples of the current luma block. Further, for example, the decoding apparatus may derive the reconstructed samples of the current chroma blocks through addition of the prediction samples of the current chroma blocks and the residual samples of the current chroma blocks. That is, for example, the decoding apparatus may derive the reconstructed samples of the current chroma Cb block through addition of the prediction samples of the current chroma Cb block and the residual samples of the current chroma Cb block, and may derive the reconstructed samples of the current chroma Cr block through addition of the prediction samples of the current chroma Cr block and the residual samples of the current chroma Cr block.

(254) Meanwhile, for example, the decoding apparatus may derive residual samples of the current luma block based on the received residual information, and may derive residual samples of the current chroma blocks (residual samples of the current chroma Cb block and residual samples of the current chroma Cr block) based on the received residual information.

(255) For example, if the BDPCM is applied to the current luma block, the residual information may include syntax elements for the residual samples of the current luma block (i.e., if the BDPCM is applied to the current luma block, the residual information may include the syntax elements for a target residual sample of the current luma block), and the syntax elements for the target residual sample may represent a difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample or the top neighboring residual sample of the target residual sample. That is, for example, if the BDPCM is applied to the current luma block, the residual information may include the syntax elements for the target residual sample of the current luma block, and the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample or the top neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample.

(256) For example, if the BDPCM is applied to the current luma block, and the prediction direction for the current luma block is the horizontal direction, the syntax elements for the target residual sample may represent the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample of the target residual sample. That is, for example, the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample. Thereafter, the residual coefficient of the target residual sample may be derived through the sum of the residual coefficient value of the left neighboring residual sample of the target residual sample and the difference. Here, the target residual sample may be the residual sample in columns excluding the first column of the current luma block. For example, the residual coefficient of the target residual sample may be derived based on Equation 4 as described above. Meanwhile, for example, if the target residual sample is the residual sample in the first column of the current luma block, the residual coefficient of the target residual sample may be derived based on the syntax element of the target residual sample.

(257) Further, for example, if the BDPCM is applied to the current luma block, and the prediction direction for the current luma block is the vertical direction, the syntax elements for the target residual sample may represent the difference between the residual coefficient value of the target

residual sample and the residual coefficient value of the top neighboring residual sample of the target residual sample. That is, for example, the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the top neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample. Thereafter, the residual coefficient of the target residual sample may be derived through the sum of the residual coefficient value of the top neighboring residual sample of the target residual sample and the difference. Here, the target residual sample may be the residual sample in rows excluding the first row of the current luma block. For example, the residual coefficient of the target residual sample may be derived based on Equation 3 as described above. Meanwhile, for example, if the target residual sample is the residual sample in the first row of the current luma block, the residual coefficient of the target residual sample may be derived based on the syntax element of the target residual sample.

(258) Thereafter, for example, the decoding apparatus may derive the target residual sample by dequantizing the residual coefficient. That is, for example, the target residual sample may be derived by dequantizing the residual coefficient.

(259) For example, if the BDPCM is applied to the current chroma block (e.g., current chroma Cb block or current chroma Cr block), the residual information may include syntax elements for the residual samples of the current chroma block (i.e., if the BDPCM is applied to the current chroma blocks, the residual information may include the syntax elements for a target residual sample of the current chroma blocks (current chrome Cb block and current chroma Cr block), and the syntax elements for the target residual sample may represent a difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample or the top neighboring residual sample of the target residual sample. That is, for example, if the BDPCM is applied to the current chroma blocks, the residual information may include the syntax elements for the target residual sample of the current chroma block (e.g., current chroma Cb block or the current chroma Cr block), and the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample or the top neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample.

(260) For example, if the BDPCM is applied to the current chroma blocks, and the prediction direction for the current chroma blocks is the horizontal direction, the syntax elements for the target residual sample may represent the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample of the target residual sample. That is, for example, the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample. Thereafter, the residual coefficient of the target residual sample may be derived through the sum of the residual coefficient value of the left neighboring residual sample of the target residual sample and the difference. Here, the target residual sample may be the residual sample in columns excluding the first column of the current chroma blocks. For example, the residual coefficient of the target residual sample may be derived based on Equation 4 as described above. Meanwhile, for example, if the target residual sample is the residual sample in the first column of the current chroma blocks, the residual coefficient of the target residual sample may be derived based on the syntax element of the target residual sample.

