

BIDIRECTIONAL INTRA PREDICTION SIGNALLING

TECHNICAL FIELD

- 5 The invention relates to the field of video coding. More specifically, the invention relates to a method for a bidirectional intra prediction mode signaling mechanism as well as a video encoder and a video decoder.

BACKGROUND

- 10 Digital video communication and storage applications are implemented by a wide range of digital devices, e.g., digital cameras, cellular radio telephones, laptops, broadcasting systems, video teleconferencing systems, etc. One of the most important and challenging tasks of these applications is video compression. The task of video compression is complex and is constrained by two contradicting parameters:
- 15 compression efficiency and computational complexity. Video coding standards, such as ITU-T H.264/Advanced Video Coding (AVC) or ITU-T H.265/ High Efficiency Video Coding (HEVC), provide a good tradeoff between these parameters.

- Next Generation Video Coding (NGVC) is the latest video compression standard, which is being developed by the Joint Collaborative Team on Video Coding (JCT-VC)
- 20 formed by ISO/IEC Moving Picture Experts Group (MPEG) and ITU-T Video Coding Experts Group (VCEG). NGVC is being developed in response to the previous H.265/HEVC (High Efficiency Video Coding) standard. Similar to previous video coding standards, NGVC includes basic functional modules such as intra/inter prediction, Transform, quantization, in-loop filtering, and entropy coding.

- 25 The coding standards, including NGVC, are based on partitioning of a source picture into video coding blocks, e.g., coding units (CUs). Each of the CUs can be further split into either smaller CUs or prediction units (PUs). Processing of these blocks depend on their size, spatial position and a coding mode specified by an encoder. Coding modes can be classified into two groups according to the type of prediction: intra- and
- 30 inter-prediction modes. Intra prediction modes use pixels of the same picture (also referred to as frame or image) to generate reference samples to calculate the prediction values for the pixels of the block being reconstructed. Intra prediction is also referred to as spatial prediction. Inter-prediction modes are designed for temporal

prediction and uses reference samples of previous or next pictures to predict pixels of the block of the current picture. After a prediction stage, transform coding is performed for a prediction error that is the difference between an original signal and its prediction.

When one of the prediction modes is selected for the current CU or PU, the prediction value is generated by extrapolation using the already coded pels surrounding the current CU or PU. For the bidirectional prediction method, the prediction value is generated in combination with two kinds of the intra prediction modes at each sub-block. A set of bidirectional intra prediction modes are introduced in the state-of-the-art, which needs a high bitrate.

10 SUMMARY

It is an object of the invention to provide improved devices and methods for video coding, which allow reducing the high bitrate caused by introducing a set of bidirectional intra prediction modes.

15 Embodiments of the invention are described in the claims and in the below description. The scope of protection is defined by the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Further embodiments of the invention will be described with respect to the following figures, wherein:

FIG. 1 shows a schematic diagram illustrating an example of a video encoding and decoding system 100.

FIG. 2 shows a schematic diagram illustrating an example of a video encoder 200.

FIG. 3 shows a schematic diagram illustrating an example of a video decoder 300.

25 FIG. 4 shows a schematic diagram illustrating proposed 67 intra prediction modes.

FIG. 5A shows an example of a fixed block coding order (BCO).

FIG. 5B shown an example of a flexible Block Coding Order (FBCO).

FIG. 6 shows a schematic diagram illustrating Generalized DWDIP.

FIG. 7A and 7B shows a relationship between primary reference samples and the accuracy of a constructed predictor.

FIG. 8 shows a relationship between a primary-to-primary propagation ratio with BIP being signaled or not.

FIG. 9 shows an exemplary scenario when BIP is disabled.

FIG. 10 shows an exemplary scenario when BIP is applied by default.

5 FIG. 11 shows a schematic diagram illustrating examples of intra prediction modes.

FIG. 12 shows another example scenario when BIP is applied by default.

FIG. 13 shows a schematic diagram illustrating an example of a context selection process for a BIP flag.

10 FIG. 14A shows a schematic diagram illustrating a range of intra prediction modes when left and right sides of neighboring pixels are available.

FIG. 14B shows a schematic diagram illustrating a range of intra prediction modes when left and top sides of neighboring pixels are available.

FIG. 15 shows an exemplary scenario in which BIP is used in a context selection process.

15 FIG. 16 is a flowchart illustrating an example of a method of coding a bitstream

FIG. 17 is a flowchart illustrating an example of a method of coding a bitstream;

FIG. 18 is a flowchart illustrating an example of a method of decoding an encoded bitstream.

20 FIG. 19 is a flowchart illustrating an example of a method of decoding an encoded bitstream.

Fig. 20 is a block diagram of a network element that can be used to implement various embodiments.

In the various figures, identical reference signs will be used for identical or at least functionally equivalent features.

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DETAILED DESCRIPTION OF EMBODIMENTS

In the following description, reference is made to the accompanying drawings, which form part of the disclosure, and in which are shown, by way of illustration, specific aspects in which the invention may be placed.

For instance, it is understood that a disclosure in connection with a described method may also hold true for a corresponding device or system configured to perform the method and vice versa. For example, if a specific method step is described, a corresponding device may include a unit to perform the described method step, even
5 if such unit is not explicitly described or illustrated in the figures. Further, it is understood that the features of the various exemplary aspects described herein may be combined with each other, unless specifically noted otherwise.

In order to reduce the high bitrate caused by introducing a set of bidirectional intra prediction modes, such as the signaling overhead by adding a bidirectional intra prediction (BIP) flag to a bitstream, any one of the following three techniques may be
10 implemented:

- bidirectional intra prediction modes are not signaled and not used;
- bidirectional intra prediction modes are not signaled and used by default instead of conventional directional intra prediction modes; or
- 15 – bidirectional intra prediction modes are signaled using Context-Adaptive Binary Arithmetic Coding (CABAC) contexts.

These techniques are described further below with reference to various examples.

The following factors may be taken into account to decide whether a BIP flag should be put into a bitstream or what CABAC context should be selected as described below:

- 20 – number and position of available primary reference samples;
- intra prediction mode index;
- aspect ratio of a block being predicted; and/or
- size of a block being predicted.

FIG. 1 is a block diagram illustrating an example video encoding and decoding system
25 100 that may utilize the techniques described in this disclosure, including techniques for encoding and decoding blocks in an intra prediction mode. As shown in FIG. 1, system 100 includes a source device 102 that generates encoded video data to be decoded at a later time by a destination device 104. Video encoder 200 as shown in FIG. 2, is an example of the source device 102. Video decoder 300 as shown in FIG.
30 3, is an example of the destination device 104. Source device 102 and destination device 104 may comprise any of a wide range of devices, including desktop computers, notebook (i.e., laptop) computers, tablet computers, set-top boxes, telephone handsets

such as so-called “smart” phones, so-called “smart” pads, televisions, cameras, display devices, digital media players, video gaming consoles, video streaming device, or the like. In some cases, source device 102 and destination device 104 may be equipped for wireless communication.

