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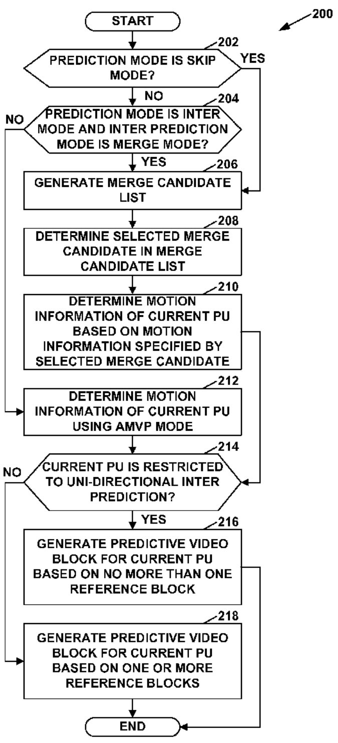

FIG. 4

(57) Abstract: A computing device determines whether a prediction unit (PU) in a B slice is restricted to uni-directional inter prediction. In addition, the computing device generates a merge candidate list for the PU and determines a selected merge candidate in the merge candidate list. If the PU is restricted to uni-directional inter prediction, the computing device generates a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate. If the PU is not restricted to uni-directional inter prediction, the computing device generates the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

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RESTRICTION OF PREDICTION UNITS IN B SLICES TO UNI-DIRECTIONAL INTER PREDICTION

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/596,597, filed February 8, 2012, and U.S. Provisional Patent Application No. 61/622,968, filed April 11, 2012, the entire content of each of which are incorporated here by reference.

TECHNICAL FIELD

[0002] This disclosure relates to video coding and, in particular, to inter prediction in video coding.

BACKGROUND

[0003] Digital video capabilities can be incorporated into a wide range of devices, including digital televisions, digital direct broadcast systems, wireless broadcast systems, personal digital assistants (PDAs), laptop or desktop computers, tablet computers, e-book readers, digital cameras, digital recording devices, digital media players, video gaming devices, video game consoles, cellular or satellite radio telephones, so-called “smart phones,” video teleconferencing devices, video streaming devices, and the like. Digital video devices implement video compression techniques, such as those described in the standards defined by 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) standard presently under development, and extensions of such standards. The video devices may transmit, receive, encode, decode, and/or store digital video information more efficiently by implementing such video compression techniques.

[0004] Video compression techniques perform spatial (intra-picture) prediction and/or temporal (inter-picture) prediction to reduce or remove redundancy inherent in video sequences. For block-based video coding, a video slice (i.e., a video frame or a portion of a video frame) may be partitioned into video blocks, which may also be referred to as treeblocks, coding units (CUs) and/or coding nodes. Video blocks in an intra-coded (I) slice of a picture are encoded using spatial prediction with respect to reference samples in neighboring blocks in the same picture. Video blocks in an inter-coded (P or B) slice of a picture may use spatial prediction with respect to reference samples in neighboring blocks in the same picture or temporal prediction with respect to reference samples in other reference pictures. Pictures may be referred to as frames, and reference pictures may be referred to a reference frames.

[0005] Spatial or temporal prediction results in a predictive video block for a block to be coded. Residual data represents pixel differences between the original block to be coded and the predictive video block. An inter-coded block is encoded according to a motion vector that points to a block of reference samples forming the predictive video block, and the residual data indicating the difference between the coded block and the predictive video block. An intra-coded block is encoded according to an intra-coding mode and the residual data. For further compression, the residual data may be transformed from the pixel domain to a transform domain, resulting in residual transform coefficients, which then may be quantized. The quantized transform coefficients, initially arranged in a two-dimensional array, may be scanned in order to produce a one-dimensional vector of transform coefficients, and entropy coding may be applied to achieve even more compression.

SUMMARY

[0006] In general, this disclosure describes techniques for inter prediction in a video coding process. A video coder determines whether a prediction unit (PU) in a B slice is restricted to uni-directional inter prediction. In addition, the video coder generates a merge candidate list for the PU and determines a selected merge candidate in the merge candidate list. If the PU is restricted to uni-directional inter prediction, the video coder generates a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate. If the PU is not restricted to uni-directional inter prediction, the video coder generates the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

[0007] In one aspect, this disclosure describes a method for coding video data. The method comprises determining whether a PU in a B slice is restricted to uni-directional inter prediction. The method also comprises generating a merge candidate list for the PU. In addition, the method comprises determining a selected merge candidate in the merge candidate list. In addition, the method comprises, if the PU is restricted to uni-directional inter prediction, generating a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate. The method also comprises if the PU is not restricted to uni-directional inter prediction, generating the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

[0008] In another aspect, this disclosure describes a video coding device that comprises one or more processors configured to determine whether a PU in a B slice is restricted to uni-directional inter prediction. The one or more processors are also configured to generate a merge candidate list for the PU and determine a selected merge candidate in the merge candidate list. The one or more processors are configured such that if the PU is restricted to uni-directional inter prediction, the one or more processors generate a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate. Furthermore, the one or more processors are configured such that if the PU is not restricted to uni-directional inter prediction, the one or more processors generate the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

[0009] In another aspect, this disclosure describes a video coding device comprising means for determining whether a PU in a B slice is restricted to uni-directional inter prediction. The video coding device also comprises means for generating a merge candidate list for the PU. In addition, the video coding device comprises means for determining a selected merge candidate in the merge candidate list. The video coding device also comprises means for generating, if the PU is restricted to uni-directional inter prediction, a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate. The video coding device also comprises means for generating, if the PU is not restricted to uni-directional inter prediction, the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

[0010] In another aspect, this disclosure describes a computer program product that comprises one or more computer readable storage media that store instructions that, when executed, configure one or more processors to determine whether a PU in a B slice is restricted to uni-directional inter prediction. The instructions also configure the one or more processors to generate a merge candidate list for the PU and determine a selected merge candidate in the merge candidate list. If the PU is restricted to uni-directional inter prediction, the instructions configure the one or more processors to generate a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate. If the PU is not restricted to uni-directional inter prediction, the instructions configure the one or more processors to generate the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

[0011] The details of one or more examples are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF DRAWINGS

[0012] FIG. 1 is a block diagram illustrating an example video coding system that may utilize the techniques described in this disclosure.

[0013] FIG. 2 is a block diagram illustrating an example video encoder that is configured to implement the techniques described in this disclosure.

[0014] FIG. 3 is a block diagram illustrating an example video decoder that is configured to implement the techniques described in this disclosure.

[0015] FIG. 4 is a flowchart illustrating an example motion compensation operation.

[0016] FIG. 5 is a flowchart that illustrates another example motion compensation operation.

[0017] FIG. 6 is a flowchart that illustrates an example operation for generating a merge candidate list.

[0018] FIG. 7 is a flowchart that illustrates an example process for generating artificial merge candidates.

[0019] FIG. 8 is a flowchart that illustrates an example operation for determining the motion information of a prediction unit using advanced motion vector prediction mode.

DETAILED DESCRIPTION

[0020] As described below, a picture may be divided into one or more slices. Each of the slices may include an integer number of coding units (CUs). Each CU may have one or more prediction units (PUs). Slices may be I slices, P slices, or B slices. In an I slice, all PUs are intra predicted. A video encoder may perform intra prediction or uni-directional inter prediction on PUs in P slices. When the video encoder performs uni-directional inter prediction on a PU in a P slice, the video encoder may identify or synthesize a reference sample in a reference picture listed in a first list of reference pictures ("list 0"). The reference block may be a block of reference samples within the reference picture. The reference samples may correspond to actual pixels in a reference block, or pixels that are synthesized, e.g., by interpolation using actual pixels. The video encoder may then generate a predictive video block for the PU based on the reference block for the PU.

[0021] The video encoder may perform list 0 uni-directional inter prediction, list 1 uni-directional inter prediction, or bi-directional inter prediction on PUs in B-slices. When the video encoder performs list 0 uni-directional inter prediction on a PU, the video encoder may identify a reference block in a reference picture listed in list 0 or synthesize a reference block based on reference samples in a reference picture listed in list 0. The video encoder may then generate the predictive video block for the PU based on the reference block. When the video encoder performs list 1 uni-directional inter prediction on a PU, the video encoder may identify a reference block in a reference picture listed in a second reference picture list ("list 1") or may synthesize a reference block based on reference samples in a reference picture listed in list 1. The video encoder may then generate the predictive video block for the PU based on the reference block. When the video encoder performs bi-directional inter prediction on a PU, the video encoder may identify a reference block in a reference picture listed in list 0 or synthesize a reference block based on reference samples in a reference picture listed in list 0. In addition, when the video encoder performs bi-directional inter prediction on the PU, the video encoder may identify a reference block in a reference picture listed in list 1 or synthesize a reference block based on reference samples in a reference picture listed in list 1. The video encoder may then generate the predictive video block for the PU based on the two reference blocks.

[0022] The video encoder may signal motion information of a PU to enable a video decoder to identify or synthesize the reference block or reference blocks that the video encoder used to generate the predictive video block for the PU. The motion information of the PU may include one or more motion vectors, reference picture indexes, and flags to indicate whether inter prediction is based on list 0 and/or list 1. In some instances, the video encoder may signal the motion information of the PU using merge mode. When the video encoder signals the motion information of the PU using merge mode, the video encoder may generate a merge candidate list for the PU. The merge candidate list may include a plurality of merge candidates, each of which specifies a set of motion information.

[0023] A merge candidate may be a uni-directional merge candidate if the merge candidate specifies motion information that identifies a single location in a reference picture listed in either list 0 or list 1. A reference block may be associated with a set of motion information if the samples in the reference block are determined based on samples at a location identified by the motion information in a reference picture identified by the motion information. For instance, a reference block may be associated with a set of motion information if the samples in the reference block are the same as the samples in a video block at a location identified by the motion information in a reference picture identified by the motion information. A reference block may also be associated with a set of motion information if the samples in the reference block are synthesized (e.g., interpolated) from the samples in a video block at a location identified by the motion information in a reference frame identified by the motion information.

[0024] A merge candidate may be a bi-directional merge candidate if the merge candidate specifies motion information that identifies a location in a reference picture listed in list 0 and a location in a reference picture listed in list 1. The video encoder may generate the motion information specified by the merge candidates based on motion information of PUs that spatially neighbor the current PU and/or a co-located PU in a different picture. After generating the merge list for the current PU, the video encoder may select one of the merge candidates in the merge candidate list and signal a position within the merge candidate list of the selected merge candidate. The video decoder may determine the motion information of the current PU based on the motion information specified by the selected merge candidate.

[0025] In terms of operations and required memory bandwidth, generating a predictive video block for a PU based on two reference blocks may be more complex than generating the predictive video block for the PU based on a single reference block. The complexity associated with generating predictive video blocks based on two reference blocks may increase as the number of bi-directionally inter predicted PUs in a B slice increases. This may be especially true when the number of small bi-directionally inter predicted PUs increases. Accordingly, it may be advantageous to restrict some PUs in B slices to uni-directional inter prediction.

[0026] The video encoder may restrict a PU in a B slice to uni-directional inter prediction by only selecting uni-directional merge candidates from the merge candidate list for the PU. However, in some instances, the merge candidate list may not include any uni-directional merge candidates. In such instances, the video encoder may be unable to signal the motion information of the PU using merge mode. This may decrease coding performance. Furthermore, even if the merge candidate list includes at least one uni-directional merge candidate, coding efficiency may be diminished if the reference blocks associated with the motion information specified by the uni-directional merge candidates are not sufficiently similar to the video block associated with the PU.

[0027] In accordance with the techniques of this disclosure, a video coder (e.g., a video encoder or a video decoder) may determine whether a PU in a B slice is restricted to uni-directional inter prediction. For example, the video coder may determine that a PU is restricted to uni-directional inter prediction if a size characteristic of the PU is less than a particular threshold. The size characteristic of the PU may be a characteristic of a size of a video block associated with the PU, such as a height, width, diagonal length, etc. of the video block associated with the PU. In addition, the video coder may generate a merge candidate list for the PU and determine a selected merge candidate in the merge candidate list. If the PU is restricted to uni-directional inter prediction, the video coder may generate the predictive video block for the PU based on no more than one reference block associated with the motion information specified by the selected merge candidate. If the PU is not restricted to uni-directional inter prediction, the video coder may generate the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate. By restricting some PUs to uni-directional inter prediction in this way, the video coder may reduce complexity associated with generating predictive video blocks based on multiple reference blocks. This may increase the speed at which the video coder is able to code video data and may reduce data bandwidth requirements.

[0028] For ease of explanation, this disclosure may describe locations or video blocks as having various spatial relationships with CUs or PUs. Such description may be interpreted to mean that the locations or video blocks have the various spatial relationships to the video blocks associated with the CUs or PUs. Furthermore, this disclosure may refer to a PU that a video coder is currently coding as the current PU.

This disclosure may refer to a CU that a video coder is currently coding as the current CU. This disclosure may refer to a picture that a video coder is currently coding as the current picture.

[0029] The attached drawings illustrate examples. Elements indicated by reference numbers in the attached drawings correspond to elements indicated by like reference numbers in the following description. In this disclosure, elements having names that start with ordinal words (e.g., "first," "second," "third," and so on) do not necessarily imply that the elements have a particular order. Rather, such ordinal words are merely used to refer to different elements of a same or similar type.

[0030] FIG. 1 is a block diagram that illustrates an example video coding system 10 that may utilize the techniques of this disclosure. As used described herein, the term "video coder" refers generically to both video encoders and video decoders. In this disclosure, the terms "video coding" or "coding" may refer generically to video encoding or video decoding.

[0031] As shown in FIG. 1, video coding system 10 includes a source device 12 and a destination device 14. Source device 12 generates encoded video data. Accordingly, source device 12 may be referred to as a video encoding device or a video encoding apparatus. Destination device 14 may decode the encoded video data generated by source device 12. Accordingly, destination device 14 may be referred to as a video decoding device or a video decoding apparatus. Source device 12 and destination device 14 may be examples of video coding devices or video coding apparatuses.

[0032] Source device 12 and destination device 14 may comprise a wide range of devices, including desktop computers, mobile computing devices, notebook (e.g., laptop) computers, tablet computers, set-top boxes, telephone handsets such as so-called "smart" phones, televisions, cameras, display devices, digital media players, video gaming consoles, in-car computers, or the like. In some examples, source device 12 and destination device 14 may be equipped for wireless communication.

[0033] Destination device 14 may receive encoded video data from source device 12 via a channel 16. Channel 16 may comprise a type of medium or device capable of moving the encoded video data from source device 12 to destination device 14. In one example, channel 16 may comprise a communication medium that enables source device 12 to transmit encoded video data directly to destination device 14 in real-time. In this example, source device 12 may modulate the encoded video data according to a communication standard, such as a wireless communication protocol, and may transmit the modulated video data to destination device 14. The communication medium may comprise a 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 area network, a wide-area network, or a global network such as the Internet. The communication medium may include routers, switches, base stations, or other equipment that facilitates communication from source device 12 to destination device 14.

[0034] In another example, channel 16 may correspond to a storage medium that stores the encoded video data generated by source device 12. In this example, destination device 14 may access the storage medium via disk access or card access. The storage medium may include a variety of locally accessed data storage media such as Blu-ray discs, DVDs, CD-ROMs, flash memory, or other suitable digital storage media for storing encoded video data. In a further example, channel 16 may include a file server or another intermediate storage device that stores the encoded video generated by source device 12. In this example, destination device 14 may access encoded video data stored at the file server or other intermediate storage device via streaming or download. The file server may be a type of server capable of storing encoded video data and transmitting the encoded video data to destination device 14. Example file servers include web servers (e.g., for a website), file transfer protocol (FTP) servers, network attached storage (NAS) devices, and local disk drives. Destination device 14 may access the encoded video data through a standard data connection, including an Internet connection. Example types of data connections may include wireless channels (e.g., Wi-Fi connections), wired connections (e.g., DSL, cable modem, etc.), or combinations of both that are suitable for accessing encoded video data stored on a file server. The transmission of encoded video data from the file server may be a streaming transmission, a download transmission, or a combination of both.

[0035] The techniques of this disclosure are not 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 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, video coding system 10 may be configured to support one-way or two-way video transmission to support applications such as video streaming, video playback, video broadcasting, and/or video telephony.

[0036] In the example of FIG. 1, source device 12 includes a video source 18, video encoder 20, and an output interface 22. In some cases, output interface 22 may include a modulator/demodulator (modem) and/or a transmitter. In source device 12, video source 18 may include a source such as a video capture device, e.g., a video camera, a video archive containing previously captured video data, a video feed interface to receive video data from a video content provider, and/or a computer graphics system for generating video data, or a combination of such sources.