(261) Further, for example, if the BDPCM is applied to the current chroma blocks, and the prediction direction for the current chroma blocks is the vertical direction, the syntax elements for the target residual sample may represent the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the top neighboring residual sample of the target residual sample. That is, for example, the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the top neighboring residual

sample of the target residual sample may be derived based on the syntax elements for the target residual sample. Thereafter, the residual coefficient of the target residual sample may be derived through the sum of the residual coefficient value of the top neighboring residual sample of the target residual sample and the difference. Here, the target residual sample may be the residual sample in rows excluding the first row of the current chroma blocks. For example, the residual coefficient of the target residual sample may be derived based on Equation 3 as described above. Meanwhile, for example, if the target residual sample is the residual sample in the first row of the current chroma blocks, the residual coefficient of the target residual sample may be derived based on the syntax element of the target residual sample.

(262) Thereafter, for example, the decoding apparatus may derive the target residual sample by dequantizing the residual coefficient. That is, for example, the target residual sample may be derived by dequantizing the residual coefficient.

(263) Meanwhile, although not illustrated in the drawing, for example, the decoding apparatus may obtain the residual information for the current luma block based on the BDPCM luma flag. For example, if the BDPCM luma flag represents that the BDPCM is applied to the current luma block, that is, if the BDPCM is applied to the current luma block, the residual information may include the syntax elements for the residual samples of the current luma block, and the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample or the top neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample. For example, if the prediction direction of the current luma block is the horizontal direction, that is, if the prediction direction of the current luma block is derived as the horizontal direction based on the BDPCM luma direction flag, the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample. Further, for example, if the prediction direction of the current luma block is the vertical direction, that is, if the prediction direction of the current luma block is derived as the vertical direction based on the BDPCM luma direction flag, the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the top neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample. Further, if the target residual sample is located in the first row or column of the current block, the residual coefficient value of the target residual sample may be derived based on the syntax elements for the target residual sample.

(264) Further, for example, the decoding apparatus may obtain the residual information for the current chroma blocks based on the BDPCM chroma flag. For example, if the BDPCM chroma flag represents that the BDPCM is applied to the current chroma blocks, that is, if the BDPCM is applied to the current chroma blocks, the residual information may include the syntax elements for the residual samples of the current chroma blocks, and the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample or the top neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample. For example, if the prediction direction of the current chroma blocks is the horizontal direction, that is, if the prediction direction of the current chroma blocks is derived as the horizontal direction based on the BDPCM chroma direction flag, the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the left neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample. Further, for example, if the prediction direction of the current chroma blocks is the vertical direction, that is, if the prediction direction of the current chroma blocks is derived as the vertical direction based on the BDPCM chroma direction flag, the difference between the residual coefficient value of the target residual sample and the residual coefficient value of the top

neighboring residual sample of the target residual sample may be derived based on the syntax elements for the target residual sample. Further, if the target residual sample is located in the first row or column of the current chroma blocks, the residual coefficient value of the target residual sample may be derived based on the syntax elements for the target residual sample.

(265) The decoding apparatus may derive reconstructed samples through addition of the prediction samples and the residual samples. Thereafter, as needed, to improve the subjective/objective image quality, an in-loop filtering procedure, such as deblocking filtering, SAO and/or ALF procedures, may be applied to the reconstructed samples as described above.

(266) FIG. **12** schematically shows a decoding apparatus for performing an image decoding method according to this disclosure. The method disclosed in FIG. **11** may be performed by the decoding apparatus disclosed in FIG. **12**. Specifically, for example, the entropy decoder of the decoding apparatus of FIG. **12** may perform S**1100** to S**1120** and S**1140** to S**1150** of FIG. **11**, the predictor of the decoding apparatus of FIG. **12** may perform S**1130** and S**1160** of FIG. **11**, and the adder of the decoding apparatus of FIG. **12** may perform S**1170**.

(267) According to the present disclosure as described above, in order to derive the chroma quantization parameter for the chroma components, it can be determined whether the BDPCM of the luma block and the chroma block in the image is enabled through one syntax element, and through this, the bit amount for the BDPCM can be reduced, and the overall coding efficiency can be improved.