5 Destination device 104 may receive the encoded video data to be decoded via a link 112. Link 112 may include any type of medium or device capable of moving the encoded video data from source device 102 to destination device 104. In one example, link 112 may comprise a communication medium to enable source device 102 to transmit encoded video data directly to destination device 104 in real-time. The
10 encoded video data may be modulated according to a communication standard, such as a wireless communication protocol, and transmitted to destination device 104. The communication medium may comprise any wireless or wired communication medium, such as a radio frequency (RF) spectrum or one or more physical transmission lines. The communication medium may form part of a packet-based network, such as a local
15 area network, a wide-area network, or a global network such as the Internet. The communication medium may include routers, switches, base stations, or any other equipment that may be useful to facilitate communication from source device 102 to destination device 104.

Alternatively, encoded data may be output from output interface 110 to a storage
20 device (not shown in FIG.1). Similarly, encoded data may be accessed from the storage device by input interface 114. Destination device 104 may access stored video data from storage device via streaming or download. The techniques of this disclosure are not necessarily limited to wireless applications or settings. The techniques may be applied to video coding in support of any of a variety of multimedia applications, such
25 as over-the-air television broadcasts, cable television transmissions, satellite television transmissions, streaming video transmissions, e.g., via the Internet, encoding of digital video for storage on a data storage medium, decoding of digital video stored on a data storage medium, or other applications. In some examples, system 100 may be configured to support one-way or two-way video transmission to support applications
30 such as video streaming, video playback, video broadcasting, and/or video telephony.

In the example of FIG. 1, source device 102 includes a video source 106, video encoder 108 and an output interface 110. In some cases, output interface 110 may include a modulator/demodulator (modem) and/or a transmitter. In source device 102,

video source 106 may include a source such as a video capture device, e.g., a video camera, a video archive containing previously captured video, a video feed interface to receive video from a video content provider, and/or a computer graphics system for generating computer graphics data as the source video, or a combination of such sources. As one example, if video source 106 is a video camera, source device 102 and destination device 104 may form so-called camera phones or video phones. However, the techniques described in this disclosure may be applicable to video coding in general, and may be applied to wireless and/or wired applications.

The captured, pre-captured, or computer-generated video may be encoded by video encoder 108. The encoded video data may be transmitted directly to destination device 104 via output interface 110 of source device 102. The encoded video data may also (or alternatively) be stored onto the storage device for later access by destination device 104 or other devices, for decoding and/or playback.

Destination device 104 includes an input interface 114, a video decoder 116, and a display device 118. In some cases, input interface 114 may include a receiver and/or a modem. Input interface 114 of destination device 104 receives the encoded video data over link 112. The encoded video data communicated over link 112, or provided on the storage device, may include a variety of syntax elements generated by video encoder 108 for use by a video decoder, such as video decoder 116, in decoding the video data. Such syntax elements may be included with the encoded video data transmitted on a communication medium, stored on a storage medium, or stored a file server.

Display device 118 may be integrated with, or external to, destination device 104. In some examples, destination device 104 may include an integrated display device and also be configured to interface with an external display device. In other examples, destination device 104 may be a display device. In general, display device 118 displays the decoded video data to a user, and may comprise any of a variety of display devices such as a liquid crystal display (LCD), a plasma display, an organic light emitting diode (OLED) display, or another type of display device.

Video encoder 108 and video decoder 116 may operate according to all kind of video compression standards, includes but not limited to MPEG-2, MPEG-4, ITU-T H.263,

ITU-T H.264/MPEG-4, Part 10, Advanced Video Coding (AVC), the High Efficiency Video Coding (HEVC), ITU-T H.266/Next Generation Video Coding (NGVC) standard.

It is generally contemplated that video encoder 108 of source device 102 may be configured to encode video data according to any of these current or future standards.

5 Similarly, it is also generally contemplated that video decoder 116 of destination device 104 may be configured to decode video data according to any of these current or future standards.

Video encoder 108 and video decoder 116 each may be implemented as any of a variety of suitable encoder circuitry, such as one or more microprocessors, digital
10 signal processors (DSPs), application specific integrated circuits (ASICs), field programmable gate arrays (FPGAs), discrete logic, software, hardware, firmware or any combinations thereof. When the techniques are implemented partially in software, a device may store instructions for the software in a suitable, non-transitory computer-readable medium and execute the instructions in hardware using one or more
15 processors to perform the techniques of this disclosure. Each of video encoder 108 and video decoder 116 may be included in one or more encoders or decoders, either of which may be integrated as part of a combined encoder/decoder (CODEC) in a respective device.

In video coding specifications, a video sequence typically includes a series of pictures.
20 Pictures may also be referred to as “frames.” Video encoder 108 may output a bitstream that includes a sequence of bits that forms a representation of coded pictures and associated data. Video decoder 116 may receive a bitstream generated by video encoder 108. In addition, video decoder 116 may parse the bitstream to obtain syntax elements from the bitstream. Video decoder 116 may reconstruct the pictures of the
25 video data based at least in part on the syntax elements obtained from the bitstream. The process to reconstruct the video data may be generally reciprocal to the process performed by video encoder 108.

FIG. 2 shows a schematic diagram illustrating an example of a video encoder 200. The video encoder 200 comprises an input for receiving input blocks of frames or pictures
30 of a video stream and an output for generating an encoded video bit stream. The video encoder 200 is adapted to apply prediction, transformation, quantization, and entropy coding to the video stream. The transformation, quantization, and entropy coding are

carried out respectively by a transform unit 201, a quantization unit 202 and an entropy encoding unit 203 so as to generate as an output the encoded video bit stream.

The video stream corresponds to a plurality of frames, wherein each frame is divided into blocks of a certain size that are either intra or inter coded. The blocks of for example the first frame of the video stream are intra coded by means of an intra prediction unit 209. An intra frame is coded using only the information within the same frame, so that it can be independently decoded and it can provide an entry point in the bit stream for random access. Blocks of other frames of the video stream are inter coded by means of an inter prediction unit 210: information from coded frames, which are called reference frames, are used to reduce the temporal redundancy, so that each block of an inter coded frame is predicted from a block of the same size in a reference frame. A mode selection unit 208 is adapted to select whether a block of a frame is to be processed by the intra prediction unit 209 or the inter prediction unit 210.