[0037] Video encoder 20 may encode the captured, pre-captured, or computer-generated video data. The encoded video data may be transmitted directly to destination device 14 via output interface 22 of source device 12. The encoded video data may also be stored onto a storage medium or a file server for later access by destination device 14 for decoding and/or playback.

[0038] In the example of FIG. 1, destination device 14 includes an input interface 28, a video decoder 30, and a display device 32. In some cases, input interface 28 may include a receiver and/or a modem. Input interface 28 of destination device 14 receives encoded video data over channel 16. The encoded video data may include a variety of syntax elements generated by video encoder 20 that represent 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.

[0039] Display device 32 may be integrated with or may be external to destination device 14. In some examples, destination device 14 may include an integrated display device and may also be configured to interface with an external display device. In other examples, destination device 14 may be a display device. In general, display device 32 displays the decoded video data to a user. Display device 32 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.

[0040] Video encoder 20 and video decoder 30 may operate according to a video compression standard, such as the High Efficiency Video Coding (HEVC) standard presently under development, and may conform to a HEVC Test Model (HM). A recent draft of the upcoming HEVC standard, referred to as "HEVC Working Draft 7" or "WD7," is described in document JCTVC-I1003_d54, Bross et al., "High efficiency video coding (HEVC) text specification draft 7," Joint Collaborative Team on Video

Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 9th Meeting: Geneva, Switzerland, May, 2012, which, as of July 19, 2012, is downloadable from: http://phenix.int-evry.fr/jct/doc_end_user/documents/9_Geneva/wg11/JCTVC-I1003-v6.zip, the entire content of which is incorporated herein by reference. Alternatively, video encoder 20 and video decoder 30 may operate according to other proprietary or industry standards, such as the ITU-T H.264 standard, alternatively referred to as MPEG-4, Part 10, Advanced Video Coding (AVC), or extensions of such standards. The techniques of this disclosure, however, are not limited to any particular coding standard or technique. Other examples of video compression standards and techniques include MPEG-2, ITU-T H.263 and proprietary or open source compression formats such as VP8 and related formats.

[0041] Although not shown in the example of FIG. 1, video encoder 20 and video decoder 30 may each be integrated with an audio encoder and decoder, and may include appropriate MUX-DEMUX units, or other hardware and software, to handle encoding of both audio and video in a common data stream or separate data streams. If applicable, in some examples, MUX-DEMUX units may conform to the ITU H.223 multiplexer protocol, or other protocols such as the user datagram protocol (UDP).

[0042] Again, FIG. 1 is merely an example and the techniques of this disclosure may apply to video coding settings (e.g., video encoding or video decoding) that do not necessarily include any data communication between the encoding and decoding devices. In other examples, data can be retrieved from a local memory, streamed over a network, or the like. An encoding device may encode and store data to memory, and/or a decoding device may retrieve and decode data from memory. In many examples, the encoding and decoding is performed by devices that do not communicate with one another, but simply encode data to memory and/or retrieve and decode data from memory.

[0043] Video encoder 20 and video decoder 30 each may be implemented as any of a variety of suitable circuitry, such as one or more microprocessors, digital signal processors (DSPs), application specific integrated circuits (ASICs), field programmable gate arrays (FPGAs), discrete logic, hardware, 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 storage medium and may execute the instructions in hardware using one or more processors to perform the techniques of this disclosure. Any of the foregoing (including hardware, software, a combination of hardware and software, etc.) may be considered to be one or more processors. Each of video encoder 20 and video decoder 30 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.

[0044] This disclosure may generally refer to video encoder 20 "signaling" certain information to another device, such as video decoder 30. It should be understood, however, that video encoder 20 may signal information by associating certain syntax elements with various encoded portions of video data. That is, video encoder 20 may "signal" data by storing certain syntax elements to headers of various encoded portions of video data. In some cases, such syntax elements may be encoded and stored (e.g., in a storage system) prior to being received and decoded by video decoder 30. Thus, the term "signaling" may generally refer to the communication of syntax or other data used to decode the compressed video data. Such communication may occur in real- or near-real-time. Alternately, such communication may occur over a span of time, such as might occur when storing syntax elements to a medium in an encoded bitstream at the time of encoding, which then may be retrieved by a decoding device at any time after being stored to this medium.

[0045] As mentioned briefly above, video encoder 20 encodes video data. The video data may comprise one or more pictures. Each of the pictures may be a still image forming part of a video. In some instances, a picture may be referred to as a video "frame." When video encoder 20 encodes the video data, video encoder 20 may generate a bitstream. The bitstream may include a sequence of bits that form a coded representation of the video data. The bitstream may include coded pictures and associated data. A coded picture is a coded representation of a picture.

[0046] To generate the bitstream, video encoder 20 may perform encoding operations on each picture in the video data. When video encoder 20 performs encoding operations on the pictures, video encoder 20 may generate a series of coded pictures and associated data. The associated data may include sequence parameter sets, picture parameter sets, adaptation parameter sets, and other syntax structures. A sequence parameter set (SPS) may contain parameters applicable to zero or more sequences of pictures. A picture parameter set (PPS) may contain parameters applicable to zero or more pictures. An adaptation parameter set (APS) may contain parameters applicable to zero or more pictures. Parameters in an APS may be parameters that are more likely to change than parameters in a PPS.

[0047] To generate a coded picture, video encoder 20 may partition a picture into equally-sized video blocks. A video block may be a two-dimensional array of samples. Each of the video blocks is associated with a treeblock. In some instances, a treeblock may be referred to as a largest coding unit (LCU) or a "coding treeblock." The treeblocks of HEVC may be broadly analogous to the macroblocks of previous standards, such as H.264/AVC. However, a treeblock is not necessarily limited to a particular size and may include one or more coding units (CUs). Video encoder 20 may use quadtree partitioning to partition the video blocks of treeblocks into video blocks associated with CUs, hence the name "treeblocks."

[0048] In some examples, video encoder 20 may partition a picture into a plurality of slices. Each of the slices may include an integer number of CUs. In some instances, a slice comprises an integer number of treeblocks. In other instances, a boundary of a slice may be within a treeblock.

[0049] As part of performing an encoding operation on a picture, video encoder 20 may perform encoding operations on each slice of the picture. When video encoder 20 performs an encoding operation on a slice, video encoder 20 may generate encoded data associated with the slice. The encoded data associated with the slice may be referred to as a "coded slice."

[0050] To generate a coded slice, video encoder 20 may perform encoding operations on each treeblock in a slice. When video encoder 20 performs an encoding operation on a treeblock, video encoder 20 may generate a coded treeblock. The coded treeblock may comprise an encoded representation of the treeblock.

[0051] When video encoder 20 generates a coded slice, video encoder 20 may perform encoding operations on (i.e., encode) the treeblocks (which in this case represent largest coding units) in the slice according to a raster scan order. In other words, video encoder 20 may encode the treeblocks of the slice in an order that proceeds from left to right across a topmost row of treeblocks in the slice, then proceeds from left to right across a next lower row of treeblocks, and so on until video encoder 20 has encoded each of the treeblocks in the slice.

[0052] As a result of encoding the treeblocks according to the raster scan order, the treeblocks above and to the left of a given treeblock may have been encoded, but treeblocks below and to the right of the given treeblock have not yet been encoded. Consequently, video encoder 20 may be able to access information generated by encoding treeblocks above and to the left of the given treeblock when encoding the given treeblock. However, video encoder 20 may be unable to access information generated by encoding treeblocks below and to the right of the given treeblock when encoding the given treeblock.

[0053] To generate a coded treeblock, video encoder 20 may recursively perform quadtree partitioning on the video block of the treeblock to divide the video block into progressively smaller video blocks. Each of the smaller video blocks may be associated with a different CU. For example, video encoder 20 may partition the video block of a treeblock into four equally-sized sub-blocks, partition one or more of the sub-blocks into four equally-sized sub-sub-blocks, and so on. A partitioned CU may be a CU whose video block is partitioned into video blocks associated with other CUs. A non-partitioned CU may be a CU whose video block is not partitioned into video blocks associated with other CUs.

[0054] One or more syntax elements in the bitstream may indicate a maximum number of times video encoder 20 may partition the video block of a treeblock. A video block of a CU may be square in shape. The size of the video block of a CU (i.e., the size of the CU) may range from 8x8 pixels up to the size of a video block of a treeblock (i.e., the size of the treeblock) with a maximum of 64x64 pixels or greater.

[0055] Video encoder 20 may perform encoding operations on (i.e., encode) each CU of a treeblock according to a z-scan order. In other words, video encoder 20 may encode a top-left CU, a top-right CU, a bottom-left CU, and then a bottom-right CU, in that order. When video encoder 20 performs an encoding operation on a partitioned CU, video encoder 20 may encode CUs associated with sub-blocks of the video block of the partitioned CU according to the z-scan order. In other words, video encoder 20 may encode a CU associated with a top-left sub-block, a CU associated with a top-right sub-block, a CU associated with a bottom-left sub-block, and then a CU associated with a bottom-right sub-block, in that order.

[0056] As a result of encoding the CUs of a treeblock according to a z-scan order, the CUs above, above-and-to-the-left, above-and-to-the-right, left, and below-and-to-the left of a given CU may have been encoded. CUs below or to the right of the given CU have not yet been encoded. Consequently, video encoder 20 may be able to access information generated by encoding some CUs that neighbor the given CU when encoding the given CU. However, video encoder 20 may be unable to access information generated by encoding other CUs that neighbor the given CU when encoding the given CU.

[0057] When video encoder 20 encodes a non-partitioned CU, video encoder 20 may generate one or more prediction units (PUs) for the CU. Each of the PUs of the CU may be associated with a different video block within the video block of the CU. Video encoder 20 may generate a predictive video block for each PU of the CU. The predictive video block of a PU may be a block of samples. Video encoder 20 may use intra prediction or inter prediction to generate the predictive video block for a PU.

[0058] When video encoder 20 uses intra prediction to generate the predictive video block of a PU, video encoder 20 may generate the predictive video block of the PU based on decoded samples of the picture associated with the PU. If video encoder 20 uses intra prediction to generate predictive video blocks of the PUs of a CU, the CU is an intra-predicted CU.

[0059] When video encoder 20 uses inter prediction to generate the predictive video block of the PU, video encoder 20 may generate the predictive video block of the PU based on decoded samples of one or more pictures other than the picture associated with the PU. If video encoder 20 uses inter prediction to generate predictive video blocks of the PUs of a CU, the CU is an inter-predicted CU.

[0060] Furthermore, when video encoder 20 uses inter prediction to generate a predictive video block for a PU, video encoder 20 may generate motion information for the PU. The motion information for a PU may indicate one or more reference blocks of the PU. Each reference block of the PU may be a video block within a reference picture. The reference picture may be a picture other than the picture associated with the PU. In some instances, a reference block of a PU may also be referred to as the "reference sample" of the PU. Video encoder 20 may generate the predictive video block for the PU based on the reference blocks of the PU.

[0061] As discussed above, a slice may be an I slice, a P slice, or a B slice. In an I slice, all PUs are intra predicted. In P slices and B slices, PUs may be intra predicted or inter predicted. When video encoder 20 performs inter prediction on a PU in a P slice, video encoder 20 may generate motion information that identifies a location in a single reference picture. In other words, the PU may be uni-directionally inter predicted. The motion information may include a reference picture index and a motion vector. The reference picture index may indicate a position in a first reference picture list ("list 0") of a reference picture. The motion vector may indicate a spatial displacement between the video block associated with the PU and a reference block within the reference picture. A video coder, such as video encoder 20 or video decoder 30, may subsequently generate the predictive video block for the PU based on the single reference block associated with the motion information of the PU. For instance, the video coder may generate the predictive video block for the PU such that the predictive video block matches the reference block.

[0062] A PU in a B slice may be uni-directionally inter predicted based on list 0, uni-directionally inter predicted based on a second reference picture list ("list 1"), or bi-directionally inter-predicted. If a PU in a B slice is uni-directionally inter predicted based on list 0, the motion information of the PU may include a list 0 reference picture index and a list 0 motion vector. The list 0 reference picture index may identify a reference picture by indicating a position in list 0 of the reference picture. The list 0 motion vector may indicate a spatial displacement between the video block associated with the PU and a reference block within the reference picture. Video encoder 20 may generate the predictive video block for the PU based on the reference block associated with the list 0 motion vector. In other words, video encoder 20 may generate the predictive video block for the PU based on a block of reference samples identified by the list 0 motion vector or may generate the predictive video block for the PU based on a block of reference samples synthesized (e.g., interpolated) from the block of reference samples identified by the list 0 motion vector.

[0063] If a PU in a B slice is uni-directionally inter predicted based on list 1, the motion information of the PU may include a list 1 reference picture index and a list 1 motion vector. The list 1 reference picture index may identify a reference picture by indicating a position in list 1 of the reference picture. The list 1 motion vector may indicate a spatial displacement between the PU and a reference block within the reference picture. Video encoder 20 may generate the predictive video block for the PU based on a block of reference samples associated with the list 1 motion vector. For example, video encoder 20 may generate the predictive video block for the PU based on a block of reference samples identified by the list 1 motion vector or may generate the predictive video block for the PU based on a block of reference samples synthesized (e.g., interpolated) from the block of reference samples identified by the list 1 motion vector.

[0064] If a PU in a B slice is bi-directionally inter predicted, the motion information of the PU may include a list 0 reference picture index, a list 0 motion vector, a list 1 reference picture index, and a list 1 motion vector. In some instances, the list 0 and list 1 reference picture indexes may identify the same picture. Video encoder 20 may generate the predictive video block for the PU based on the reference blocks associated with the list 0 and list 1 motion vectors. In some examples, video encoder 20 may generate the predictive video block for the PU by interpolating the predictive video block from samples in a reference block associated with the list 0 motion vector and samples in a reference block associated with the list 1 motion vector.

[0065] After video encoder 20 generates predictive video blocks for one or more PUs of a CU, video encoder 20 may generate residual data for the CU based on the predictive video blocks for the PUs of the CU. The residual data for the CU may indicate differences between samples in the predictive video blocks for the PUs of the CU and the original video block of the CU.

[0066] Furthermore, as part of performing an encoding operation on a non-partitioned CU, video encoder 20 may perform recursive quadtree partitioning on the residual data of the CU to partition the residual data of the CU into one or more blocks of residual data (i.e., residual video blocks) associated with transform units (TUs) of the CU. Each TU of a CU may be associated with a different residual video block.

[0067] Video coder 20 may apply one or more transforms to residual video blocks associated with the TUs to generate transform coefficient blocks (i.e., blocks of transform coefficients) associated with the TUs. Conceptually, a transform coefficient block may be a two-dimensional (2D) matrix of transform coefficients.

[0068] After generating a transform coefficient block, video encoder 20 may perform a quantization process on the transform coefficient block. Quantization generally refers to a process in which transform coefficients are quantized to possibly reduce the amount of data used to represent the transform coefficients, providing further compression. The quantization process may reduce the bit depth associated with some or all of the transform coefficients. For example, an n-bit transform coefficient may be rounded down to an m-bit transform coefficient during quantization, where n is greater than m.

[0069] Video encoder 20 may associate each CU with a quantization parameter (QP) value. The QP value associated with a CU may determine how video encoder 20 quantizes transform coefficient blocks associated with the CU. Video encoder 20 may adjust the degree of quantization applied to the transform coefficient blocks associated with a CU by adjusting the QP value associated with the CU.

[0070] After video encoder 20 quantizes a transform coefficient block, video encoder 20 may generate sets of syntax elements that represent the transform coefficients in the quantized transform coefficient block. Video encoder 20 may apply entropy encoding operations, such as Context Adaptive Binary Arithmetic Coding (CABAC) operations, to some of these syntax elements.

[0071] The bitstream generated by video encoder 20 may include a series of Network Abstraction Layer (NAL) units. Each of the NAL units may be a syntax structure containing an indication of a type of data in the NAL unit and bytes containing the data. For example, a NAL unit may contain data representing a sequence parameter set, a picture parameter set, a coded slice, supplemental enhancement information (SEI), an access unit delimiter, filler data, or another type of data. The data in a NAL unit may include various syntax structures.