(268) Further, according to the present disclosure, the BDPCM enabled flag representing whether the BDPCM of the luma block and the chroma block in the image is enabled can be signaled regardless of the chroma format of the image, and through this, complexity for the BDPCM can be reduced, and the overall coding efficiency can be improved.

(269) In the above-described embodiment, the methods are described based on the flowchart having a series of steps or blocks. The present disclosure is not limited to the order of the above steps or blocks. Some steps or blocks may occur simultaneously or in a different order from other steps or blocks as described above. Further, those skilled in the art will understand that the steps shown in the above flowchart are not exclusive, that further steps may be included, or that one or more steps in the flowchart may be deleted without affecting the scope of the present disclosure.

(270) The embodiments described in this specification may be performed by being implemented on a processor, a microprocessor, a controller or a chip. For example, the functional units shown in each drawing may be performed by being implemented on a computer, a processor, a microprocessor, a controller or a chip. In this case, information for implementation (e.g., information on instructions) or algorithm may be stored in a digital storage medium.

(271) In addition, the decoding apparatus and the encoding apparatus to which the present disclosure is applied may be included in a multimedia broadcasting transmission/reception apparatus, a mobile communication terminal, a home cinema video apparatus, a digital cinema video apparatus, a surveillance camera, a video chatting apparatus, a real-time communication apparatus such as video communication, a mobile streaming apparatus, a storage medium, a camcorder, a VoD service providing apparatus, an Over the top (OTT) video apparatus, an Internet streaming service providing apparatus, a three-dimensional (3D) video apparatus, a teleconference video apparatus, a transportation user equipment (e.g., vehicle user equipment, an airplane user equipment, a ship user equipment, etc.) and a medical video apparatus and may be used to process video signals and data signals. For example, the Over the top (OTT) video apparatus may include a game console, a blue-ray player, an internet access TV, a home theater system, a smart phone, a tablet PC, a Digital Video Recorder (DVR), and the like.

(272) Furthermore, the processing method to which the present disclosure is applied may be produced in the form of a program that is to be executed by a computer and may be stored in a computer-readable recording medium. Multimedia data having a data structure according to the present disclosure may also be stored in computer-readable recording media. The computer-

readable recording media include all types of storage devices in which data readable by a computer system is stored. The computer-readable recording media may include a BD, a Universal Serial Bus (USB), ROM, PROM, EPROM, EEPROM, RAM, CD-ROM, a magnetic tape, a floppy disk, and an optical data storage device, for example. Furthermore, the computer-readable recording media includes media implemented in the form of carrier waves (e.g., transmission through the Internet). In addition, a bit stream generated by the encoding method may be stored in a computer-readable recording medium or may be transmitted over wired/wireless communication networks.

(273) In addition, the embodiments of the present disclosure may be implemented with a computer program product according to program codes, and the program codes may be performed in a computer by the embodiments of the present disclosure. The program codes may be stored on a carrier which is readable by a computer.

(274) FIG. **13** illustrates a structural diagram of a contents streaming system to which the present disclosure is applied.

(275) The content streaming system to which the embodiment(s) of the present disclosure is applied may largely include an encoding server, a streaming server, a web server, a media storage, a user device, and a multimedia input device.

(276) The encoding server compresses content input from multimedia input devices such as a smartphone, a camera, a camcorder, etc. Into digital data to generate a bitstream and transmit the bitstream to the streaming server. As another example, when the multimedia input devices such as smartphones, cameras, camcorders, etc. directly generate a bitstream, the encoding server may be omitted.

(277) The bitstream may be generated by an encoding method or a bitstream generating method to which the embodiment(s) of the present disclosure is applied, and the streaming server may temporarily store the bitstream in the process of transmitting or receiving the bitstream.

(278) The streaming server transmits the multimedia data to the user device based on a user's request through the web server, and the web server serves as a medium for informing the user of a service. When the user requests a desired service from the web server, the web server delivers it to a streaming server, and the streaming server transmits multimedia data to the user. In this case, the content streaming system may include a separate control server. In this case, the control server serves to control a command/response between devices in the content streaming system.