For performing inter prediction, the coded reference frames are processed by an inverse quantization unit 204, an inverse transform unit 205, a filtering unit 206 (optional) so as to obtain the reference frames that are then stored in a frame buffer 207. Particularly, reference blocks of the reference frame can be processed by these units to obtain reconstructed reference blocks. The reconstructed reference blocks are then recombined into the reference frame.

The inter prediction unit 210 comprises as input a current frame or picture to be inter coded and one or several reference frames or pictures from the frame buffer 207. Motion estimation and motion compensation are applied by the inter prediction unit 210. The motion estimation is used to obtain a motion vector and a reference frame based on certain cost function. The motion compensation then describes a current block of the current frame in terms of the transformation of a reference block of the reference frame to the current frame. The inter prediction unit 210 outputs a prediction block for the current block, wherein said prediction block minimizes the difference between the current block to be coded and its prediction block, i.e. minimizes the residual block. The minimization of the residual block is based e.g., on a rate-distortion optimization procedure.

The difference between the current block and its prediction, i.e. the residual block, is then transformed by the transform unit 201. The transform coefficients are quantized

and entropy coded by the quantization unit 202 and the entropy encoding unit 203. The thus generated encoded video bit stream comprises intra coded blocks and inter coded blocks.

FIG. 3 shows a schematic diagram illustrating an example of a video decoder 300.

- 5 The video decoder 300 comprises particularly a frame buffer 307, an inter prediction unit 310. The frame buffer 307 is adapted to store at least one reference frame obtained from the encoded video bit stream. The inter prediction unit 310 is adapted to generate a prediction block of a current block of a current frame from a reference block of the reference frame.
- 10 The decoder 300 is adapted to decode the encoded video bit stream generated by the video encoder 200, and both the decoder 300 and the coder 200 generate identical predictions. The features of the frame buffer 307, the inter prediction unit 310 are similar to the features of the frame buffer 207, the inter prediction unit 210, of FIG. 2. Particularly, the video decoder 300 comprises units that are also present in the video
- 15 encoder 200 like e.g., an inverse quantization unit 304, an inverse transform unit 305, a filtering unit 306 (optional) and an intra prediction unit 309, which respectively correspond to the inverse quantization unit 204, the inverse transform unit 205, the filtering unit 206 and the intra prediction unit 209 of the video encoder 200. An entropy decoding unit 303 is adapted to decode the received encoded video bit stream and to
- 20 correspondingly obtain quantized residual transform coefficients. The quantized residual transform coefficients are fed to the inverse quantization unit 304 and an inverse transform unit 305 to generate a residual block. The residual block is added to a prediction block and the addition is fed to the filtering unit 306 to obtain the decoded video. Frames of the decoded video can be stored in the frame buffer 307 and serve
- 25 as a reference frame for inter prediction.

According to the HEVC/H.265 standard, 35 intra prediction modes are available. As shown in **Error! Reference source not found.** 4, this set contains the following modes: planar mode (the intra prediction mode index is 0), DC mode (the intra prediction mode index is 1), and directional (angular) modes that cover the 180° range

30 and have the intra prediction mode index value range of 2 to 34 shown by black arrows in **Error! Reference source not found.** 4. To capture the arbitrary edge directions present in natural video, the number of directional intra modes is extended from 33, as used in HEVC, to 65. The additional directional modes are depicted as dotted arrows

in **Error! Reference source not found.** 4, and the planar and DC modes remain the same. It is worth noting that the range that is covered by intra prediction modes can be wider than 180° . In particular, 62 directional modes with index values of 3 to 64 cover the range of approximately 230° , i.e. several pairs of modes have opposite directionality. In the case of the HEVC Reference Model (HM) and JEM platforms, only one pair of angular modes (namely, modes 2 and 66) has opposite directionality as shown in **Error! Reference source not found.** 4. For constructing a predictor, conventional angular modes take reference samples and (if needed) filter them to get a pixel predictor. The number of reference samples required for constructing a predictor depends on the length of the filter used for interpolation (e.g., bilinear and cubic filters have lengths of 2 and 4, respectively).

In order to take advantage of availability of reference samples that are used at the stage of intra prediction, a more flexible block coding order (BCO) is introduced, as schematically illustrated by the example at FIG. 5B. Comparing to an example of a fixed block coding order (BCO) as illustrated at FIG. 5A, flexible block coding order (FBCO) as illustrated at FIG. 5B, is a block coding order mechanisms that enables a non-fixed block coding order. FBCO encompasses different mechanisms such as Split Unit Coding Order (SUCO), Arbitrary Block Coding Order (ABCO), and others. For example, FBCO can be used at Figures 9, 12 and 15. With FBCO, not only top and left (LR_10) reference sample sides can be available for intra prediction but also, for example, top and right (LR_01) sides as well as three (top, left and right) sides. However, in some cases, even for blocks located not on a picture boundary, only one (namely, top) side can be available that is impossible for partitioning frameworks with fixed BCO.

Bidirectional Intra prediction (BIP) is a mechanism of constructing a directional predictor by generating a prediction value in combination with two kinds of the intra prediction modes within each block. Distance-Weighted Direction Intra Prediction (DWDIP) is a particular implementation of BIP. Generating a predictor by DWDIP includes the following two steps:

- a) Initialization where secondary reference samples are generated; and
- b) Generate a predictor using a distance-weighted mechanism.

Both primary and secondary reference samples can be used at b) step.

Samples within the predictor are calculated as a weighted sum of reference samples defined by the selected prediction direction and placed on opposite sides as shown in **Error! Reference source not found.** Prediction of a block may include steps of generating secondary reference samples that are located on the sides of the block that are not yet reconstructed and to be predicted, i.e. unknown pixels. Values of these secondary reference samples are derived from the primary reference samples which are obtained from the pixels of the previously reconstructed part of the picture, i.e., known pixels. That means primary reference samples 602 are taken from adjacent blocks. Secondary reference samples 604 are generated using primary reference samples 602. In FIG. 6, the primary reference pixels/samples 602 are identified by squares with dots, and the secondary reference pixels/samples 604 are identified by squares with grids. A pixels/samples 606 are predicted using a distance-weighted mechanism.

The flag of BIP based modes is always signaled in conventional methods, which causes signaling overhead in the bitstream.