[0072] Video decoder 30 may receive the bitstream generated by video encoder 20. The bitstream may include a coded representation of the video data encoded by video encoder 20. When video decoder 30 receives the bitstream, video decoder 30 may perform a parsing operation on the bitstream. When video decoder 30 performs the parsing operation, video decoder 30 may extract syntax elements from the bitstream. Video decoder 30 may reconstruct the pictures of the video data based on the syntax elements extracted from the bitstream. The process to reconstruct the video data based on the syntax elements may be generally reciprocal to the process performed by video encoder 20 to generate the syntax elements.

[0073] After video decoder 30 extracts the syntax elements associated with a CU, video decoder 30 may generate predictive video blocks for the PUs of the CU based on the syntax elements. In addition, video decoder 30 may inverse quantize transform coefficient blocks associated with TUs of the CU. Video decoder 30 may perform inverse transforms on the transform coefficient blocks to reconstruct residual video blocks associated with the TUs of the CU. After generating the predictive video blocks and reconstructing the residual video blocks, video decoder 30 may reconstruct the video block of the CU based on the predictive video blocks and the residual video blocks. In this way, video decoder 30 may reconstruct the video blocks of CUs based on the syntax elements in the bitstream.

[0074] As described above, video encoder 20 may use inter prediction to generate predictive video blocks associated with motion information for the PUs of a CU. In many instances, the motion information of a given PU is likely to be the same or similar to the motion information of one or more nearby PUs (i.e., PUs whose video blocks are spatially or temporally nearby to the video block of the given PU). Because nearby PUs frequently have similar motion information, video encoder 20 may encode the motion information of the given PU with reference to the motion information of one or more nearby PUs. Encoding the motion information of the given PU with reference to the motion information of the one or more nearby PUs may reduce the number of bits required in the bitstream to indicate the motion information of the given PU.

[0075] Video encoder 20 may encode the motion information of a given PU with reference to the motion information of one or more nearby PUs in various ways. For example, video encoder 20 may encode the motion information of the given PU using merge mode or advanced motion vector prediction (AMVP) mode. To encode the motion information of a PU using merge mode, video encoder 20 may generate a merge candidate list for the PU. The merge candidate list may include one or more merge candidates. Each of the merge candidates specifies a set of motion information. Video encoder 20 may generate one or more of the merge candidates based on the motion information specified by PUs that spatially neighbor the PU in the same picture, which may be referred to as spatial merge candidates, or based on a co-located PU in another picture, which may be referred to as a temporal merge candidate. If the motion information specified by a merge candidate is associated with two reference blocks, the merge candidate may be referred to herein as a bi-directional merge candidate or a merge candidate that is bi-directional. Otherwise, if the motion information specified by a merge candidate is associated with only a single reference block, the merge candidate may be referred to herein as a uni-directional merge candidate or a merge candidate that is uni-directional. Video encoder 20 may select one of the merge candidates from the merge candidate list and signal a candidate index value for the PU. The candidate index value may indicate a position in the merge candidate list of the selected merge candidate.

[0076] When video encoder 20 encodes the motion information of a PU using merge mode, video decoder 30 may generate the same merge candidate list for the PU as video encoder 20 generated for the PU. Video decoder 30 may then determine, based on the candidate index value for the PU, which one of the merge candidates in the merge candidate list was selected by video encoder 20. Video decoder 30 may then adopt the motion information specified by the selected merge candidate as the motion information of the PU. The motion information specified by the selected candidate may include one or more motion vectors and one or more reference picture indexes.

[0077] When video encoder 20 signals the motion information of a PU using AMVP, video encoder 20 may generate a list 0 MV predictor candidate list for the PU if the PU is uni-directionally inter predicted based on list 0 or if the PU is bi-directionally inter predicted based reference pictures in list 0 and list 1. The list 0 MV predictor candidate list may include one or more MV predictor candidates. Each of the MV predictor candidates specifies a set of motion information. Video encoder 20 may select a list 0 MV predictor candidate from the list 0 MV predictor candidate list. Video encoder 20 may signal a list 0 MV predictor flag that indicates a position in the list 0 MV predictor candidate list of the selected list 0 MV predictor candidate. The list 0 MV predictor flag may be denoted as "mvp_l0_flag."

[0078] In addition, when video encoder 20 signals the motion information of a PU using AMVP, video encoder 20 may generate a list 1 MV predictor candidate list for the PU if the PU is uni-directionally inter predicted based on list 1 or if the PU is bi-directionally inter predicted. The list 1 MV predictor candidate list may include one or more MV predictor candidates. Each of the MV predictor candidates specifies a set of motion information. Video encoder 20 may then select a list 1 MV predictor candidate from the list 1 MV predictor candidate list. Video encoder 20 may signal a list 1 MV predictor flag that indicates a position in the list 1 MV predictor candidate list of the selected list 1 MV predictor candidate. The list 1 MV predictor flag may be denoted as "mvp_l1_flag."

[0079] In addition, when video encoder 20 encodes the motion information of a PU using AMVP, video encoder 20 may calculate a list 0 motion vector difference (MVD) for the PU if the PU is uni-directionally inter predicted based on list 0 or if the PU is bi-directionally inter predicted. The list 0 MVD indicates a difference between a list 0 motion vector of the PU and a list 0 motion vector specified by the selected list 0 MV predictor candidate. In addition, video encoder 20 may output a list 1 MVD for the PU if the PU is uni-directionally predicted based on list 1 or if the PU is bi-directionally inter predicted. The list 1 MVD indicates a difference between the list 1 motion vector of the PU and a list 1 motion vector specified by the selected list 1 MV predictor candidate. Video encoder 20 may signal the list 0 MVD and/or the list 1 MVD.

[0080] When video encoder 20 signals the motion information of a PU using AMVP mode, video decoder 30 may independently generate the same list 0 and/or list 1 MV predictor candidate lists generated by video encoder 20. In other examples, video encoder 20 may encode syntax elements that specify the list 0 and list 1 MV predictor candidate lists. If the PU is uni-directionally inter predicted based on list 0 or if the PU is bi-directionally inter predicted, video decoder 30 may determine the selected list 0

MV predictor candidate from the list 0 MV predictor candidate list. Video decoder 30 may then determine a list 0 motion vector of the PU based on the selected list 0 MV predictor candidate and the list 0 MVD for the PU. For instance, video decoder 30 may determine the list 0 motion vector of the PU by adding the list 0 motion vector specified by the selected list 0 MV predictor candidate and the list 0 MVD. If the PU is uni-directionally inter predicted based on list 1 or if the PU is bi-directionally inter predicted, video decoder 30 may determine the selected list 1 MV predictor candidate from the list 1 MV predictor candidate list. Video decoder 30 may then determine a list 1 motion vector of the PU based on a list 1 motion vector specified by the selected list 1 MV candidate and the list 1 MVD. For instance, video decoder 30 may determine the list 1 motion vector of the PU by adding the list 1 motion vector specified by the selected list 1 MV candidate and the list 1 MVD.

[0081] As discussed briefly above, when video encoder 20 performs inter prediction on a PU in a B slice, video encoder 20 may generate motion information associated with one or two reference blocks for the PU. A video coder, such as video encoder 20 or video decoder 30, may then generate the predictive video block for the PU based on the reference blocks associated with the motion information of the PU. In order to generate the predictive video block based on the two reference blocks, the video coder may retrieve both of the reference blocks from memory. Because memory bandwidth (i.e., the rate at which data can be transferred from memory) may be limited, it may take longer to retrieve the two reference blocks from memory than it would take to retrieve a single reference block from memory. Hence, if a B slice includes many small bi-directionally inter predicted PUs, the additional time required to retrieve two reference blocks for each of the PUs may diminish the speed at which the video coder is able to generate the predictive video blocks for PUs in the B slice.

[0082] In accordance with various examples of the techniques of this disclosure, a video coder, such as video encoder 20 or video decoder 30, may determine whether a PU in a B slice is restricted to uni-directional inter prediction. In some examples, the video coder may determine that the PU is restricted to uni-directional inter prediction based on a size characteristic of the PU or a parameter. In addition, the video coder may generate a merge candidate list for the PU and determine a selected merge candidate in the merge candidate list. If the PU is restricted to uni-directional inter prediction, the video coder may generate the predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate.

On the other hand, if the PU is not restricted to uni-directional inter prediction, the video coder may generate the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate. Because the video coder transfers less data from memory when generating a predictive video block based on a single reference block than when generating a predictive video block based on two reference blocks, restricting certain PUs in B slices to uni-directional inter prediction by video encoders and decoders may increase the speed at which the video encoders and decoders are able to generate the predictive video blocks for the PUs in the B slices.

[0083] The video coder, i.e., the video encoder or video decoder, may determine that a PU in a B slice is restricted to uni-directional inter prediction based on various criteria. For example, the video coder may determine that a PU in a B slice is restricted to uni-directional inter prediction if a size characteristic of the PU is below a particular threshold. In this example, the video coder may determine that the PU is not restricted to uni-directional inter prediction if the size characteristic of the PU is not below the threshold. For instance, in this example, the video coder may determine that the PU is restricted to uni-directional inter prediction if a height or a width of the video block associated with the PU is below the threshold. For example, if a height and/or a width of the video block associated with the PU is less than N (e.g., N = 8) pixels, the video coder may determine that the PU is restricted to uni-directional inter prediction.

[0084] In another example, the video coder may determine that a PU in a B slice is restricted to uni-directional inter prediction if a first dimension of a video block associated with the PU is less than a threshold and a second dimension of the video block associated with the PU is less than or equal to the threshold. A dimension of a video block may be a width or a height of the video block. For instance, if the threshold is equal to 8, the video coder may determine that the PU is not restricted to uni-directional inter prediction if a width of the video block is equal to 4, but the height of the video block is equal to 16. However, if the threshold is equal to 8, the video coder may determine that the PU is restricted to uni-directional inter prediction if a width of the video block is equal to 4 and the height of the video block is equal to 8.

[0085] In another example, the video coder may determine that a PU in a B slice is restricted to uni-directional inter prediction if a first dimension of a video block associated with the PU is less than a first threshold and a second dimension of the video block associated with the PU is less than a second threshold. For instance, the video coder may determine that the PU is restricted to uni-directional inter prediction if a width of the video block is less than 8 and the height of the video block is less than 16. In some instances, the first threshold may be the same as the second threshold.

[0086] In another example, the video coder may determine that the PU is restricted to uni-directional inter prediction if a size characteristic of a CU associated with the PU (e.g., the current CU) is equal to a particular size and a size characteristic of the PU is below a threshold. In this example, the video coder may determine that the PU is not restricted to uni-directional inter prediction if the size characteristic of the CU is not equal to the particular size or the size characteristic of the PU is not below the threshold. In this example, the particular size may be equal to N (e.g., N = 8) pixels and the threshold may also be equal to N (e.g., N = 8) pixels. In this example, for a CU with a size of 8x8, any PU of the CU that has a size smaller than 8x8 may be prohibited from bi-directional inter prediction.

[0087] In another example, the video coder may determine that a PU in a B slice is restricted to uni-directional inter prediction if a parameter indicates that PUs in the B slice are to be restricted to uni-directional inter prediction.

[0088] The video coder may restrict a PU in a B slice to uni-directional inter prediction in various ways. For example, the video coder may ignore one of the reference blocks associated with the PU's motion information and generate the PU's predictive video block based on the other one of the reference blocks associated with the PU's motion information. For instance, the video coder may generate a merge candidate list and, if the selected merge candidate is a bi-directional merge candidate, the video coder may generate the predictive video block for the PU based on the reference block associated with the selected merge candidate's list 0 reference picture index and the selected merge candidate's list 0 motion vector. In a similar example, the video coder may generate the predictive video block for the PU based on the reference block associated with the selected merge candidate's list 1 reference picture index and the selected merge candidate's list 1 motion vector.

[0089] In another example of how the video coder may restrict a PU in a B slice to uni-directional inter prediction, the video coder may include uni-directional merge candidates in a merge candidate list for the PU without including bi-directional merge candidates in the merge candidate list for the PU. The video coder does not, in this example, convert the bi-directional merge candidates into uni-directional merge candidates. In this example, the video coder may include artificial uni-directional merge candidates in the merge candidate list if the number of available uni-directional merge candidates is insufficient to fill the merge candidate list. An artificial merge candidate may be a merge candidate that is generated based on the motion information of one or more PUs, but that does not specify the motion information of the one or more PUs.

[0090] In another example of how the video coder may restrict a PU in a B slice to uni-directional inter prediction, the video coder may convert bi-directional merge candidates into one or more uni-directional merge candidates and include the one or more uni-directional merge candidates in the merge candidate list. In some such examples, the video coder may convert the bi-directional merge candidate into a single uni-directional merge candidate associated with a reference picture in list 0 or a reference picture in list 1. In some such cases, whenever the video coder converts bi-directional merge candidates to uni-directional merge candidates, the uni-directional merge candidates are associated with reference pictures in a particular reference list. For example, the video coder may only convert the bi-directional merge candidate into a single uni-directional merge candidate associated with a reference picture in list 0. Alternatively, the video coder may only convert the bi-directional merge candidate into a single uni-directional merge candidate associated with a reference picture in list 1. In other such examples, the video coder may convert the bi-directional merge candidate into two uni-directional merge candidates, one of which is associated with a reference picture in list 0 and the other of which is associated with a reference picture in list 1. Hence, in some examples, after generating the merge candidate list, the video coder may convert a bi-directional merge candidate in the merge candidate list into a uni-directional merge candidate and include the uni-directional merge candidate in the merge candidate list in place of the bi-directional merge candidate.

[0091] In some examples, the video coder may remove duplicate merge candidates from the merge candidate list before converting bi-directional merge candidates to uni-directional merge candidates. In other examples, the video coder may remove duplicate merge candidates from the merge candidate list after converting bi-directional merge candidates to uni-directional merge candidates.

[0092] When video encoder 20 encodes the motion information of a PU in a B slice using AMVP, video encoder 20 may generate, entropy encode, and output an inter prediction mode indicator for the PU. The inter prediction mode indicator may be denoted as "inter_pred_idc." The inter prediction mode indicator may indicate whether the PU is uni-directionally inter predicted based on list 0, uni-directionally inter predicted based on list 1, or is bi-directionally inter predicted. Video decoder 30 may use the inter prediction mode indicator when performing inter prediction on the PU. Because the inter prediction mode indicator has three possible values, the inter prediction mode indicator may conventionally be represented using two bits.

[0093] However, if a PU in a B slice is restricted to uni-directional inter prediction, the inter prediction mode indicator can have two possible values: uni-directional inter-prediction based on list 0 and uni-directional inter prediction based on list 1. Hence, in accordance with the techniques of this disclosure, if a PU in a B slice is restricted to uni-directional inter prediction, the inter prediction mode indicator may be represented using a single bit. Otherwise, if the PU is not restricted to uni-directional inter prediction, the inter prediction mode indicator may be represented using two bits. Representing the inter prediction mode indicator using a single bit when the PU is restricted to uni-directional inter prediction may increase coding efficiency.

[0094] Furthermore, different contexts may be used to entropy code the inter prediction mode indicator of a PU in a B slice if the PU is restricted to uni-directional inter prediction than if the PU is not restricted to uni-directional inter prediction. This may further increase coding efficiency.

[0095] FIG. 2 is a block diagram that illustrates an example video encoder 20 that is configured to implement the techniques of this disclosure. FIG. 2 is provided for purposes of explanation and should not be considered limiting of the techniques as broadly exemplified and described in this disclosure. For purposes of explanation, this disclosure describes video encoder 20 in the context of HEVC coding. However, the techniques of this disclosure may be applicable to other coding standards or methods.

[0096] In the example of FIG. 2, video encoder 20 includes a plurality of functional components. The functional components of video encoder 20 include a prediction module 100, a residual generation module 102, a transform module 104, a quantization module 106, an inverse quantization module 108, an inverse transform module 110, a reconstruction module 112, a filter module 113, a decoded picture buffer 114, and an entropy encoding module 116. Prediction module 100 includes an inter prediction module 121, motion estimation module 122, a motion compensation module 124, and an intra prediction module 126. In other examples, video encoder 20 may include more, fewer, or different functional components. Furthermore, motion estimation module 122 and motion compensation module 124 may be highly integrated, but are represented in the example of FIG. 2 separately for purposes of explanation.

[0097] Video encoder 20 may receive video data. Video encoder 20 may receive the video data from various sources. For example, video encoder 20 may receive the video data from video source 18 (FIG. 1) or another source. The video data may represent a series of pictures. To encode the video data, video encoder 20 may perform an encoding operation on each of the pictures. As part of performing the encoding operation on a picture, video encoder 20 may perform encoding operations on each slice of the picture. As part of performing an encoding operation on a slice, video encoder 20 may perform encoding operations on treeblocks in the slice.