(279) The streaming server may receive content from a media storage and/or an encoding server. For example, when the content is received from the encoding server, the content may be received in real time. In this case, in order to provide a smooth streaming service, the streaming server may store the bitstream for a predetermined time.

(280) Examples of the user device may include a mobile phone, a smartphone, a laptop computer, a digital broadcasting terminal, a personal digital assistant (PDA), a portable multimedia player (PMP), navigation, a slate PC, tablet PCs, ultrabooks, wearable devices (ex. Smartwatches, smart glasses, head mounted displays), digital TVs, desktops computer, digital signage, and the like. Each server in the content streaming system may be operated as a distributed server, in which case data received from each server may be distributed.

(281) The claims described in the present disclosure may be combined in various ways. For example, the technical features of the method claims of the present disclosure may be combined to be implemented as an apparatus, and the technical features of the apparatus claims of the present disclosure may be combined to be implemented as a method. In addition, the technical features of the method claim of the present disclosure and the technical features of the apparatus claim may be combined to be implemented as an apparatus, and the technical features of the method claim of the present disclosure and the technical features of the apparatus claim may be combined to be implemented as a method.

Claims

1. An image decoding method performed by a decoding apparatus, the method comprising: obtaining a Block-based Delta Pulse Code Modulation (BDPCM) enabled flag indicating whether a BDPCM luma flag for a luma block and a BDPCM chroma flag for a chroma block are present in a current coding unit, where the BDPCM luma flag indicates whether the BDPCM is applied to the luma block, and the BDPCM chroma flag indicates whether the BDPCM is applied to the chroma block; obtaining the BDPCM luma flag based on the BDPCM enabled flag; obtaining a BDPCM luma direction flag for a prediction direction of a current luma block based on the BDPCM luma flag; deriving prediction samples of the current luma block based on an intra prediction mode derived based on the BDPCM luma direction flag; obtaining the BDPCM chroma flag based on the BDPCM enabled flag; obtaining a BDPCM chroma direction flag for a prediction direction of current chroma blocks based on the BDPCM chroma flag; and deriving prediction samples of the current chroma blocks based on an intra prediction mode derived based on the BDPCM chroma direction flag, wherein the BDPCM enabled flag is obtained in units of sequences, wherein the BDPCM luma flag, the BDPCM luma direction flag, the BDPCM chroma flag and the BDPCM chroma direction flag are obtained in units of coding units, wherein whether the BDPCM luma flag for the luma block is present in the current coding unit is determined based on a size of the luma block and only a value of the BDPCM enabled flag, wherein whether the BDPCM chroma flag for the chroma block is present in the current coding unit is determined based on a size of the chroma block and only the value of the BDPCM enabled flag, wherein, in response to the value of the BDPCM enabled flag being equal to 0, the BDPCM luma flag and the BDPCM chroma flag are not obtained from a bitstream, and wherein, in response to the value of the BDPCM enabled flag being equal to 1, the BDPCM luma flag and the BDPCM chroma flag are obtained from the bitstream.

2. An image encoding method performed by an encoding apparatus, the method comprising: determining whether Block-based Delta Pulse Code Modulation (BDPCM) is enabled for a chroma block and a luma block; generating a BDPCM enabled flag based on a result of the determination, the luma block and the chroma block being included in a current coding unit; generating prediction samples for a current luma block based on the BDPCM; generating prediction samples for current chroma blocks based on the BDPCM; generating BDPCM related information for the current luma block and BDPCM related information for the current chroma blocks; and encoding image information including the BDPCM enabled flag, the BDPCM related information for the current luma block and the BDPCM related information for the current chroma blocks, wherein the BDPCM related information for the current luma block includes a BDPCM luma flag for whether the BDPCM is applied to the current luma block and a BDPCM luma direction flag for a prediction direction of the current luma block, wherein the BDPCM related information for the current chroma blocks includes a BDPCM chroma flag for whether the BDPCM is applied to the current chroma blocks and a BDPCM chroma direction flag for a prediction direction of the current chroma blocks, wherein the image information is encoded so that whether the BDPCM luma flag for the luma block is present in the current coding unit is determined based on a size of the luma block and only a value of the BDPCM enabled flag, wherein the image information is encoded so that whether the BDPCM chroma flag for the chroma block is present in the current coding unit is determined based on a size of the chroma block and only the value of the BDPCM enabled flag, wherein, in response to the value of the BDPCM enabled flag being equal to 0, the BDPCM luma flag and the BDPCM chroma flag are not encoded, wherein, in response to the value of the BDPCM enabled flag being equal to 1, the BDPCM luma flag and the BDPCM chroma flag are encoded, wherein the BDPCM enabled flag is encoded in units of sequences, and wherein the BDPCM luma flag, the BDPCM luma direction flag, the BDPCM chroma flag and the BDPCM chroma direction flag are encoded in units of coding units.