As secondary reference samples are typically not as close to source pixels as primary reference samples, the more pixels within a block are predicted using only primary reference samples, the higher the probability is that a constructed predictor is closer to an original block, as illustrated at FIG. 7A and FIG. 7B. FIG. 7A and 7B schematically illustrate the relationship between the primary reference samples and the accuracy of the constructed predictor. In view of this, the ratio of the number of pixels generated using primary-to-primary prediction to the entire number of pixels within a block is used to make decisions on what context should be selected to signal BIP. Primary-to-primary propagation ratio is a ratio of the number of pixels that are predicted from two primary references to the total number of pixels in the block. As shown in FIG. 8, when the primary-to-primary propagation ratio is below a first threshold, BIP is disabled and a corresponding flag is not signaled. When the primary-to-primary propagation ratio is above a second threshold, BIP is used by default and corresponding flag is not signaled. When the primary-to-primary propagation ratio is between the first threshold and the second threshold, BIP is signaled using CABAC contexts. Different scenarios are discussed below for detail.

BIP is disabled and corresponding flag is not signaled

For a block of width w and height h being intra-predicted using mode I_{IPM} , BIP is disabled and a corresponding flag is not signaled if any of the following conditions is true:

- 5 - Top side of neighboring pixels is not available
- Left and right sides of neighboring pixels are not available
- w = a minimum size and h = a minimum size, for example, the minimum size is 4
 - 10 ○ w > a first maximum threshold, for example the first maximum threshold is 32
 - h > a second maximum threshold, for example the second maximum threshold is 32
- Only left or right side is available and one of the following is true:
 - 15 ○ w = a minimum size and the number of intra prediction mode differs from the number of horizontal one by a third threshold or less; or
 - h = a minimum size and the number of intra prediction mode differs from the number of vertical one by a fourth threshold or less. The third threshold may be same as or different from the fourth threshold. For example, the third threshold is same as the fourth threshold, and may be 20 five (5).
- Left and right sides of neighboring pixels are available, and either
 - $I_{IPM}=47$ (intra prediction direction is horizontal), or
 - I_{IPM} is less than range start value or I_{IPM} is greater than range end value. Start and end values are specified in Table 1 for a given block aspect ratio, i.e. $\log_2(w)-\log_2(h)$.
- 25 - $I_{IPM} > 2$ (intra prediction is angular)

Top side of neighboring pixels means a primary reference sample in top sides of the current coding block. Correspondingly, left side of neighboring pixels means a primary reference sample in left sides of the current coding block. Right side of neighboring pixels means a primary reference sample in right sides of the current coding block.

Table 1. Dependency of the range start and end values on block aspect ratio

$\log_2(w)-\log_2(h)$	-3	-2	-1	0	1	2	3
Range start value	3	3	6	11	16	17	17

Range end value	50	50	53	59	63	64	64
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FIG. 9 shows an example scenario in which BIP is disabled because only an upper reference sample row is available for intra prediction (LR_00), left and right sides of neighboring pixels are not available.

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BIP is used by default and corresponding flag is not signaled

BIP replaces conventional intra prediction by default and a corresponding flag is not signaled when additional reference pixels are available, and the intra prediction mode belongs to the specific sub-range.

- 10 For example, as shown in FIG. 10, ranges are specified by horizontal (HOR) intra prediction mode number (47) and the ultimate intra prediction mode number specified in Table 2, depending on the block aspect ratio.

Table 2. Ultimate intra prediction mode number, horizontally aligned range

$\log_2(w)-\log_2(h)$	-3	-2	-1	0	1	2	3
Ultimate intra prediction mode number I_{IPM_TL}	46	44	40	35	31	27	25
Ultimate intra prediction mode number I_{IPM_LL}	48	50	54	59	63	64	64

- 15 I_{IPM_TL} , as described in Table 2, represents an intra-predicted using mode I_{IPM} selected for the top-left block; I_{IPM_LL} represents an intra-predicted using mode I_{IPM} selected for the lower-left block.

- Besides a range aligned with horizontal intra prediction, an additional range is specified for the case in which lower-left side is available (see the rightmost part of **Error! Reference source not found.**). The range for this case is defined by the first available
20 angular intra prediction mode (#3) and the corresponding value from Table 3.

Table 3. Ultimate intra prediction mode number, range aligned to the 1st available intra prediction mode

$\log_2(w)-\log_2(h)$	-3	-2	-1	0	1	2	3
Ultimate intra prediction mode number I_{IPM_TR}	N/A	N/A	6	11	15	19	21

I_{IPM_TR} , as described in Table 3, represents an intra-predicted using mode I_{IPM} selected for the top-right block.

In addition to the cases described above, BIP replaces conventional intra prediction and a corresponding flag is not signaled when:

- 5 - the lower-left side and the upper-right side are available and the intra prediction mode is equal either to the one specified in Table 3 or the one specified in Table 2;
- the lower-right side and the upper-left side are available and the intra prediction mode is equal the one specified in Table 2.

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Intra prediction mode numbers listed in Table 2 and Table 3 are shown in **Error! Reference source not found.** Among FIG. 11, I_{IPM_LA} represents an intra prediction mode I_{IPM} for the last-available intra prediction direction; and I_{IPM_FA} represents an intra prediction mode I_{IPM} for the first-available intra prediction direction. Intra prediction modes numbers are arranged in ascending order from I_{IPM_FA} to I_{IPM_LA} . Horizontal (HOR) and vertical (VER) directions modes (I_{IPM_HOR} and I_{IPM_VER} , respectively) do not depend on block aspect ratio R_A . The remaining intra prediction mode numbers shown in **Error! Reference source not found.** have a dependency on R_A which is given by Table 2 and Table 3.

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FIG. 12 shows an example scenario when BIP is used by default because not only top sides, but also left and right sides (three sides) of neighboring pixels are available.

BIP is signaled using CABAC contexts (or probability model)

25 A context selection process is performed for a BIP flag when none of the procedures described in sections “BIP is disabled and corresponding flag is not signaled” section and “BIP is used by default and corresponding flag is not signaled” are in effect. A flowchart of an exemplary context selection procedure is given in **Error! Reference source not found.** Input of this process is given at the first step (block 1302) of the flowchart. It contains:

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- an intra prediction mode selected for a block (I_{IPM}),
- block width (w) and height (h),

- a set of available sides of neighboring pixels S , namely: left (s_L), right (s_R), top (s_T), lower-left (s_{LL}), lower-right (s_{LR}) and top-right (s_{TR}) one.