[0098] As part of performing an encoding operation on a treeblock, prediction module 100 may perform quadtree partitioning on the video block of the treeblock to divide the video block into progressively smaller video blocks. Each of the smaller video blocks may be associated with a different CU. For example, prediction module 100 may partition a video block of a treeblock into four equally-sized sub-blocks, partition one or more of the sub-blocks into four equally-sized sub-sub-blocks, and so on.

[0099] The sizes of the video blocks associated with CUs may range from 8x8 samples up to the size of the treeblock with a maximum of 64x64 samples or greater. In this disclosure, "NxN" and "N by N" may be used interchangeably to refer to the sample dimensions of a video block in terms of vertical and horizontal dimensions, e.g., 16x16 samples or 16 by 16 samples. In general, a 16x16 video block has sixteen samples in a vertical direction ($y = 16$) and sixteen samples in a horizontal direction ($x = 16$). Likewise, an NxN block generally has N samples in a vertical direction and N samples in a horizontal direction, where N represents a nonnegative integer value.

[0100] Furthermore, as part of performing the encoding operation on a treeblock, prediction module 100 may generate a hierarchical quadtree data structure for the treeblock. For example, a treeblock may correspond to a root node of the quadtree data structure. If prediction module 100 partitions the video block of the treeblock into four sub-blocks, the root node has four child nodes in the quadtree data structure. Each of the child nodes corresponds to a CU associated with one of the sub-blocks. If prediction module 100 partitions one of the sub-blocks into four sub-sub-blocks, the node corresponding to the CU associated with the sub-block may have four child nodes, each of which corresponds to a CU associated with one of the sub-sub-blocks.

[0101] Each node of the quadtree data structure may contain syntax data (e.g., syntax elements) for the corresponding treeblock or CU. For example, a node in the quadtree may include a split flag that indicates whether the video block of the CU corresponding to the node is partitioned (i.e., split) into four sub-blocks. Syntax elements for a CU may be defined recursively, and may depend on whether the video block of the CU is split into sub-blocks. A CU whose video block is not partitioned may correspond to a leaf node in the quadtree data structure. A coded treeblock may include data based on the quadtree data structure for a corresponding treeblock.

[0102] Video encoder 20 may perform encoding operations on each non-partitioned CU of a treeblock. When video encoder 20 performs an encoding operation on a non-partitioned CU, video encoder 20 may generate an encoded representation of the non-partitioned CU.

[0103] As part of performing an encoding operation on a CU, prediction module 100 may partition the video block of the CU among one or more PUs of the CU. Video encoder 20 and video decoder 30 may support various PU sizes. Assuming that the size of a particular CU is 2Nx2N, video encoder 20 and video decoder 30 may support PU sizes of 2Nx2N or NxN for intra prediction, and symmetric PU sizes of 2Nx2N, 2NxN, Nx2N, NxN, or similar for inter prediction. Video encoder 20 and video decoder 30 may also support asymmetric partitioning for PU sizes of 2NxnU, 2NxnD, nLx2N, and nRx2N for inter prediction. In some examples, prediction module 100 may perform geometric partitioning to partition the video block of a CU among PUs of the CU along a boundary that does not meet the sides of the video block of the CU at right angles.

[0104] Inter prediction module 121 may perform inter prediction on each PU of the CU. Inter prediction may provide temporal compression. When inter prediction module 121 performs inter prediction on a PU, inter prediction module 121 may generate predictive data for the PU. The predictive data for the PU may include a predictive video block that corresponds to the PU and motion information for the PU. Motion estimation module 122 may generate the motion information for the PU. In some instances, motion estimation module 122 may use merge mode or AMVP mode to signal the motion information of the PU. Motion compensation module 124 may generate the predictive video block of the PU based on samples of one or more pictures other than the current picture (i.e., reference pictures).

[0105] Slices may be I slices, P slices, or B slices. Motion estimation module 122 and motion compensation module 124 may perform different operations for a PU of a CU depending on whether the PU is in an I slice, a P slice, or a B slice. In an I slice, all PUs are intra predicted. Hence, if the PU is in an I slice, motion estimation module 122 and motion compensation module 124 do not perform inter prediction on the PU.

[0106] If the PU is in a P slice, the picture containing the PU is associated with a list of reference pictures referred to as "list 0." In some examples, each reference picture listed in list 0 occurs before the current picture in display order. Each of the reference pictures in list 0 contains samples that may be used for inter prediction of other pictures. When motion estimation module 122 performs the motion estimation operation with regard to a PU in a P slice, motion estimation module 122 may search the reference pictures in list 0 for a reference block for the PU. The reference block of the PU may be a set of samples, e.g., a block of samples, that most closely corresponds to the samples in the video block of the PU. Motion estimation module 122 may use a variety of metrics to determine how closely a set of samples in a reference picture corresponds to the samples in the video block of a PU. For example, motion estimation module 122 may determine how closely a set of samples in a reference picture corresponds to the samples in the video block of a PU by sum of absolute difference (SAD), sum of square difference (SSD), or other difference metrics.

[0107] After identifying or synthesizing a reference block of a PU in a P slice, motion estimation module 122 may generate a reference picture index that indicates the reference picture in list 0 containing the reference block and a motion vector that indicates a spatial displacement between the PU and the reference block. Motion estimation module 122 may generate motion vectors to varying degrees of precision. For example, motion estimation module 122 may generate motion vectors at one-quarter sample precision, one-eighth sample precision, or other fractional sample precision. In the case of fractional sample precision, reference block values may be interpolated from integer-position sample values in the reference picture. Motion estimation module 122 may output the reference picture index and the motion vector as the motion information of the PU. Motion compensation module 124 may generate a predictive video block of the PU based on the reference block associated with the motion information of the PU.

[0108] If the PU is in a B slice, the picture containing the PU may be associated with two lists of reference pictures, referred to as "list 0" and "list 1." In some examples, a picture containing a B slice may be associated with a list combination that is a combination of list 0 and list 1. In some examples, each reference picture listed in list 1 occurs after the current picture in display order.

[0109] Furthermore, if the PU is in a B slice, motion estimation module 122 may perform uni-directional inter prediction or bi-directional inter prediction for the PU. When motion estimation module 122 performs uni-directional inter prediction for the PU, motion estimation module 122 may search the reference pictures of list 0 or list 1 for a reference block for the PU. Motion estimation module 122 may then generate a reference picture index that indicates the reference picture in list 0 or list 1 that contains the reference block and a motion vector that indicates a spatial displacement between the PU and the reference block.

[0110] When motion estimation module 122 performs bi-directional inter prediction for a PU, motion estimation module 122 may search the reference pictures in list 0 for a reference block for the PU and may also search the reference pictures in list 1 for another reference block for the PU. Motion estimation module 122 may then generate reference picture indexes that indicate the reference pictures in list 0 and list 1 containing the reference blocks and motion vectors that indicate spatial displacements between the reference blocks and the PU. The motion information of the PU may include the reference picture indexes and the motion vectors of the PU. Motion compensation module 124 may generate the predictive video block of the PU based on the reference blocks indicated by the motion information of the PU.

[0111] Motion compensation module 124 may generate the predictive video block of the PU based on one or more reference blocks associated with the motion information of the PU. In accordance with the techniques of this disclosure, motion compensation module 124 may determine whether the PU is restricted to uni-directional inter prediction. In addition, motion compensation module 124 may generate a merge candidate list for the PU and determine a selected merge candidate in the merge candidate list. If the PU is restricted to uni-directional inter prediction, motion compensation module 124 may generate the predictive video block for the PU based on no more than one reference block associated with the motion information specified by the selected merge candidate. If the PU is not restricted to uni-directional inter prediction, motion compensation module 124 may generate the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

[0112] As part of performing an encoding operation on a CU, intra prediction module 126 may perform intra prediction on PUs of the CU. Intra prediction may provide spatial compression. When intra prediction module 126 performs intra prediction on a

PU, intra prediction module 126 may generate prediction data for the PU based on decoded samples of other PUs in the same picture. The prediction data for the PU may include a predictive video block and various syntax elements. Intra prediction module 126 may perform intra prediction on PUs in I slices, P slices, and B slices.

[0113] To perform intra prediction on a PU, intra prediction module 126 may use multiple intra prediction modes to generate multiple sets of prediction data for the PU. When intra prediction module 126 uses an intra prediction mode to generate a set of prediction data for the PU, intra prediction module 126 may extend samples from video blocks of neighboring PUs across the video block of the PU in a direction and/or gradient associated with the intra prediction mode. The neighboring PUs may be above, above and to the right, above and to the left, or to the left of the PU, assuming a left-to-right, top-to-bottom encoding order for PUs, CUs, and treeblocks. Intra prediction module 126 may use various numbers of intra prediction modes, e.g., 33 directional intra prediction modes. In some examples, the number of intra prediction modes may depend on the size of the PU.

[0114] Prediction module 100 may select the prediction data for a PU from among the prediction data generated by motion compensation module 124 for the PU or the prediction data generated by intra prediction module 126 for the PU. In some examples, prediction module 100 selects the prediction data for the PU based on rate/distortion metrics of the sets of prediction data.

[0115] If prediction module 100 selects prediction data generated by intra prediction module 126, prediction module 100 may signal the intra prediction mode that was used to generate the prediction data for the PUs, i.e., the selected intra prediction mode. Prediction module 100 may signal the selected intra prediction mode in various ways. For example, it is probable the selected intra prediction mode is the same as the intra prediction mode of a neighboring PU. In other words, the intra prediction mode of the neighboring PU may be the most probable mode for the current PU. Thus, prediction module 100 may generate a syntax element to indicate that the selected intra prediction mode is the same as the intra prediction mode of the neighboring PU.

[0116] After prediction module 100 selects the prediction data for PUs of a CU, residual generation module 102 may generate residual data for the CU by subtracting the predictive video blocks of the PUs of the CU from the video block of the CU. The residual data of a CU may include 2D residual video blocks that correspond to different sample components of the samples in the video block of the CU. For example, the residual data may include a residual video block that corresponds to differences between luminance components of samples in the predictive video blocks of the PUs of the CU and luminance components of samples in the original video block of the CU. In addition, the residual data of the CU may include residual video blocks that correspond to the differences between chrominance components of samples in the predictive video blocks of the PUs of the CU and the chrominance components of the samples in the original video block of the CU.

[0117] Prediction module 100 may perform quadtree partitioning to partition the residual video blocks of a CU into sub-blocks. Each undivided residual video block may be associated with a different TU of the CU. The sizes and positions of the residual video blocks associated with TUs of a CU may or may not be based on the sizes and positions of video blocks associated with the PUs of the CU. A quadtree structure known as a “residual quad tree” (RQT) may include nodes associated with each of the residual video blocks. The TUs of a CU may correspond to leaf nodes of the RQT.

[0118] Transform module 104 may generate one or more transform coefficient blocks for each TU of a CU by applying one or more transforms to a residual video block associated with the TU. Each of the transform coefficient blocks may be a 2D matrix of transform coefficients. Transform module 104 may apply various transforms to the residual video block associated with a TU. For example, transform module 104 may apply a discrete cosine transform (DCT), a directional transform, or a conceptually similar transform to the residual video block associated with a TU.

[0119] After transform module 104 generates a transform coefficient block associated with a TU, quantization module 106 may quantize the transform coefficients in the transform coefficient block. Quantization module 106 may quantize a transform coefficient block associated with a TU of a CU based on a QP value associated with the CU.

[0120] Video encoder 20 may associate a QP value with a CU in various ways. For example, video encoder 20 may perform a rate-distortion analysis on a treeblock associated with the CU. In the rate-distortion analysis, video encoder 20 may generate multiple coded representations of the treeblock by performing an encoding operation multiple times on the treeblock. Video encoder 20 may associate different QP values with the CU when video encoder 20 generates different encoded representations of the treeblock. Video encoder 20 may signal that a given QP value is associated with the

CU when the given QP value is associated with the CU in a coded representation of the treeblock that has a lowest bitrate and distortion metric.

[0121] Inverse quantization module 108 and inverse transform module 110 may apply inverse quantization and inverse transforms to the transform coefficient block, respectively, to reconstruct a residual video block from the transform coefficient block. Reconstruction module 112 may add the reconstructed residual video block to corresponding samples from one or more predictive video blocks generated by prediction module 100 to produce a reconstructed video block associated with a TU. By reconstructing video blocks for each TU of a CU in this way, video encoder 20 may reconstruct the video block of the CU.

[0122] After reconstruction module 112, represented as a summer, reconstructs the video block of a CU, filter module 113 may perform a deblocking operation to reduce blocking artifacts in the video block associated with the CU. After performing the one or more deblocking operations, filter module 113 may store the reconstructed video block of the CU in decoded picture buffer 114. Motion estimation module 122 and motion compensation module 124 may use a reference picture that contains the reconstructed video block to perform inter prediction on PUs of subsequent pictures. In addition, intra prediction module 126 may use reconstructed video blocks in decoded picture buffer 114 to perform intra prediction on other PUs in the same picture as the CU.

[0123] Entropy encoding module 116 may receive data from other functional components of video encoder 20. For example, entropy encoding module 116 may receive transform coefficient blocks from quantization module 106 and may receive syntax elements from prediction module 100. When entropy encoding module 116 receives the data, entropy encoding module 116 may perform one or more entropy encoding operations to generate entropy encoded data. For example, video encoder 20 may perform a context adaptive variable length coding (CAVLC) operation, a CABAC operation, a variable-to-variable (V2V) length coding operation, a syntax-based context-adaptive binary arithmetic coding (SBAC) operation, a Probability Interval Partitioning Entropy (PIPE) coding operation, or another type of entropy encoding operation on the data. Entropy encoding module 116 may output a bitstream that includes the entropy encoded data.

[0124] As part of performing an entropy encoding operation on data, entropy encoding module 116 may select a context model. If entropy encoding module 116 is performing a CABAC operation, the context model may indicate estimates of probabilities of particular bins having particular values. In the context of CABAC, the term “bin” is used to refer to a bit of a binarized version of a syntax element.

[0125] FIG. 3 is a block diagram that illustrates an example video decoder 30 that is configured to implement the techniques of this disclosure. FIG. 3 is provided for purposes of explanation and is not limiting on the techniques as broadly exemplified and described in this disclosure. For purposes of explanation, this disclosure describes video decoder 30 in the context of HEVC coding. However, the techniques of this disclosure may be applicable to other coding standards or methods.

[0126] In the example of FIG. 3, video decoder 30 includes a plurality of functional components. The functional components of video decoder 30 include an entropy decoding module 150, a prediction module 152, an inverse quantization module 154, an inverse transform module 156, a reconstruction module 158, a filter module 159, and a decoded picture buffer 160. Prediction module 152 includes a motion compensation module 162 and an intra prediction module 164. In some examples, video decoder 30 may perform a decoding pass generally reciprocal to the encoding pass described with respect to video encoder 20 of FIG. 2. In other examples, video decoder 30 may include more, fewer, or different functional components.

[0127] Video decoder 30 may receive a bitstream that comprises encoded video data. The bitstream may include a plurality of syntax elements. When video decoder 30 receives the bitstream, entropy decoding module 150 may perform a parsing operation on the bitstream. As a result of performing the parsing operation on the bitstream, entropy decoding module 150 may extract syntax elements from the bitstream. As part of performing the parsing operation, entropy decoding module 150 may entropy decode entropy encoded syntax elements in the bitstream. Prediction module 152, inverse quantization module 154, inverse transform module 156, reconstruction module 158, and filter module 159 may perform a reconstruction operation that generates decoded video data based on the syntax elements extracted from the bitstream.

[0128] As discussed above, the bitstream may comprise a series of NAL units. The NAL units of the bitstream may include sequence parameter set NAL units, picture parameter set NAL units, SEI NAL units, and so on. As part of performing the parsing operation on the bitstream, entropy decoding module 150 may perform parsing operations that extract and entropy decode sequence parameter sets from sequence parameter set NAL units, picture parameter sets from picture parameter set NAL units, SEI data from SEI NAL units, and so on.

[0129] In addition, the NAL units of the bitstream may include coded slice NAL units. As part of performing the parsing operation on the bitstream, entropy decoding module 150 may perform parsing operations that extract and entropy decode coded slices from the coded slice NAL units. Each of the coded slices may include a slice header and slice data. The slice header may contain syntax elements pertaining to a slice. The syntax elements in the slice header may include a syntax element that identifies a picture parameter set associated with a picture that contains the slice. Entropy decoding module 150 may perform entropy decoding operations, such as CABAC decoding operations, on syntax elements in the coded slice header to recover the slice header.