3. A non-transitory computer-readable storage medium storing a bitstream generated by a method, the method comprising: determining whether Block-based Delta Pulse Code Modulation (BDPCM) is enabled for a chroma block and a luma block; generating a BDPCM enabled flag based on a result of the determination, the luma block and the chroma block being included in a current coding unit; generating prediction samples for a current luma block based on the BDPCM; generating prediction samples for current chroma blocks based on the BDPCM; generating BDPCM related information for the current luma block and BDPCM related information for the current chroma blocks; encoding image information including the BDPCM enabled flag, the BDPCM related information for the current luma block and the BDPCM related information for the current chroma blocks; and generating the bitstream including the image information, wherein the BDPCM related information for the current luma block includes a BDPCM luma flag for whether the BDPCM is applied to the current luma block and a BDPCM luma direction flag for a prediction direction of the current luma block, wherein the BDPCM related information for the current chroma blocks includes a BDPCM chroma flag for whether the BDPCM is applied to the current chroma blocks and a BDPCM chroma direction flag for a prediction direction of the current chroma blocks, wherein the image information is encoded so that whether the BDPCM luma flag for the luma block is present in the current coding unit is determined based on a size of the luma block and only a value of the BDPCM enabled flag, wherein the image information is encoded so that whether the BDPCM chroma flag for the chroma block is present in the current coding unit is determined based on a size of the chroma block and only the value of the BDPCM enabled flag, wherein, in response to the value of the BDPCM enabled flag being equal to 0, the BDPCM luma flag and the BDPCM chroma flag are not encoded, wherein, in response to the value of the BDPCM enabled flag being equal to 1, the BDPCM luma flag and the BDPCM chroma flag are encoded, wherein the BDPCM enabled flag is encoded in units of sequences, and wherein the BDPCM luma flag, the BDPCM luma direction flag, the BDPCM chroma flag and the BDPCM chroma direction flag are encoded in units of coding units.

4. A transmission method of data for an image, the method comprising: obtaining a bitstream of image information including a Block-based Delta Pulse Code Modulation (BDPCM) enabled flag, BDPCM related information for a current luma block and BDPCM related information for current chroma blocks; and transmitting the data including the bitstream of the image information including the BDPCM enabled flag, the BDPCM related information for the current luma block and the BDPCM related information for the current chroma blocks, wherein a luma block and a chroma block are included in the current coding unit, wherein the BDPCM related information for the current luma block includes a BDPCM luma flag for whether the BDPCM is applied to the current luma block and a BDPCM luma direction flag for a prediction direction of the current luma block, wherein the BDPCM related information for the current chroma blocks includes a BDPCM chroma flag for whether the BDPCM is applied to the current chroma blocks and a BDPCM chroma direction flag for a prediction direction of the current chroma blocks, wherein the image information is encoded so that whether the BDPCM luma flag for the luma block is present in the current coding unit is determined based on a size of the luma block and only a value of the BDPCM enabled flag, wherein the image information is encoded so that the BDPCM chroma flag for the chroma block is present in the current coding unit is determined based on a size of the chroma block and only the value of the BDPCM enabled flag, wherein, in response to the value of the BDPCM enabled flag being equal to 0, the BDPCM luma flag and the BDPCM chroma flag are not included in the bitstream, wherein, in response to the value of the BDPCM enabled flag being equal to 1, the BDPCM luma flag and the BDPCM chroma flag are included in the bitstream, wherein the BDPCM enabled flag is encoded in units of sequences, and wherein the BDPCM luma flag, the BDPCM luma direction flag, the BDPCM chroma flag and the BDPCM chroma direction flag are encoded in units of coding units.