Different contexts could be specified for a probability model, for example low-reliable prediction (denoted as CTX_{LR}), medium-reliable prediction (denoted as CTX_{MR}) and highly-reliable prediction (denoted as CTX_{HR}) cases. Default context is medium-reliable context. The reliability of prediction affects the probability of BIP flag being equal 0, and could be estimated by how close I_{IPM} is to one of the ultimate modes listed above. These modes are determined according to the aspect ratio of a block which is calculated at the next step (block 1304). Such as, $R_A = \log_2(w) - \log_2(h)$. Aspect ratio is represented by a value that is positive if a block is aligned horizontally (i.e. width is greater than height) and negative if the block is aligned vertically. The next step (block 1306) is to select ultimate modes as specified by Table 2 and Table 3. For example, $\{I_{IPM_LL}, I_{IPM_TL}, I_{IPM_TR}\} = LUT(R_A)$.

Following decision making on context selection is performed depending on whether

- left and right sides are available,
- left side is available, and/or
- the rest cases

Depending on the availability of reference samples sides (S) different ranges are defined and context is selected on the fact of whether I_{IPM} belongs to this range or not.

If left and right sides are available at block 1308, $\{s_L, s_R\} \supseteq S$, CTX_{LR} is selected at block 1328 when top side is not available and I_{IPM} belongs to the range as shown in **Error! Reference source not found.A** (block 1310). At block 1310, that whether top side is not available and whether I_{IPM} belongs to the range as shown in **Error! Reference source not found.A** is determined, for example,

$$(\{s_T\} \not\supseteq S) \text{ and } (I_{IPM_TR} < I_{IPM} < I_{IPM_LT} \text{ Or } I_{IPM_LL} < I_{IPM} < I_{IPM_LA}) .$$

If left and right sides are available at block 1308, $\{s_L, s_R\} \supseteq S$, CTX_{MR} is selected at block 1326 when top side is available or I_{IPM} does not belong to the range as shown in **Error! Reference source not found.A** (block 1310).

If left and top sides are available, CTX_{HR} is selected if right side is not available and I_{IPM} belongs to the range as shown in **Error! Reference source not found.B**. In FIG. 14A and FIG. 14B, for the rest cases additional calculations may be performed at block 1312, specifically:

whether I_{IPM} falls in between of horizontal and vertical directions (condition C); and value of a threshold difference with the ultimate intra prediction modes (Δ_{IPM});

$$\text{where } C = I_{IPM_VER} \leq I_{IPM} \leq I_{IPM_HOR}$$

$$\Delta_{IPM} = \min(I_{IPM_VER} - I_{IPM_TR}, I_{IPM_LL} - I_{IPM_HOR})/2$$

- 5 The rest of the context selection process is shown in **Error! Reference source not found.**, which results in selection of one of the above-specified contexts depending on the prediction reliability estimation. When left side is available, and right side is not available at block 1314, whether C is true or $\{S_{LL,STR}\} \not\supseteq S$ is determined at block 1318. When C is true or $\{S_{LL,STR}\} \not\supseteq S$, CTX_{MR} is selected at block 1326. If C is false and $\{S_{LL,STR}\} \supseteq S$, *whether*

$$\max(I_{IPM_TR} - \Delta_{IPM}, I_{IPM_FA}) \leq I_{IPM} \leq I_{IPM_TR} + \Delta_{IPM} \text{ or}$$

$I_{IPM_LL} - \Delta_{IPM} \leq I_{IPM} \leq \min(I_{IPM_LL} + \Delta_{IPM}, I_{IPM_LA})$ is determined at block 1322. If yes at block 1322, CTX_{MR} is selected at block 1326; otherwise CTX_{HR} is selected at block 1324.

- 15 If left side is not available, or right side is available at block 1314, whether C is false or $\{S_{LR,STL}\} \not\supseteq S$ is determined at block 1316. If C is false or $\{S_{LR,STL}\} \not\supseteq S$, CTX_{MR} is selected at block 1326. If C is true and $\{S_{LR,STL}\} \supseteq S$, *whether*

$I_{IPM_TL} - \Delta_{IPM} \leq I_{IPM} \leq I_{IPM_TL} + \Delta_{IPM}$ is determined at block 1320. If yes at block 1320, CTX_{HR} is selected at block 1324; otherwise CTX_{MR} is selected at block 1326.

- 20 There may be fewer or more than three different contexts. Generally, a context could be defined as a function of

- closest ultimate intra prediction mode;
- difference between I_{IPM} and a number of that ultimate intra prediction mode.

- 25 Thus, more than just one context could be provided per an ultimate intra prediction, e.g., if several threshold difference values Δ_{IPM} are introduced.

FIG. 15 shows an example scenario when BIP is used by context selection process when either top and left reference sample sides (LR_10) or top and right sides (LR_01) are available for intra prediction.

Exemplary encoding processes

FIG. 16 is a flowchart of an example of a method of encoding (or compressing) a bitstream, which may be performed by the source device 102 as shown in FIG. 1, or by the video encoder 200 as shown in FIG. 2. Process 1600 is an example for the encoder's processing. Encoder-side changes introduced by the present disclosure primarily relate to the selection of intra prediction mode using rate-distortion optimization (RDO) procedure. This procedure may notably comprise the following blocks.

Block 1602, the encoder generates a list of candidate intra prediction modes for a current coding block of the picture, where the list of candidate intra prediction modes comprises at least one BIP mode.

Block 1604, the encoder determines whether a BIP flag is to be signaled in the bitstream according to prediction related information, where the BIP flag indicates a BIP mode selected for the current coding block. The prediction related information comprises:

- number and position of available primary reference samples;
- intra prediction mode index;
- aspect ratio of a block being predicted; and/or
- size of a block being predicted.

Exemplary determining whether BIP flag is to be signaled in the bitstream described earlier and shown in FIG. 1 to FIG. 15.

Block 1606, when the BIP flag is not to be signaled in the bitstream, the encoder does not code value of the BIP flag to the bitstream. The two examples are described earlier at sections "BIP is disabled and corresponding flag is not signaled" and "BIP is used by default and corresponding flag is not signaled."

Block 1608, when the BIP flag is to be signaled in the bitstream, the encoder derives a probability model for encoding from the prediction related information. Then at block 1610, the encoder codes a value of the BIP flag to the bitstream using the probability model. The example is described earlier at section "BIP is signaled using CABAC contexts (or probability model)."

FIG. 17 is another flowchart of an example of a method of encoding (or compressing) a bitstream, which may be performed by the source device 102 as shown in FIG. 1,

or by the video encoder 200 as shown in FIG. 2. Process 1700 is an example for the encoder's processing. Encoder-side changes introduced by the present disclosure primarily relate to the selection of intra prediction mode using rate-distortion optimization (RDO) procedure. This procedure may notably comprise:

- 5 – preparing a list of candidate intra prediction modes L_{RC} using cost estimation based on estimation of intra prediction residual; and
- selecting a best intra prediction out of the L_{RC} list using cost estimation based on coding of intra prediction residual.