[0130] As part of extracting the slice data from coded slice NAL units, entropy decoding module 150 may perform parsing operations that extract syntax elements from coded CUs in the slice data. The extracted syntax elements may include syntax elements associated with transform coefficient blocks. Entropy decoding module 150 may then perform CABAC decoding operations on some of the syntax elements.

[0131] After entropy decoding module 150 performs a parsing operation on a non-partitioned CU, video decoder 30 may perform a reconstruction operation on the non-partitioned CU. To perform the reconstruction operation on a non-partitioned CU, video decoder 30 may perform a reconstruction operation on each TU of the CU. By performing the reconstruction operation for each TU of the CU, video decoder 30 may reconstruct a residual video block associated with the CU.

[0132] As part of performing a reconstruction operation on a TU, inverse quantization module 154 may inverse quantize, i.e., de-quantize, a transform coefficient block associated with the TU. Inverse quantization module 154 may inverse quantize the transform coefficient block in a manner similar to the inverse quantization processes proposed for HEVC or defined by the H.264 decoding standard. Inverse quantization module 154 may use a quantization parameter QP calculated by video encoder 20 for a CU of the transform coefficient block to determine a degree of quantization and, likewise, a degree of inverse quantization for inverse quantization module 154 to apply.

[0133] After inverse quantization module 154 inverse quantizes a transform coefficient block, inverse transform module 156 may generate a residual video block for the TU associated with the transform coefficient block. Inverse transform module 156 may apply an inverse transform to the transform coefficient block in order to generate the residual video block for the TU. For example, inverse transform module 156 may apply an inverse DCT, an inverse integer transform, an inverse Karhunen-Loeve transform (KLT), an inverse rotational transform, an inverse directional transform, or another inverse transform to the transform coefficient block.

[0134] In some examples, inverse transform module 156 may determine an inverse transform to apply to the transform coefficient block based on signaling from video encoder 20. In such examples, inverse transform module 156 may determine the inverse transform based on a signaled transform at the root node of a quadtree for a treeblock associated with the transform coefficient block. In other examples, inverse transform module 156 may infer the inverse transform from one or more coding characteristics, such as block size, coding mode, or the like. In some examples, inverse transform module 156 may apply a cascaded inverse transform.

[0135] If a PU is encoded in skip mode or motion information of the PU is encoded using merge mode, motion compensation module 162 may generate a merge candidate list for the PU. Motion compensation module 162 may then identify a selected merge candidate in the merge candidate list. After identifying the selected merge candidate in the merge candidate list, motion compensation module 162 may generate a predictive video block for the PU based on the one or more reference blocks associated with the motion information indicated by the selected merge candidate.

[0136] In accordance with the techniques of this disclosure, motion compensation module 162 may determine whether a PU is restricted to uni-directional inter prediction. Furthermore, motion compensation module 162 may generate a merge candidate list for the PU and determine a selected merge candidate in the merge candidate list. If the PU is restricted to uni-directional inter prediction, motion compensation module 162 may generate a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate. Otherwise, if the PU is not restricted to uni-directional inter prediction, motion compensation module 162 may generate the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

[0137] If motion information of a PU is encoded using AMVP mode, motion compensation module 162 may generate a list 0 MV predictor candidate list and/or a list 1 MV predictor candidate list. Motion compensation module 162 may then determine a selected list 0 MV predictor candidate and/or a selected list 1 MV predictor candidate.

Next, motion compensation module 162 may determine a list 0 motion vector for the PU and/or a list 1 motion vector for the PU based on a list 0 MVD, a list 1 MVD, a list 0 motion vector specified by the selected list 0 MV predictor candidate, and/or a list 1 motion vector specified by the selected list 1 MV predictor candidate. Motion compensation module 162 may then generate a predictive video block for the PU based on reference blocks associated with the list 0 motion vector and a list 0 reference picture index and/or a list 1 motion vector and a list 1 reference picture index.

[0138] In some examples, motion compensation module 162 may refine the predictive video block of a PU by performing interpolation based on interpolation filters. Identifiers for interpolation filters to be used for motion compensation with sub-sample precision may be included in the syntax elements. Motion compensation module 162 may use the same interpolation filters used by video encoder 20 during generation of the predictive video block of the PU to calculate interpolated values for sub-integer samples of a reference block. Motion compensation module 162 may determine the interpolation filters used by video encoder 20 according to received syntax information and use the interpolation filters to produce the predictive video block.

[0139] If a PU is encoded using intra prediction, intra prediction module 164 may perform intra prediction to generate a predictive video block for the PU. For example, intra prediction module 164 may determine an intra prediction mode for the PU based on syntax elements in the bitstream. The bitstream may include syntax elements that intra prediction module 164 may use to determine the intra prediction mode of the PU.

[0140] In some instances, the syntax elements may indicate that intra prediction module 164 is to use the intra prediction mode of another PU to determine the intra prediction mode of the current PU. For example, it may be probable that the intra prediction mode of the current PU is the same as the intra prediction mode of a neighboring PU. In other words, the intra prediction mode of the neighboring PU may be the most probable mode for the current PU. Hence, in this example, the bitstream may include a small syntax element that indicates that the intra prediction mode of the PU is the same as the intra prediction mode of the neighboring PU. Intra prediction module 164 may then use the intra prediction mode to generate prediction data (e.g., predictive samples) for the PU based on the video blocks of spatially neighboring PUs.

[0141] Reconstruction module 158 may use the residual video blocks associated with TUs of a CU and the predictive video blocks of the PUs of the CU, i.e., either intra-prediction data or inter-prediction data, as applicable, to reconstruct the video block of the CU. In particular, reconstruction module 158 may add the residual data to the predictive data to reconstruct the coded video data. Thus, video decoder 30 may generate a predictive video block and a residual video block based on syntax elements in the bitstream and may generate a video block based on the predictive video block and the residual video block.

[0142] After reconstruction module 158 reconstructs the video block of the CU, filter module 159 may perform a deblocking operation to reduce blocking artifacts associated with the CU. After filter module 159 performs a deblocking operation to reduce blocking artifacts associated with the CU, video decoder 30 may store the video block of the CU in decoded picture buffer 160. Decoded picture buffer 160 may provide reference pictures for subsequent motion compensation, intra prediction, and presentation on a display device, such as display device 32 of FIG. 1. For instance, video decoder 30 may perform, based on the video blocks in decoded picture buffer 160, intra prediction or inter prediction operations on PUs of other CUs.

[0143] FIG. 4 is a flowchart that illustrates an example motion compensation operation 200. A video coder, such as video encoder 20 or video decoder 30, may perform motion compensation operation 200. The video coder may perform motion compensation operation 200 to generate a predictive video block for a current PU.

[0144] After the video coder starts motion compensation operation 200, the video coder may determine whether the prediction mode for the current PU is skip mode (202). If the prediction mode for the current PU is not skip mode ("NO" of 202), the video coder may determine whether the prediction mode for the current PU is inter mode and that the inter prediction mode of the current PU is merge mode (204). If the prediction mode of the current PU is skip mode ("YES" of 202) or if the prediction mode of the current PU is inter mode and the inter prediction mode of the current PU is merge mode ("YES" of 204), the video coder may generate a merge candidate list for the current PU (206). The merge candidate list may include a plurality of merge candidates. Each of the merge candidates specifies a set of motion information, such as one or more motion vectors, one or more reference picture indexes, a list 0 prediction flag, and a list 1 prediction flag. The merge candidate list may include one or more uni-directional merge candidates or bi-directional merge candidates. In some examples, the video coder may perform the example operation described below with regard to FIG. 6 to generate the merge candidate list.

[0145] After generating the merge candidate list, the video coder may determine a selected merge candidate in the merge candidate list (208). If the video coder is a video encoder, the video coder may select a merge candidate from the merge candidate list based on a rate-distortion analysis. If the video coder is a video decoder, the video coder may select the merge candidate based on a syntax element (e.g., merge_idx) that identifies a position of the selected merge candidate in the merge candidate list.

[0146] The video coder may then determine the motion information of the current PU based on the motion information specified by the selected merge candidate (210). The motion information may include one or more motion vectors and reference picture indexes. The video coder may determine the motion information of the current PU based on the motion information specified by the selected merge candidate in various ways. For example, the video coder may determine that the motion information of the current PU is the same as the motion information specified by the selected merge candidate.

[0147] If the inter prediction mode for the current PU is not merge mode ("NO" of 204), the video coder may determine the motion information of the current PU using AMVP mode (212). FIG. 8, described in detail below, is a flowchart that illustrates an example operation for determining the motion information of a PU using AMVP mode.

[0148] After determining the motion information of the current PU, the video coder may determine whether the current PU is restricted to uni-directional inter prediction (214). The video coder may determine whether the current PU is restricted to uni-directional inter prediction in various ways. For example, the video coder may determine that the current PU is restricted to uni-directional inter prediction if a size characteristic of the current PU is less than a threshold. In this example, the video coder may determine that the current PU is restricted to uni-directional inter prediction if the size of the PU is 8x4, 4x8, or smaller. In another example, if the video coder is a video decoder, the video decoder may determine based on a syntax element in the received bitstream that the current PU is restricted to uni-directional inter prediction.

[0149] In response to determining that the current PU is restricted to uni-directional inter prediction ("YES" of 214), the video coder may generate a predictive video block for the current PU based on no more than one reference block associated with the motion information of the current PU (216). As indicated above, the reference block may be identified by the motion information specified by the selected merge candidate or synthesized from reference samples identified by the motion information specified by the selected merge candidate.

[0150] On the other hand, in response to determining that the current PU is not restricted to uni-directional inter prediction (“NO” of 214), the video coder may generate a predictive video block for the current PU based on one or more reference blocks associated with the motion information of the current PU (218). As indicated above, the one or more reference blocks may be identified by the motion information specified by the selected merge candidate and/or synthesized from reference samples identified by the motion information specified by the selected merge candidate.

[0151] FIG. 5 is a flowchart that illustrates another example motion compensation operation 270. A video coder, such as video encoder 20 or video decoder 30, may perform motion compensation operation 270 to generate a predictive video block for a current PU. The video coder may perform motion compensation operation 270 as an alternative to performing motion compensation operation 200.

[0152] After the video coder starts motion operation 270, the video coder may determine whether the prediction mode for the current PU is skip mode (272). If the prediction mode for the current PU is not skip mode (“NO” of 272), the video coder may determine whether the prediction mode for the current PU is inter mode and that the inter prediction mode of the current PU is merge mode (273). If the prediction mode of the current PU is skip mode (“YES” of 272) or if the prediction mode of the current PU is inter mode and the inter prediction mode of the current PU is merge mode (“YES” of 273), the video coder may determine whether the current PU is restricted to uni-directional inter prediction (274). If the current PU is restricted to uni-directional inter prediction (“YES” of 274), the video coder may generate a merge candidate list for the current PU such that the merge candidate list does not include bi-directional merge candidates (276). The video coder may use the example operation illustrated in FIG. 6 to generate the merge candidate list for the current PU.

[0153] On the other hand, if the current PU is not restricted to uni-directional inter prediction (“NO” of 274), the video coder may generate a merge candidate list that may include uni-directional and bi-directional merge candidates (278). In some examples, the video coder may perform the example operation described below with regard to FIG. 6 to generate the merge candidate list. Hence, if the current PU is not restricted to uni-directional inter prediction, the merge candidate list may include uni-directional merge candidates and bi-directional merge candidates.

[0154] After generating the merge candidate list for the current PU, the video coder may determine a selected merge candidate in the merge candidate list (280). If the video coder is a video encoder, the video coder may select a merge candidate from the merge candidate list based on a rate-distortion analysis. If the video coder is a video decoder, the video coder may select the merge candidate based on a syntax element (e.g., merge_idx) that identifies a position of the selected merge candidate in the merge candidate list.

[0155] The video coder may then determine the motion information of the current PU based on the motion information specified by the selected merge candidate (282). The motion information specified by the selected merge candidate may specify one or more motion vectors and one or more reference picture indexes. The video coder may determine the motion information of the current PU based on the motion information specified by the selected merge candidate in various ways. For example, the video coder may determine that the motion information of the current PU is the same as the motion information specified by the selected merge candidate.

[0156] If the inter prediction mode for the current PU is not merge mode ("NO" of 273), the video coder may determine the motion information of the current PU using AMVP mode (284). FIG. 8, described in detail below, is a flowchart that illustrates an example operation for determining the motion information of a PU using AMVP mode.

[0157] After determining the motion information of the current PU, the video coder may generate a predictive video block for the current PU (286). Because the merge candidate list includes only uni-directional merge candidates if the current PU is restricted to uni-directional inter prediction, the selected merge candidate is associated with only a single reference block. Hence, if the current PU is in a B slice and is restricted to uni-directional inter prediction, the predictive video block for the current PU may be based on no more than one reference block associated with the motion information specified by the selected merge candidate.

[0158] On the other hand, if the current PU is not restricted to uni-directional inter prediction, the merge candidate list may include uni-directional merge candidates and bi-directional merge candidates. Because the merge candidate list may include uni-directional merge candidates and bi-directional merge candidates, the selected merge candidate may be associated with one or two reference blocks. Hence, if the current PU is in a B slice and is not restricted to uni-directional inter prediction, the predictive video block for the current PU may be based on one or more reference blocks associated with the selected merge candidate.

[0159] FIG. 6 is a flowchart that illustrates an example operation 300 for generating a merge candidate list. A video coder, such as video encoder 20 or video decoder 30, may perform operation 300 to generate a merge candidate list for a current PU. The video coder may perform operation 300 when the prediction mode of the current PU is skip mode or when the prediction mode of the current PU is inter mode and the inter prediction mode of the current PU is merge mode.

[0160] After the video coder starts operation 300, the video coder may determine motion information and availabilities of spatial merge candidates (302). The video coder may determine the motion information of a spatial merge candidate based on the motion information of a PU that covers a location that spatially neighbors the current PU. For example, the video coder may determine the motion information of the spatial merge candidates based on the motion information of PUs that cover locations left, below-left, above-left, above, and above-right of the current PU.

[0161] The video coder may determine the availability of a spatial merge candidate in various ways. For example, the video coder may determine that a spatial merge candidate is unavailable if the spatial merge candidate corresponds to a PU that is intra predicted, located outside the current frame, or located outside the current slice. Furthermore, the video coder may determine that a spatial merge candidate is unavailable if the motion information of the spatial merge candidate is the same as the motion information of another spatial merge candidate.

[0162] In addition, the video coder may determine motion information and the availability of a temporal merge candidate (304). The temporal merge candidate may specify the motion information of a PU that is collocated with the current PU, but is in a different picture than the current PU. The video coder may determine the availability of the temporal merge candidate in various ways. For example, the video coder may determine that the temporal merge candidate is unavailable if the temporal merge candidate corresponds to a PU that is intra predicted.

[0163] After generating the spatial merge candidates and the temporal merge candidate, the video coder may include available ones of the spatial merge candidates and the temporal merge candidate in the merge candidate list for the current PU (306). The video coder may include a spatial or temporal merge candidate in the merge candidate list if the merge candidate is available and may exclude the merge candidate from the merge candidate list if the merge candidate is unavailable. By excluding unavailable merge candidates from the merge candidate list, the video coder may, in effect, perform a pruning process that prunes (e.g., omits) unavailable merge candidates from the merge candidate list.

[0164] In some examples, the video coder generates the merge candidate list such that the merge candidate list only includes uni-directional merge candidates. In some such examples, the video coder may determine that bi-directional merge candidates are unavailable. That is, the video coder may determine that a merge candidate is unavailable if the merge candidate specifies a list 0 motion vector and a list 1 motion vector. Hence, if the current PU is restricted to uni-directional prediction, the video coder may determine that uni-directional merge candidates are available, but not bi-directional merge candidates. Because the video coder may not include unavailable merge candidates in the merge candidate list, the merge candidate list may, in some examples, only include uni-directional merge candidates. In this example, the video coder may, in effect, perform a pruning process that prunes bi-directional merge candidates from the merge list.