One of the possible implementation forms involves a particular way of preparing a list
10 of candidate intra prediction modes L_{RC} . Besides the numbers of intra prediction modes, The L_{RC} list would also contain the values of `bip_flag` associated with the corresponding intra prediction modes. FIG. 17 shows an exemplary flowchart for preparing a list of candidate intra prediction modes and corresponding values of `bip_flag` using cost estimation based on estimation of intra prediction residual.
15 According to the flowchart 1700, available intra prediction modes are scanned twice having the value of `bip_flag` equal 0 and 1, respectively. The flowchart 1700 also skips Rate-Distortion Optimization (RDO) cost estimations for the cases when `bip_flag` is incompliant with the intra prediction mode I_{IPM} being checked.

At block 1702, the encoder genereates `intra_pred_list()` for a current block. At
20 beginning, `bip_flag` is 0 as shown at block 1704, and the I_{IPM} is 0 as shown at block 1706.

At block 1708, the encoder determines that `bip_flag` is 0 or `bip_flag` is 1. If the `bip_flag` is 0, the encoder determines whether the BIP is applied by default at block 1710. If the `bip_flag` is 1, the encoder determines whether the BIP is enabled at block 1712.

25 If the BIP is not applied by default, or the BIP is enabled, the encoder uses I_{IPM} as the intra_prediction modes of the current block at block 1714. The encoder performs RDO cost estimation at block 1716. Then, the encoder prepares a list of candidate intra prediction modes L_{RC} using RDO cost estimation based on estimation of intra prediction residual at block 1718, where the L_{RC} list may contain the values of `bip_flag`
30 associated with the corresponding intra prediction modes. Then at block 1718, a best

intra prediction is selected or updated out of the L_{RC} list using cost estimation based on coding of intra prediction residual.

After updating L_{RC} with I_{IPM} at block 1718, or the BIP is applied by default at block 1710, or the BIP is not enabled at block 1712, the encoder determines whether I_{IPM} is the last-available intra prediction I_{IPM_LA} at block 1720. If I_{IPM} is not the last-available intra prediction I_{IPM_LA} , $I_{IPM} = I_{IPM} + 1$ at block 1722. After $I_{IPM} = I_{IPM} + 1$, the process goes back to block 1708 to determine that bip_flag is 0 or bip_flag is 1. If I_{IPM} is the last-available intra prediction I_{IPM_LA} , the encoder determines whether $bip_flag < 1$ at block 1724. If the $bip_flag < 1$, $bip_flag = bip_flag + 1$ at block 1726. After $bip_flag = bip_flag + 1$, the process goes back to block 1706.

Exemplary determining whether BIP is enabled or not, and exemplary determining whether BIP is applied by default are described earlier and shown in FIG. 1 to FIG. 15.

In this embodiment, a single list of candidate intra prediction modes L_{RC} is used. However, it is possible to prepare two separate lists and select a pair $\{bip_flag, I_{IPM}\}$ out of the two lists. In this case, the embodiment still would not affect the process of selecting a best intra prediction out of the L_{RC} list. The only difference with FIG. 17 is that bip_flag loop is external to $intra_pred_list$ process, and the list L_{RC} to be updated is selected according to the input value of bip_flag .

20 Exemplary decoding processes

FIG. 18 is an exemplary flowchart 1800 to decode (or parse or decompress) an coded bitstream, which is performed by the destination device 104 as shown in FIG. 1, or the video decoder 300 as shown in FIG. 3. Process 1800 is an example for the decoder's processing.

Block 1802, the decoder receives a bitstream, where the bitstream comprises prediction related information. The prediction related information comprises:

- number and position of available primary reference samples;
- intra prediction mode index;
- aspect ratio of a block being predicted; and/or
- size of a block being predicted.

Block 1804, the decoder determines whether a BIP flag is signaled in the bitstream according to the prediction related information, where the BIP flag indicates a BIP mode selected for the current coding block.

Exemplary determining whether BIP flag is signaled in the bitstream described earlier and shown in FIG. 1 to FIG. 15.

Block 1806, when the BIP flag is not signaled in the bitstream, the decoder derives a value of the BIP flag from the prediction related information. The two examples are described earlier at sections “BIP is disabled and corresponding flag is not signaled” and “BIP is used by default and corresponding flag is not signaled.”

Block 1808, when the BIP flag is signaled in the bitstream, the decoder derives a probability model for decoding from the prediction related information. Then the decoder restores a value of the BIP flag using the probability model. The example is described earlier at section “BIP is signaled using CABAC contexts (or probability model).”

Block 1810, the decoder reconstructs the picture based on the value of the BIP flag.

FIG. 19 is another exemplary flowchart 1900 to decode (or parse or decompress) an coded bitstream, which is performed by the destination device 104 as shown in FIG. 1, or the video decoder 300 as shown in FIG. 3. Process 1900 is an example for the decoder's processing.

Parsing of prediction-related information from the bitstream is performed by a *coding_unit* procedure at block 1902. It may comprise various symbols, but for intra predicted blocks, intra prediction mode should be parsed in the procedure 1900. In the embodiment it is proposed to conditionally parse the value of *bip_flag* after *intra_luma_pred_mode* is parsed at block 1904. Depending on intra prediction mode, shape and size of the block, the value of *bip_flag* is either assigned or parsed from the bitstream. Detailed information is disclosed above from FIG. 1 to FIG. 15. The decoder determines whether BIP is enabled or not at block 1906. If the BIP is not enabled, the *bip_flag* is false at block 1908. If the BIP is enabled, the decoder determines whether BIP is applied by default at block 1910. When BIP is applied by default, the *bip_flag* is true at block 1912. When BIP is not applied by default, the decoder parses *bip_flag* at block 1914. When decoding *bip_flag* value, a context could be selected, based on intra prediction mode, shape and size of the block. Exemplary context selection is described

earlier and shown in **Error! Reference source not found.** 13. Exemplary determining whether BIP is enabled or not, and exemplary determining whether BIP is applied by default are described earlier and shown in FIG. 1 to FIG. 15.

FIG. 20 is a schematic diagram of a network element 2000. The network element 2000 is suitable for implementing the disclosed embodiments as described herein. The network element 2000 may be the encoder or the decoder to perform the methods described above. The network element 2000 comprises ingress ports 2010 and receiver units (Rx) 2020 for receiving data; a processor, logic unit, or central processing unit (CPU) 2030 to process the data; transmitter units (Tx) 2040 and egress ports 2050 for transmitting the data; and a memory 2060 for storing the data. The network element 2000 may also comprise optical-to-electrical (OE) components and electrical-to-optical (EO) components coupled to the ingress ports 2010, the receiver units 2020, the transmitter units 2040, and the egress ports 2050 for egress or ingress of optical or electrical signals.

The processor 2030 is implemented by hardware and software. The processor 2030 may be implemented as one or more CPU chips, cores (e.g., as a multi-core processor), field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), and digital signal processors (DSPs). The processor 2030 is in communication with the ingress ports 2010, receiver units 2020, transmitter units 2040, egress ports 2050, and memory 2060. The processor 2030 includes a coding module 2070. The coding module 2070 implements the disclosed embodiments described above. For instance, the coding module 2070 implements the methods of compressing/decompressing the last coding or prediction block. The inclusion of the coding module 2070 therefore provides a substantial improvement to the functionality of the network element 2000 and effects a transformation of the network element 2000 to a different state. Alternatively, the coding module 2070 is implemented as instructions stored in the memory 2060 and executed by the processor 2030.

The memory 2060 comprises one or more disks, tape drives, and solid-state drives and may be used as an over-flow data storage device, to store programs when such programs are selected for execution, and to store instructions and data that are read during program execution. The memory 2060 may be volatile and/or non-volatile and may be read-only memory (ROM), random-access memory (RAM), ternary content-addressable memory (TCAM), and/or static random-access memory (SRAM).

The techniques disclosed herein can save overhead to determine that bidirectional intra prediction modes are not signaled and used by default, or determine that bidirectional intra prediction modes are not signaled and not used. Even for the bidirectional intra prediction modes are signaled based on different contexts, the techniques can increase the reliability of the BIP. The BIP mode may be a DWDIP mode. Correspondingly, the BIP flag may be a DWDIP flag.

The techniques may also be beneficial in the following aspects:

- increasing the compression performance of BIP within partitioning frameworks with flexible block coding order with negligible increase of computational complexity at both encoder and decoder sides;
- It can be used in many potential applications in hybrid video coding paradigms that are compatible with the HM software and the VPX video codec family as well as the JEM software, the VPX/AV1 video codec family and other similar platforms that are a state-of-the-art and a next-generation video coding frameworks, respectively.
- Estimation of probability that bidirectional prediction provides lesser RDO cost than single-directional prediction is improved by using prediction-related information. More accurate probability modelling provides better efficiency of entropy encoding and consequently, bitrate reduction.

While a particular feature or aspect of the disclosure may have been disclosed with respect to only one of several implementations or embodiments, such a feature or aspect may be combined with one or more further features or aspects of the other implementations or embodiments as may be desired or advantageous for any given or particular application. Furthermore, to the extent that the terms "include", "have", "with", or other variants thereof are used in either the detailed description or the claims, such terms are intended to be inclusive in a manner similar to the term "comprise". Also, the terms "exemplary", "for example" and "e.g." are merely meant as an example, rather than the best or optimal. The terms "coupled" and "connected", along with derivatives thereof may have been used. It should be understood that these terms may have been used to indicate that two elements cooperate or interact with each other regardless whether they are in direct physical or electrical contact, or they are not in direct contact with each other.

Although specific aspects have been illustrated and described herein, it will be appreciated that a variety of alternate and/or equivalent implementations may be substituted for the specific aspects shown and described without departing from the scope of the present disclosure. This application is intended to cover any adaptations or variations of the specific aspects discussed herein.

Although the elements in the following claims are recited in a particular sequence with corresponding labeling, unless the claim recitations otherwise imply a particular sequence for implementing some or all of those elements, those elements are not necessarily intended to be limited to being implemented in that particular sequence.

Many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the above teachings. Of course, those skilled in the art readily recognize that there are numerous applications of the disclosure beyond those described herein.

While the disclosure has been described with reference to one or more particular embodiments, those skilled in the art recognize that many changes may be made thereto without departing from the scope of the disclosure. It is therefore to be understood that within the scope of the appended claims and their equivalents, the disclosure may be practiced otherwise than as specifically described herein.

CLAIMS:

1. A method of encoding a picture, the method comprising generating a bitstream for reconstructing the picture, wherein the method comprises:

generating a list of candidate intra prediction modes for a current coding block of the picture, wherein the list of candidate intra prediction modes comprises at least one bidirectional intra prediction (BIP) mode;

determining whether a BIP flag is to be signaled in the bitstream according to prediction related information, wherein the BIP flag indicates for the current coding block whether or not a BIP mode selected, and wherein the prediction related information comprises at least one of: numbers and positions of available primary reference samples, an intra prediction mode index, or a size of the current coding block; and

when the BIP flag is to be signaled in the bitstream, deriving a probability model for encoding from the prediction related information, coding a value of the BIP flag to the bitstream using the probability model; and

when the BIP flag is not to be signaled in the bitstream, not coding a value of the BIP flag to the bitstream.

2. The method of claim 1, wherein the determining whether the BIP flag is to be signaled comprises:

determining that the BIP is enabled and the BIP flag is applied by default and is not to be signaled in the bitstream; or

determining that the BIP is disabled and the BIP flag is not to be signaled in the bitstream.

3. The method of claim 1 or claim 2, wherein the determining whether the BIP flag is to be signaled according to numbers and positions of available primary reference samples comprises:

determining that the BIP is disabled and the BIP flag is not to be signaled in the bitstream when a primary reference sample in a top side of the current coding block is not available, or

determining that the BIP is disabled and the BIP flag is not to be signaled in the bitstream when primary reference samples in left and right sides of the current coding block are not available.

4. The method of any one of claims 1 to 3, wherein the determining whether a BIP flag is to be signaled according to the size of the current coding block comprises:

determining that the BIP is disabled, and the BIP flag is not to be signaled in the bitstream when both a width and height of the current coding block equal a minimum size, or when the width of the current coding block is larger than a first maximum threshold, or when the height of the current coding block is larger than a second maximum threshold.

5. The method of any one of claims 1 to 4, wherein the determining whether the BIP flag is to be signaled according to numbers and positions of available primary reference samples, and intra prediction mode index:

determining that the BIP is disabled, and the BIP flag is not to be signaled in the bitstream when the intra prediction mode index is less than a range start value or is greater than a range end value, and when primary reference samples in left and right sides of the current coding block are available, wherein the range start value and the range end value is determined using a width and a height of the current coding block; or

determining that the BIP is disabled, and a BIP flag is not to be signaled in the bitstream when only a primary reference sample in left or right side of the current coding block is available, and one of the following is true:

a width of the current coding block is equal to a minimum size and the number of intra prediction mode differs from the number of horizontal one by a

first threshold or less; or

a height of the current coding block is equal to a minimum size and the number of intra prediction mode differs from the number of vertical one by a second threshold or less.