[0165] In other examples where the video coder generates the merge candidate list such that the merge candidate list only includes uni-directional merge candidates, the video coder may convert bi-directional merge candidates to uni-directional candidates and then include available ones of the uni-directional merge candidates in the merge candidate list. In such examples, the video coder may not add a uni-directional merge candidate to the merge candidate list if the uni-directional merge candidate is the same as a uni-directional merge candidate that is already added to the merge candidate list. In this way, the video coder may prune duplicate uni-directional merge candidates from the merge candidate list. By converting bi-directional merge candidates to uni-directional merge candidates before pruning duplicate uni-directional merge candidates from the merge candidate list, the video coder may be able to avoid redundant merge candidates in the merge candidate list after pruning. Converting bi-directional merge candidates to uni-directional merge candidates before pruning duplicate uni-directional merge candidates may increase the hardware complexity of the video coder. In addition, the video coder may convert multiple bi-directional merge candidates that are the same to uni-directional merge candidates.

[0166] In other examples, the video coder may initially include available bi-directional merge candidates in the merge candidate list for the current PU. The video coder may then prune duplicate merge candidates from the merge candidate list. After the video coder has generated the merge candidate list, the video coder may determine the selected merge candidate from the merge candidate list and convert the selected merge candidate to a uni-directional merge candidate if the selected merge candidate is a bi-directional merge candidate. In this example, the video coder may effectively convert the selected bi-directional merge candidate to a uni-directional merge candidate by using only the reference block indicated by the list 0 motion vector or the list 1 motion vector to generate the predictive video block for the current PU.

[0167] In contrast to converting bi-directional merge candidates to uni-directional merge candidates prior to pruning duplicate merge candidates from the merge candidate list, converting the selected bi-directional merge candidate to a uni-directional merge candidate after pruning duplicate merge candidates from the merge candidate list may only involve a single conversion, as opposed to multiple conversions. For example, if conversion occurs after pruning duplicate merge candidates, the selected merge candidate is the third merge candidate in the merge candidate list, and the third merge candidate is a bi-directional merge candidate, the video coder may only convert the third merge candidate into a uni-directional merge candidate. In this example, if conversion occurs before pruning duplicate merge candidates, the selected merge candidate is the third merge candidate in the merge candidate list, and the third merge candidate is a bi-directional merge candidate, the video coder may have to convert three bi-directional merge candidates before the video coder is able to determine the selected merge candidate due to performing the pruning operation after the conversion.

[0168] The video coder may generate different merge candidate lists depending on whether the video coder converts bi-directional merge candidates to uni-directional merge candidates before or after pruning duplicate merge candidates from the merge candidate list. For example, the video coder may convert bi-directional merge candidates to uni-directional merge candidates by taking the list 0 motion vectors of the bi-directional merge candidates and ignoring the list 1 motion vectors of the bi-directional merge candidates. In this example, a first merge candidate may be uni-directional and may specify a list 0 motion vector that is equal to a value MV1. In this example, a second merge candidate may be bi-directional and may specify a list 0 motion vector that is the equal to MV1 and a list 1 motion vector that is equal to a value MV2. The first and second merge candidates may specify the same list 0 reference picture indexes. In this example, if the video coder converts the second merge candidate to a uni-directional merge candidate before pruning duplicate merge candidates from the merge candidate list, there may be two uni-directional merge candidates that are equal to MV1. Accordingly, the video coder may prune the uni-directional merge candidate generated from the second merge candidate because it is redundant over the first merge candidate. As a result, the video coder may include only one merge candidate (e.g., the first merge candidate) in the merge candidate list.

[0169] However, in the example of the previous paragraph, if the video coder converts the second merge candidate to a uni-directional merge candidate after pruning duplicate merge candidates from the merge candidate list, the video coder may include both the first and second merge candidates in the merge candidate list. After including the first and second merge candidates in the merge candidate list, the video coder may convert the second merge candidate into a uni-directional merge candidate by taking (i.e., keeping) the second merge candidate's list 0 motion vector and ignoring the second merge candidate's list 1 motion vector. Thus, the merge candidate list may, in effect, include two merge candidates, both of which specify list 0 motion vectors that are equal to MV1.

[0170] After including the available merge candidates in the merge candidate list, the video coder may determine whether the current PU is in a B slice (308). In response to determining that the current PU is in a B slice ("YES" of 308), the video coder may perform a process that generates zero or more artificial merge candidates and includes the artificial merge candidates in the merge candidate list (310). FIG. 7, described in detail below, illustrates an example process for generating artificial merge candidates.

[0171] In response to determining that the current PU is not in a B slice ("NO" of 308) or after performing the process that generates artificial merge candidates, the video coder may determine whether the number of merge candidates in the merge candidate list is less than the maximum number of merge candidates (312). If the number of merge candidates in the merge candidate list is not less than the maximum number of merge candidates ("NO" of 312), the video coder has finished generating the merge candidate list.

[0172] However, in response to determining that the number of merge candidates in the merge candidate list is less than the maximum number of merge candidates ("YES" of 312), the video coder may generate a zero-value merge candidate (314). If the current PU is in a P slice, the zero-value merge candidate may specify a list 0 motion vector that has a magnitude equal to zero. If the current PU is in a B slice and the current PU is not restricted to uni-directional inter prediction, the zero-value merge candidate may specify a list 0 motion vector that has a magnitude equal to zero and a list 1 motion vector that has a magnitude equal to zero. In some examples, the zero-value merge candidate may specify either a list 0 motion vector or a list 1 motion vector that has a magnitude equal to zero if the current PU is in a B slice and the current PU is restricted to uni-directional inter prediction. The video coder may then include the zero-value merge candidate in the merge candidate list (316).

[0173] After including the zero-value merge candidate in the merge candidate list, the video coder may again determine whether the number of merge candidates in the merge candidate list is less than the maximum number of merge candidates (312) and, if not, the video coder may generate an additional zero-value merge candidate. In this way, the video coder may continue generating zero-value merge candidates and including the zero-value merge candidates in the merge candidate list until the number of merge candidates in the merge candidate list is equal to the maximum number of merge candidates.

[0174] FIG. 7 is a flowchart that illustrates an example process 350 for generating artificial merge candidates. A video coder, such as video encoder 20 or video decoder 30, may perform process 350 to generate artificial merge candidates for inclusion in a merge candidate list for a current PU.

[0175] After the video coder starts process 350, the video coder may determine whether to generate an artificial merge candidate (352). The video coder may determine whether to generate an artificial merge candidate in various ways. For example, the video coder may determine whether the number of artificial merge candidates in the merge candidate list is equal to the total number of unique artificial candidates that can be generated based on the original merge candidates in the merge candidate list. The original merge candidates may be merge candidates that specify the motion information of PUs other than the current PU. Furthermore, in this example, the video coder may determine whether the merge candidate list includes a maximum number of merge candidates. In this example, if both of these conditions are false, the video coder may make the determination to generate an artificial merge candidate.

[0176] If the video coder makes the determination to generate an artificial merge candidate ("YES" of 352), the video coder may determine whether the current PU is restricted to uni-directional inter prediction (354). As described above, the video coder may determine whether the current PU is restricted to uni-directional inter prediction in various ways. For example, the video coder may determine whether the current PU is restricted to uni-directional inter prediction based on a size characteristic of the current PU. In another example, the video coder may determine whether the current PU is restricted to uni-directional inter prediction based on a parameter indicated in the syntax elements of the current treeblock, current CU or current PU, or in a slice header, a PPS, an APS, an SPS, or in another parameter set. In some examples, a parameter in a treeblock may specify that all PUs associated with the treeblock are restricted to uni-directional inter prediction. In some examples, a parameter in a CU may specify that all PUs associated with the CU are restricted to uni-directional inter prediction. In some examples, a parameter in a PPS may specify that all PUs associated with pictures associated with the PPS are restricted to uni-directional inter prediction. In some examples, a parameter in an APS may specify that all PUs associated with pictures associated with the APS are restricted to uni-directional inter prediction. In some examples, a parameter in a SPS may specify that all PUs associated with pictures in a sequence associated with the SPS are restricted to uni-directional inter prediction.

[0177] In response to determining that the current PU is restricted to uni-directional inter prediction ("YES" of 354), the video coder may generate an artificial uni-directional merge candidate (356). After generating the artificial uni-directional merge candidate, the video coder may include the artificial uni-directional merge candidate in the merge candidate list (358). After including the artificial uni-directional merge candidate in the merge candidate list, the video coder may determine whether to generate another artificial merge candidate (352) and, if so, generate another artificial merge candidate.

[0178] The video coder may generate the artificial uni-directional merge candidate in various ways. For example, the video coder may generate the artificial uni-directional merge candidate by first taking a pair of uni-directional merge candidates that are already in the candidate list. The first and second uni-directional merge candidates may specify motion vectors MV1 and MV2, respectively. In this example, the video coder may then scale MV2 according to a temporal difference between the reference frame specified by the first uni-directional merge candidate and the reference frame specified by the second uni-directional merge candidate. In this example, video coder may generate an artificial uni-directional merge candidate that specifies the scaled version of MV2. For instance, in this example, the reference picture associated with the first uni-directional merge candidate may occur one picture after the current picture and the reference picture associated with the second uni-directional merge candidate may occur four pictures after the current picture. In this example, the video coder may divide both the horizontal and vertical components of MV2 by four and use this scaled MV2 with the reference picture index corresponding to MV1 as an artificial candidate. Similar scaling can be performed for MV1 based on MV2.

[0179] In another example, the video coder may generate an artificial uni-directional merge candidate that specifies one of the motion vectors specified by a bi-directional merge candidate. For example, a bi-directional merge candidate may specify a list 0 motion vector and a list 1 motion vector. In this example, the video coder may generate an artificial uni-directional merge candidate that specifies the list 0 motion vector, but does not specify the list 1 motion vector. In this example, the video coder may generate another artificial uni-directional merge candidate that specifies the list 1 motion vector, but does not specify the list 0 motion vector. In this way, the video coder may generate uni-directional artificial merge candidates from a bi-directional spatial or temporal merge candidate by splitting the bi-directional merge candidate into two uni-directional merge candidates, one from a list 0 motion vector and another from the list 1 motion vector. The video encoder may include either or both of the uni-directional merge candidates in the merge candidate list. In other words, the video coder may generate an artificial uni-directional merge candidate such that the artificial uni-directional merge candidate specifies a motion vector specified by the bi-directional merge candidate.

[0180] In examples where the video coder generates artificial uni-directional merge candidates based on motion vectors specified by bi-directional merge candidates, the video coder may add the artificial uni-directional merge candidates to the merge candidate list according to various orders. For example, the video coder may add an artificial uni-directional merge candidate based on a list 0 motion vector of a first bi-directional merge candidate, then add an artificial uni-directional merge candidate based on a list 1 motion vector of the first bi-directional merge candidate, then add an artificial uni-directional merge candidate based on a list 0 motion vector of a second bi-directional merge candidate, then add an artificial uni-directional merge candidate based on a list 1 motion vector of the second bi-directional merge candidate, and so on.

[0181] If the current PU is not restricted to uni-directional inter prediction ("NO" of 354), the video coder may generate an artificial bi-directional merge candidate (360). As mentioned above, the video coder may determine whether the current PU is restricted to uni-directional inter prediction based on various factors, such as a size characteristic of the PU, a parameter, etc. The video coder may generate the artificial bi-directional merge candidate in various ways. For example, the video coder may select a combination of two merge candidates in the merge candidate list. In this example, the video coder may determine whether the first one of the selected merge candidates specifies a reference picture in list 0, whether the second one of the selected merge candidates specifies a reference picture in list 1, and whether the specified reference pictures have different picture order counts. If each of these conditions is true, the video coder may generate an artificial bi-directional merge candidate that specifies the list 0 motion vector of the first merge candidate in the combination and the list 1 motion vector of the second merge candidate in the combination. In some examples, such as the example of FIG. 4, where the merge candidate list may include uni-directional merge candidates and bi-directional merge candidates, process 350 does not include acts 354, 356, and 358. Rather, the video coder may generate artificial bi-directional merge candidates in the merge candidate lists for PUs in B slices.

[0182] After generating the artificial bi-directional merge candidate, the video coder may include the artificial bi-directional merge candidate in the merge candidate list for the current PU (362). The video coder may then determine whether to generate another artificial merge candidate (352), and so on.

[0183] FIG. 8 is a flowchart that illustrates an example operation 400 for determining the motion information of a PU using AMVP mode. A video coder, such as video encoder 20 or video decoder 30, may perform operation 400 to determine the motion information of a PU using AMVP mode.

[0184] After the video coder starts operation 400, the video coder may determine whether inter prediction for the current PU is based on list 0 (402). If inter prediction for the current PU is based on list 0 ("YES" of 402), the video coder may generate a list 0 MV predictor candidate list for the current PU (404). The list 0 MV predictor candidate list may include two list 0 MV predictor candidates. Each of the list 0 MV predictor candidates may specify a list 0 motion vector.

[0185] After generating the list 0 MV predictor candidate list, the video coder may determine a selected list 0 MV predictor candidate in the list 0 MV predictor candidate list (406). The video coder may determine the selected list 0 MV predictor candidate based on a list 0 MV predictor flag ("mvp_l0_flag"). The video coder may then determine a list 0 motion vector for the current PU based on the list 0 MVD for the current PU and the list 0 motion vector specified by the selected list 0 MV predictor candidate (408).

[0186] Furthermore, after determining that inter prediction for the current PU is not based on list 0 ("NO" of 402) or after determining the list 0 motion vector for the current PU (408), the video coder may determine whether inter prediction for the current PU is based on list 1 or whether the PU is bi-directionally inter predicted (410). If inter prediction for the current PU is not based on list 1 and the current PU is not bi-directionally inter predicted ("NO" of 410), the video coder has finished determining the motion information of the current PU using AMVP mode. In response to determining that inter prediction for the current PU is based on list 1 or the current PU is bi-directionally inter predicted ("YES" of 410), the video coder may generate a list 1 MV predictor candidate list for the current PU (412). The list 1 MV predictor candidate list may include two list 1 MV predictor candidates. Each of the list 0 MV predictor candidates may specify a list 1 motion vector.

[0187] After generating the list 1 MV predictor candidate list, the video coder may determine a selected list 1 MV predictor candidate in the list 1 MV predictor candidate list (414). The video coder may determine the selected list 1 MV predictor candidate based on a list 1 MV predictor flag ("mvp_l1_flag"). The video coder may then determine a list 1 motion vector for the current PU based on a list 1 MVD for the current PU and the list 1 motion vector specified by the selected list 1 MV predictor candidate (416).

[0188] In some examples, the video coder may not add bi-directional MV predictor candidates to the list 0 and list 1 MV predictor candidate lists. In other words, if a MV predictor candidate specifies a list 0 motion vector and a list 1 motion vector, the video coder may exclude the MV predictor candidate from the list 0 and list 1 MV predictor candidate lists. Rather, the video coder may add only uni-directional MV predictor candidates to the list 0 and list 1 MV predictor candidate lists. The video coder may accomplish this by checking whether each possible and available MV predictor candidate is uni-directional, and only including the uni-directional MV predictor candidates in the MV predictor candidate lists.

[0189] In one or more examples, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted over, as one or more instructions or code, a computer-readable medium and executed by a hardware-based processing unit.

Computer-readable media may include computer-readable storage media, which corresponds to a tangible medium such as data storage media, or communication media including any medium that facilitates transfer of a computer program from one place to another, e.g., according to a communication protocol. In this manner, computer-readable media generally may correspond to (1) tangible computer-readable storage media which is non-transitory or (2) a communication medium such as a signal or carrier wave. Data storage media may be any available media that can be accessed by one or more computers or one or more processors to retrieve instructions, code and/or data structures for implementation of the techniques described in this disclosure. A computer program product may include a computer-readable medium.

[0190] By way of example, and not limitation, such computer-readable storage media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage, or other magnetic storage devices, flash memory, or any other medium that can be used to store desired program code in the form of instructions or data structures and that can be accessed by a computer. Also, any connection is properly termed a computer-readable medium. For example, if instructions are transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. It should be understood, however, that computer-readable storage media and data storage media do not include connections, carrier waves, signals, or other transient media, but are instead directed to non-transient, tangible storage media. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc, where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

[0191] Instructions may be executed by one or more processors, such as one or more digital signal processors (DSPs), general purpose microprocessors, application specific integrated circuits (ASICs), field programmable logic arrays (FPGAs), or other equivalent integrated or discrete logic circuitry. Accordingly, the term "processor," as used herein may refer to any of the foregoing structure or any other structure suitable for implementation of the techniques described herein. In addition, in some aspects, the functionality described herein may be provided within dedicated hardware and/or software modules configured for encoding and decoding, or incorporated in a combined codec. Also, the techniques could be fully implemented in one or more circuits or logic elements.

[0192] The techniques of this disclosure may be implemented in a wide variety of devices or apparatuses, including a wireless handset, an integrated circuit (IC) or a set of ICs (e.g., a chip set). Various components, modules, or units are described in this disclosure to emphasize functional aspects of devices configured to perform the disclosed techniques, but do not necessarily require realization by different hardware or software units. Rather, as described above, various components, modules, and units may be combined in a codec hardware unit or provided by a collection of interoperative hardware units, including one or more processors as described above, in conjunction with suitable software and/or firmware.

[0193] Various examples have been described. These and other examples are within the scope of the following claims.

WHAT IS CLAIMED IS:

1. A method for coding video data, the method comprising:

determining whether a prediction unit (PU) in a B slice is restricted to uni-directional inter prediction;

generating a merge candidate list for the PU;

determining a selected merge candidate in the merge candidate list;

if the PU is restricted to uni-directional inter prediction, generating a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate; and

if the PU is not restricted to uni-directional inter prediction, generating the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

2. The method of claim 1, wherein determining whether the PU is restricted to uni-directional prediction comprises:

determining that the PU is restricted to uni-directional inter prediction if a size characteristic of the PU is below a threshold; and

determining that the PU is not restricted to uni-directional inter prediction if the size characteristic of the PU is not below the threshold.

3. The method of claim 2, wherein determining that the PU is restricted to uni-directional inter prediction if the size characteristic of the PU is below the threshold comprises determining that the PU is restricted to uni-directional inter prediction if a height or a width of a video block associated with the PU is below the threshold.

4. The method of claim 2, wherein determining that the PU is restricted to uni-directional inter prediction if the size characteristic of the PU is below the threshold comprises determining that the PU is restricted to uni-directional inter prediction if a first dimension of a video block associated with the PU is less than a threshold and a second dimension of the video block associated with the PU is less than or equal to the threshold.

5. The method of claim 2, wherein determining that the PU is restricted to uni-directional inter prediction if the size characteristic of the PU is below the threshold comprises determining that the PU is restricted to uni-directional inter prediction if a first dimension of a video block associated with the PU is less than a first threshold and a second dimension of the video block associated with the PU is less than a second threshold.

6. The method of claim 5, wherein the first threshold is the same as the second threshold.

7. The method of claim 2, wherein determining whether the PU is restricted to uni-directional prediction comprises:

determining that the PU is restricted to uni-directional inter prediction if a size characteristic of a coding unit (CU) associated with the PU is less than or equal to a particular size and the size characteristic of the PU is below the threshold, wherein the size characteristic of the CU is a height or a width of a video block associated with the CU; and

determining that the PU is not restricted to uni-directional inter prediction if the size characteristic of the CU is not equal to the particular size and the size characteristic of the PU is not below the threshold.

8. The method of claim 7, wherein the particular size is equal to eight and the threshold is equal to eight.

9. The method of claim 1, further comprising:

after generating the merge candidate list, converting a bi-directional merge candidate in the merge candidate list into a uni-directional merge candidate; and

including the uni-directional merge candidate in the merge candidate list in place of the bi-directional merge candidate.

10. The method of claim 9, wherein converting the bi-directional merge candidate into the uni-directional merge candidate comprises converting the bi-directional merge candidate into the uni-directional merge candidate such that the uni-directional merge candidate is associated with a reference picture in a particular reference picture list, wherein whenever bi-directional merge candidates are converted to uni-directional merge candidates, the uni-directional merge candidates are associated with reference pictures in the particular reference picture list.

11. The method of claim 1, wherein generating the merge candidate list comprises, if the PU is restricted to uni-directional inter prediction, generating the merge candidate list such that the merge candidate list includes only uni-directional merge candidates.

12. The method of claim 11, wherein generating the merge candidate list such that the merge candidate list includes only uni-directional merge candidates comprises:

converting a bi-directional merge candidate into one or more uni-directional merge candidates; and

including either or both of the uni-directional merge candidates in the merge candidate list.

13. The method of claim 12, further comprising pruning duplicate merge candidates before converting the bi-directional merge candidate into the one or more uni-directional merge candidates.

14. The method of claim 12, further comprising pruning duplicate merge candidates after converting the bi-directional merge candidate into the uni-directional merge candidates.

15. The method of claim 12, wherein converting the bi-directional merge candidate into one or more uni-directional merge candidates comprises converting the bi-directional merge candidate into a single uni-directional merge candidate, the single uni-directional merge candidate indicating a reference picture in list 0 or a reference picture in list 1.

16. The method of claim 11, wherein generating the merge candidate list such that the merge candidate list includes only uni-directional merge candidates comprises:

generating an artificial uni-directional merge candidate; and

including the artificial uni-directional merge candidate in the merge candidate list.

17. The method of claim 16, wherein:

the merge candidate list includes a first uni-directional merge candidate and a second uni-directional merge candidate, the first uni-directional merge candidate specifying a first motion vector, the second uni-directional merge candidate specifying a second motion vector; and

generating the artificial uni-directional merge candidate comprises scaling the first motion vector based on a temporal difference between a reference picture specified by the first uni-directional merge candidate and a reference picture specified by the second uni-directional merge candidate.

18. The method of claim 16, wherein generating the artificial uni-directional merge candidate comprises generating the artificial uni-directional merge candidate such that the artificial uni-directional merge candidate specifies a motion vector specified by the bi-directional merge candidate.

19. The method of claim 1, wherein the selected merge candidate is a bi-directional merge candidate.

20. The method of claim 1, wherein determining the selected merge candidate comprises:

parsing from a bitstream a syntax element that indicates a position in the merge candidate list of the selected merge candidate; and

determining the selected merge candidate at the position in the merge candidate list of the selected merge candidate.

21. The method of claim 1, wherein the method comprises generating a bitstream that includes an encoded syntax element that indicates a position in the merge candidate list of the selected merge candidate.

22. The method of claim 1, wherein the method is performed on a mobile computing device.

23. A video coding device that comprises one or more processors configured to:

determine whether a prediction unit (PU) in a B slice is restricted to uni-directional inter prediction;

generate a merge candidate list for the PU;

determine a selected merge candidate in the merge candidate list;

if the PU is restricted to uni-directional inter prediction, generate a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate; and

if the PU is not restricted to uni-directional inter prediction, generate the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

24. The video coding device of claim 23, wherein the one or more processors are configured to:

determine that the PU is restricted to uni-directional inter prediction if a size characteristic of the PU is below a threshold; and

determine that the PU is not restricted to uni-directional inter prediction if the size characteristic of the PU is not below the threshold.

25. The video coding device of claim 24, wherein the one or more processors are configured to determine that the PU is restricted to uni-directional inter prediction if a height or a width of a video block associated with the PU is below the threshold.

26. The video coding device of claim 24, wherein the one or more processors are configured to determine that the PU is restricted to uni-directional inter prediction if a first dimension of a video block associated with the PU is less than a threshold and a second dimension of the video block associated with the PU is less than or equal to the threshold.

27. The video coding device of claim 24, wherein the one or more processors are configured to determine that the PU is restricted to uni-directional inter prediction if a first dimension of a video block associated with the PU is less than a first threshold and a second dimension of the video block associated with the PU is less than a second threshold.

28. The video coding device of claim 27, wherein the first threshold is the same as the second threshold.

29. The video coding device of claim 24, wherein the one or more processors are configured to:

determine that the PU is restricted to uni-directional inter prediction if a size characteristic of a coding unit (CU) associated with the PU is less than or equal to a particular size and the size characteristic of the PU is below the threshold; and

determine that the PU is not restricted to uni-directional inter prediction if the size characteristic of the CU is not equal to the particular size and the size characteristic of the PU is not below the threshold.

30. The video coding device of claim 29, wherein the particular size is equal to eight and the threshold is equal to eight.

31. The video coding device of claim 23, wherein the one or more processors are further configured to:

convert, after generating the merge candidate list, a bi-directional merge candidate in the merge candidate list into a uni-directional merge candidate; and

include the uni-directional merge candidate in the merge candidate list in place of the bi-directional merge candidate.

32. The video coding device of claim 31, wherein the one or more processors are configured to convert the bi-directional merge candidate into the uni-directional merge candidate such that the uni-directional merge candidate is associated with a reference picture in a particular reference picture list, wherein whenever the one or more processors convert bi-directional merge candidates to uni-directional merge candidates, the uni-directional merge candidates are associated with reference pictures in the particular reference picture list.

33. The video coding device of claim 23, wherein the one or more processors are configured to generate the merge candidate list such that, if the PU is restricted to uni-directional inter prediction, the merge candidate list includes only uni-directional merge candidates.

34. The video coding device of claim 33, wherein to generate the merge candidate list such that the merge candidate list includes only uni-directional merge candidates, the one or more processors are configured to:

convert a bi-directional merge candidate into one or more uni-directional merge candidates; and

include either or both of the uni-directional merge candidates in the merge candidate list.

35. The video coding device of claim 34, wherein the one or more processors are configured to prune duplicate merge candidates before converting the bi-directional merge candidate into the one or more uni-directional merge candidates.

36. The video coding device of claim 34, wherein the one or more processors are configured to prune duplicate merge candidates after converting the bi-directional merge candidate into the one or more uni-directional merge candidates.

37. The video coding device of claim 34, the one or more processors are configured to convert the bi-directional merge candidate into a single uni-directional merge candidate, the single uni-directional merge candidate associated with a reference picture in list 0 or a reference picture in list 1.

38. The video coding device of claim 33, wherein to generate the merge candidate list such that the merge candidate list includes only uni-directional merge candidates, the one or more processors are configured to:

generate an artificial uni-directional merge candidate; and

include the artificial uni-directional merge candidate in the merge candidate list.

39. The video coding device of claim 38, wherein:

the merge candidate list includes a first uni-directional merge candidate and a second uni-directional merge candidate, the first uni-directional merge candidate specifying a first motion vector, the second uni-directional merge candidate specifying a second motion vector; and

to generate the artificial uni-directional merge candidate, the one or more processors are configured to scale the first motion vector based on a temporal difference between a reference picture specified by the first uni-directional merge candidate and a reference picture specified by the second uni-directional merge candidate.

40. The video coding device of claim 38, wherein the one or more processors are configured to generate the artificial uni-directional merge candidate such that the artificial uni-directional merge candidate specifies a motion vector specified by a bi-directional merge candidate.

41. The video coding device of claim 23, wherein the selected merge candidate is a bi-directional merge candidate.

42. The video coding device of claim 23, wherein the video coding device decodes video data and the one or more processors are configured to determine the selected merge candidate based on a syntax element that indicates a position in the merge candidate list of the selected merge candidate.

43. The video coding device of claim 23, wherein the video coding device encodes video data and the one or more processors are configured to output a syntax element that indicates a position in the merge candidate list of the selected merge candidate.

44. The video coding device of claim 23, wherein the video coding device is a mobile computing device.

45. A video coding device comprising:

means for determining whether a prediction unit (PU) in a B slice is restricted to uni-directional inter prediction;

means for generating a merge candidate list for the PU;

means for determining a selected merge candidate in the merge candidate list;

means for generating, if the PU is restricted to uni-directional inter prediction, a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate; and

means for generating, if the PU is not restricted to uni-directional inter prediction, the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

46. The video coding device of claim 45, wherein the means for determining whether the PU is restricted to uni-directional prediction comprises:

means for determining that the PU is restricted to uni-directional inter prediction if a size characteristic of the PU is below a threshold; and

means for determining that the PU is not restricted to uni-directional inter prediction if the size characteristic of the PU is not below the threshold.

47. The video coding device of claim 45, wherein the selected merge candidate is a bi-directional merge candidate.

48. A computer program product that comprises one or more computer readable storage media that store instructions that, when executed, configure one or more processors to:

determine whether a prediction unit (PU) in a B slice is restricted to uni-directional inter prediction;

generate a merge candidate list for the PU;

determine a selected merge candidate in the merge candidate list;

if the PU is restricted to uni-directional inter prediction, generate a predictive video block for the PU based on no more than one reference block associated with motion information specified by the selected merge candidate; and

if the PU is not restricted to uni-directional inter prediction, generate the predictive video block for the PU based on one or more reference blocks associated with the motion information specified by the selected merge candidate.

49. The computer program product of claim 48, wherein the instructions configure the one or more processors to:

determine whether the PU is restricted to uni-directional prediction comprises:

determine that the PU is restricted to uni-directional inter prediction if a size characteristic of the PU is below a threshold; and

determine that the PU is not restricted to uni-directional inter prediction if the size characteristic of the PU is not below the threshold.

50. The computer program product of claim 48, wherein the selected merge candidate is a bi-directional merge candidate.

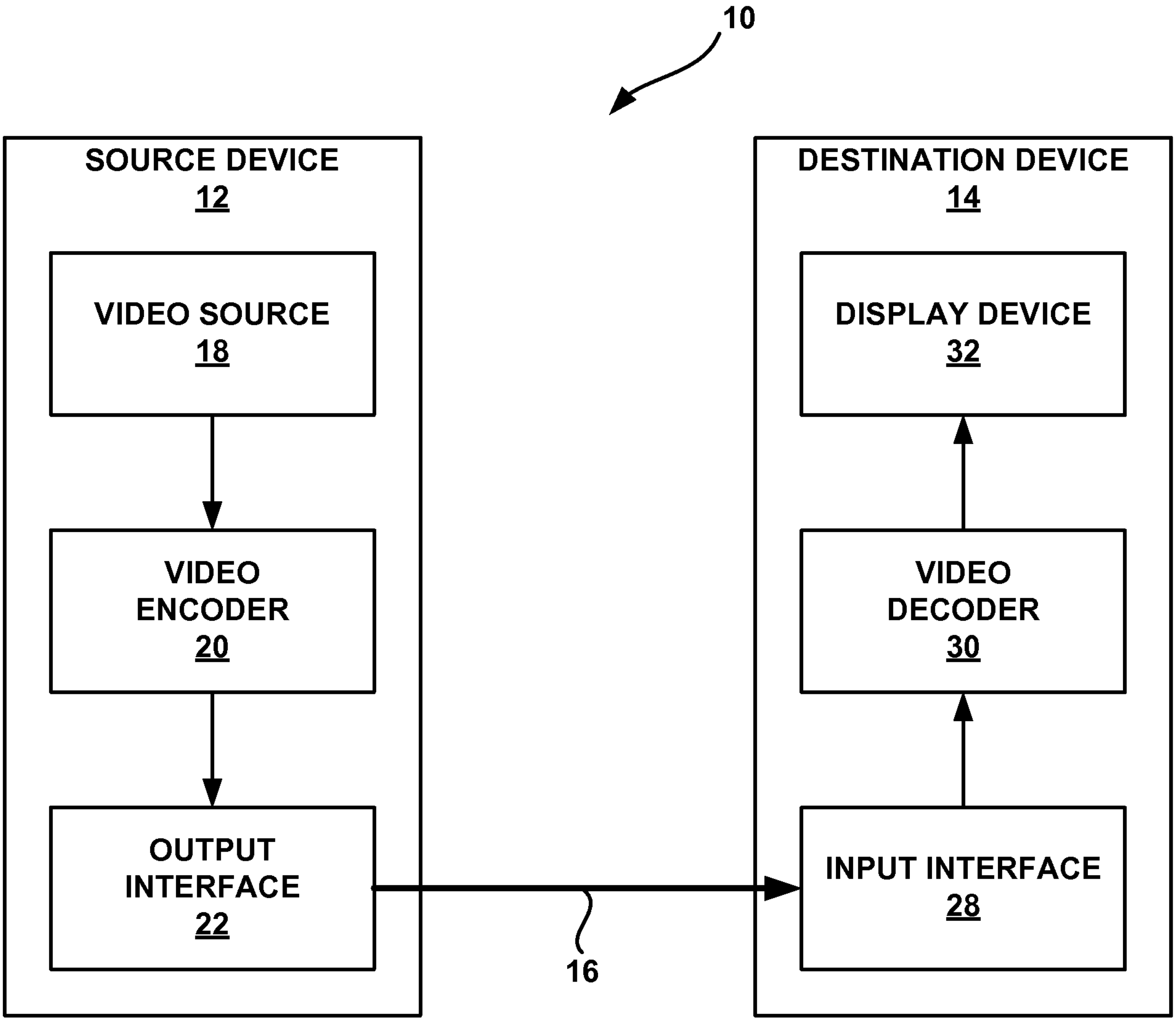
10
SOURCE DEVICE
12
VIDEO SOURCE
18
VIDEO
ENCODER
20
OUTPUT
INTERFACE
22
16
DESTINATION DEVICE
14
DISPLAY DEVICE
32
VIDEO
DECODER
30
INPUT INTERFACE
28