6. The method of claim 1 or claim 2, wherein the determining whether a BIP flag is to be signaled according to the numbers and positions of available primary reference samples, and the intra prediction mode index comprises:

determining that the BIP is enabled, and the BIP flag is applied by default and is not to be signaled in the bitstream when the intra prediction mode index is greater than a range start value and is less than a range end value, and when a primary reference sample in lower side or upper side of the current coding block is available, wherein the range start value and the range end value is determined using a width and a height of the current coding block.

7. The method of claim 1, wherein the determining whether the BIP flag is to be signaled comprises:

determining a reliability of the BIP, where the reliability of the BIP includes low-reliable prediction (CTX_{LR}), medium-reliable prediction (CTX_{MR}) or highly-reliable prediction (CTX_{HR}).

8. The method of claim 7, wherein the determining the reliability of the BIP comprises:

determining the reliability of the BIP as CTX_{LR} when primary reference samples in left and right sides of the current coding block are available, a primary reference sample in the top side of the current coding block is not available, and an intra prediction mode (I_{IPM}) belongs to a first predefined range.

9. The method of claim 7, wherein the determining the reliability of the BIP comprises:

determining the reliability of the BIP as CTX_{HR} when primary reference samples in left and top sides of the current coding block are available, a primary reference sample in right side of the current coding block is not available, and I_{IPM} belongs to a second predefined range.

10. The method of claim 7, wherein the determining the reliability of the BIP comprises:

determining the reliability of the BIP as CTX_{MR} when primary reference samples in left and right sides of the current coding block are available and one of the following is true:

a primary reference sample in top side of the current coding block is available;

or

I_{IPM} does not belong to a first predefined range.

11. A method for intra prediction of a current coding block of a picture, the method comprising:

receiving a bitstream, wherein the bitstream comprises prediction related information, and wherein the prediction related information includes at least one of: numbers and positions of available primary reference samples, an intra prediction mode index, or a size of the current coding block;

determining whether a bidirectional intra prediction (BIP) flag is signaled in the bitstream based on the prediction related information, wherein the BIP flag indicates for the current coding block whether or not a BIP mode selected;

if the BIP flag is not signaled, deriving a value of the BIP flag from the prediction related information;

if the BIP flag is signaled, deriving a probability model from the prediction

related information to restore a value of the BIP flag; and
reconstructing the picture based on the value of the BIP flag.

12. The method of claim 11, wherein the determining whether the BIP flag is signaled comprises:

determining that the BIP is enabled and the BIP flag is applied by default and is not signaled in the bitstream; or

determining that the BIP is disabled and the BIP flag is not signaled in the bitstream.

13. The method of claim 11 or claim 12, wherein the prediction related information comprises numbers and positions of available primary reference samples, and wherein the determining whether the BIP flag is signaled comprises:

determining that the BIP is disable and the BIP flag is not signaled in the bitstream when a primary reference sample in a top side of the current coding block is not available, or

determining that the BIP is disabled and the BIP flag is not signaled in the bitstream when primary reference samples in left and right sides of the current coding block are not available.

14. The method of any one of claims 11 to 13, wherein the prediction related information comprises the size of the current coding block, and wherein the determining whether the BIP flag is signaled comprises:

determining that the BIP is disable and the BIP flag is not signaled in the bitstream when both a width and height of the current coding block equal to a minimum size, or when the width of the current coding block is larger than a first maximum threshold, or when the height of the current coding block is larger than a second maximum threshold.

15. The method of any one of claims 11 to 14, wherein the prediction related information comprises numbers and positions of available primary reference samples and intra prediction mode index, and wherein the determining whether the BIP flag is signaled comprises:

determining that the BIP is disable, and the BIP flag is not signaled in the bitstream when the intra prediction mode index is less than a range start value or is greater than a range end value, and when primary reference samples in left and right sides of the current coding block are available, wherein the range start value and the range end value is determined using a width and a height of the current coding block; or

determining that the BIP is disable, and a BIP flag is not signaled in the bitstream when only a primary reference sample in left or right side of the current coding block is available, and one of the following is true:

a width of the current coding block is 4 and the number of intra prediction mode differs from the number of horizontal one by a first threshold or less; or

a height of the current coding block is 4 and the number of intra prediction mode differs from the number of vertical one by a second threshold or less.

16. The method of claim 11 or claim 12, wherein the prediction related information comprises numbers and positions of available primary reference samples and intra prediction mode index, and wherein the determining whether the BIP flag is signaled comprises:

determining that the BIP is enabled, and the BIP flag is applied by default and is not signaled in the bitstream when the intra prediction mode index is greater than a range start value and is less than a range end value, and when a primary reference sample in lower side or upper side of the current coding block is available, wherein the

range start value and the range end value is determined using a width and a height of the current coding block.

17. The method of claim 11, wherein the determining whether that BIP flag is signaled comprises:

determining a reliability of the BIP according to the prediction related information, where reliability of the BIP includes low-reliable prediction (CTX_{LR}), medium-reliable prediction (CTX_{MR}) or highly-reliable prediction (CTX_{HR}).

18. The method of claim 17, wherein the determining the reliability of the BIP comprises:

determining the reliability of the BIP as CTX_{LR} when primary reference samples in left and right sides of the current coding block are available, a primary reference sample in the top side of the current coding block is not available, and an intra prediction mode (I_{IPM}) belongs to a first predefined range.

19. The method of claim 17, wherein the determining the reliability of the BIP comprises:

determining the reliability of the BIP as CTX_{HR} when primary reference samples in left and top sides of the current coding block are available, a primary reference sample in right side of the current coding block is not available, and I_{IPM} belongs to a second predefined range.

20. The method of claim 17, wherein the determining the reliability of the BIP comprises:

determining the reliability of the BIP as CTX_{MR} when primary reference samples in left and right sides of the current coding block are available and one of the following is true:

a primary reference sample in top side of the current coding block is available; or

I_{IPM} does not belong to a first predefined range.

21. The method of any one of claims 11 to 20, wherein the BIP mode is a distance-weighted direction intra prediction (DWDIP) mode, and the BIP flag is a DWDIP flag.

22. An encoder (108; 200) comprising processing circuitry for carrying out the method according to any one of claims 1 to 10.

23. A decoder (116; 300) comprising processing circuitry for carrying out the method according to any one of claims 11 to 21.

24. A computer program comprising a program code for performing the method according to any one of claims 1 to 10, or according to any one of claims 11 to 21, when the computer program runs on a computing device.