FIG. 1

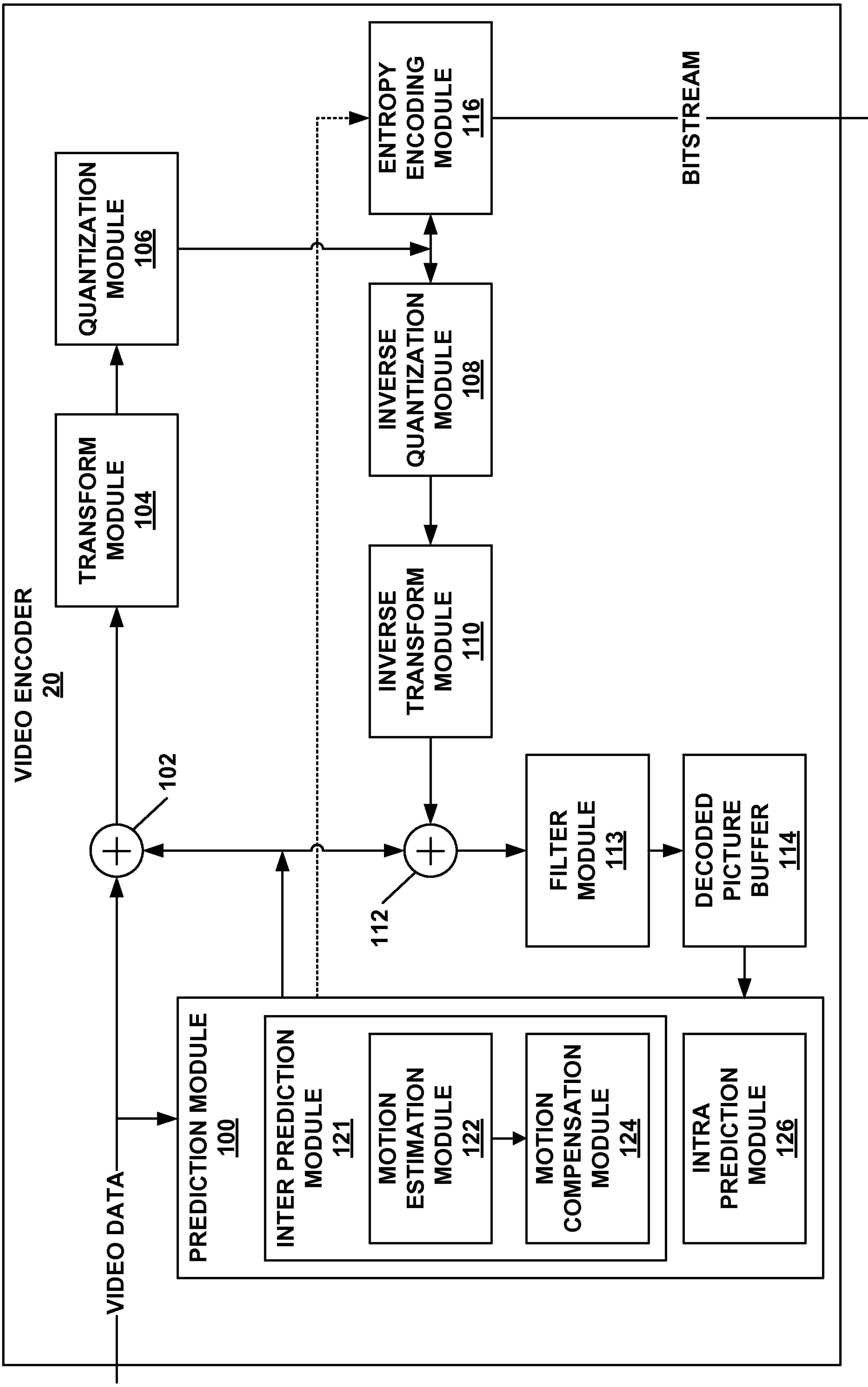
VIDEO ENCODER
20
TRANSFORM MODULE
104
QUANTIZATION MODULE
106
ENTROPY ENCODING MODULE
116
BITSTREAM
INVERSE QUANTIZATION MODULE
108
INVERSE TRANSFORM MODULE
110
102
112
FILTER MODULE
113
DECODED PICTURE BUFFER
114
VIDEO DATA
PREDICTION MODULE
100
INTER PREDICTION MODULE
121
MOTION ESTIMATION MODULE
122
MOTION COMPENSATION MODULE
124
INTRA PREDICTION MODULE
126

FIG. 2

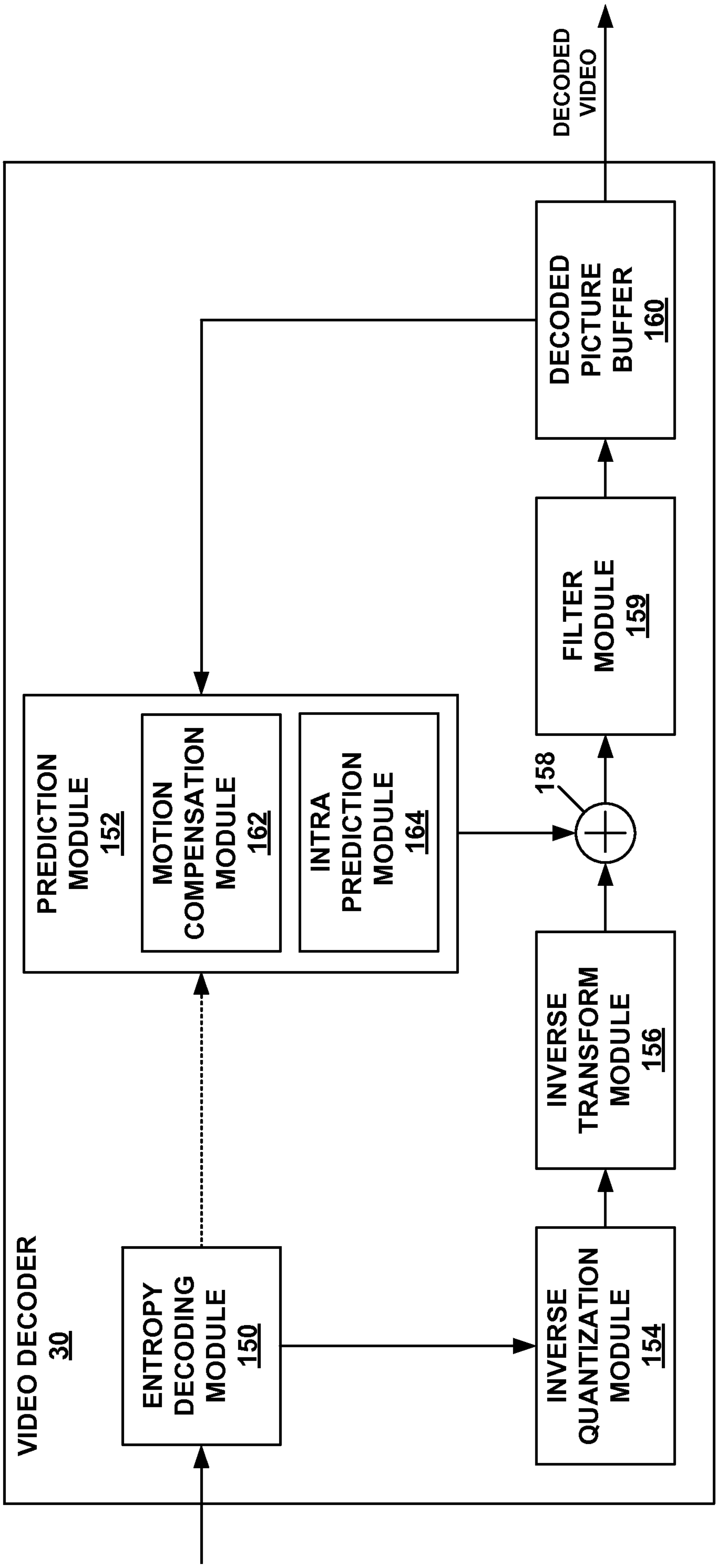
VIDEO DECODER 30
ENTROPY DECODING MODULE 150
PREDICTION MODULE 152
MOTION COMPENSATION MODULE 162
INTRA PREDICTION MODULE 164
INVERSE QUANTIZATION MODULE 154
INVERSE TRANSFORM MODULE 156
158
FILTER MODULE 159
DECODED PICTURE BUFFER 160
DECODED VIDEO

FIG. 3

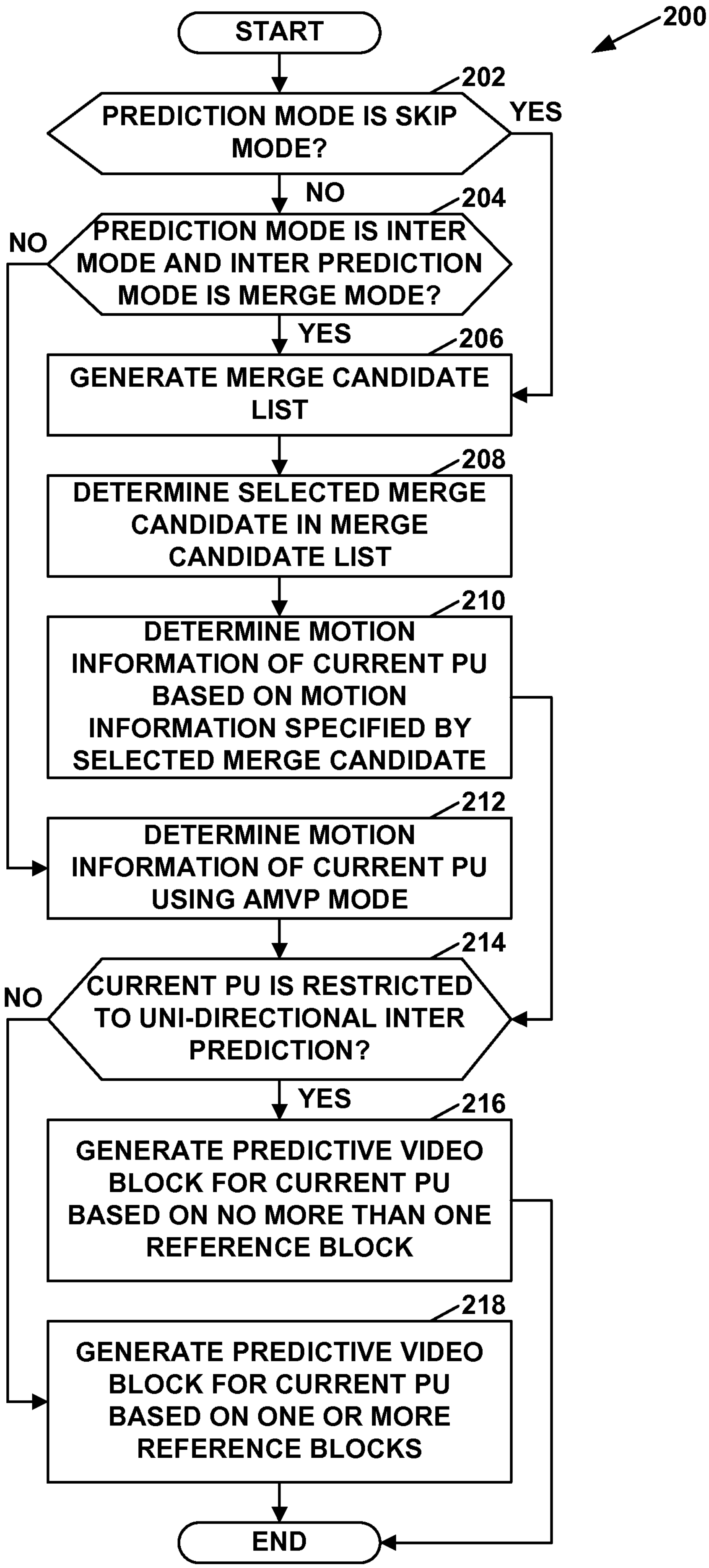
200
START
202
PREDICTION MODE IS SKIP MODE?
YES
NO
204
PREDICTION MODE IS INTER MODE AND INTER PREDICTION MODE IS MERGE MODE?
NO
YES
206
GENERATE MERGE CANDIDATE LIST
208
DETERMINE SELECTED MERGE CANDIDATE IN MERGE CANDIDATE LIST
210
DETERMINE MOTION INFORMATION OF CURRENT PU BASED ON MOTION INFORMATION SPECIFIED BY SELECTED MERGE CANDIDATE
212
DETERMINE MOTION INFORMATION OF CURRENT PU USING AMVP MODE
214
CURRENT PU IS RESTRICTED TO UNI-DIRECTIONAL INTER PREDICTION?
NO
YES
216
GENERATE PREDICTIVE VIDEO BLOCK FOR CURRENT PU BASED ON NO MORE THAN ONE REFERENCE BLOCK
218
GENERATE PREDICTIVE VIDEO BLOCK FOR CURRENT PU BASED ON ONE OR MORE REFERENCE BLOCKS
END

FIG. 4

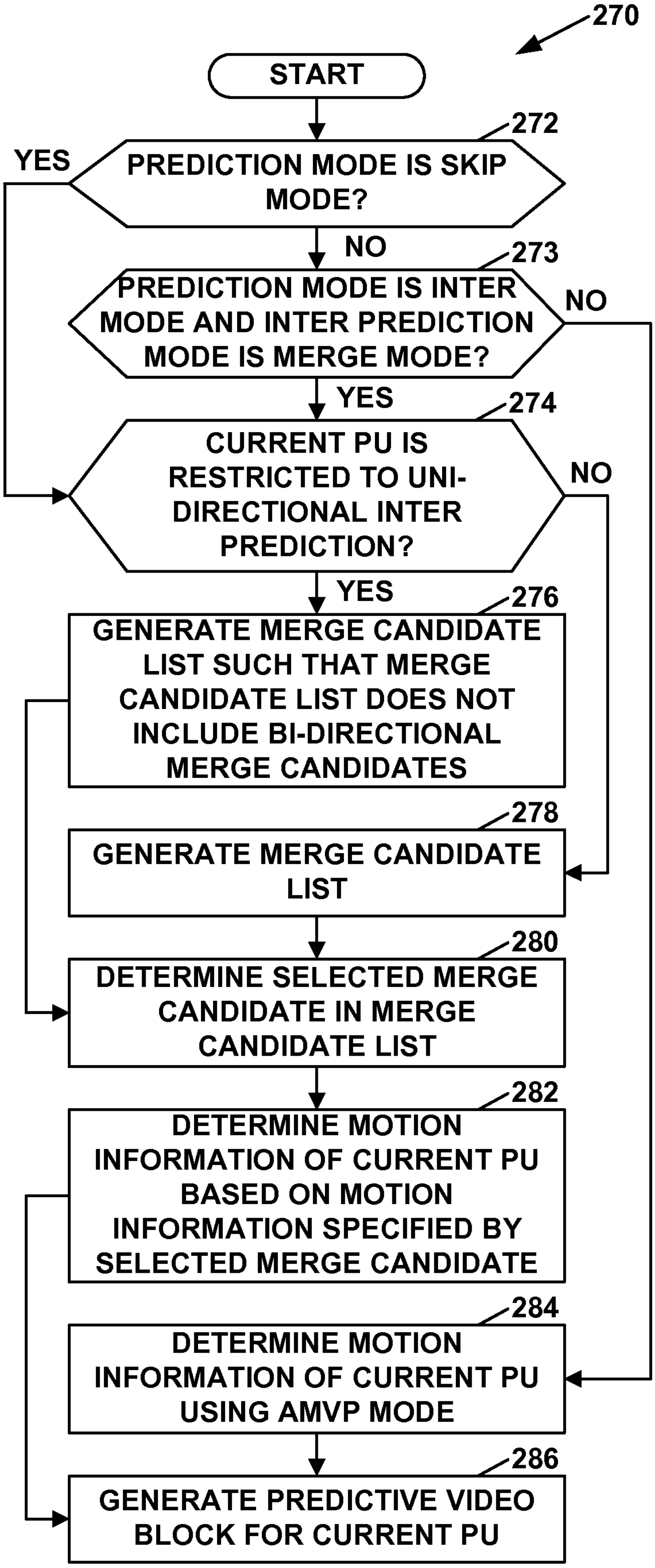
270
START
272
PREDICTION MODE IS SKIP MODE?
YES
NO
273
PREDICTION MODE IS INTER MODE AND INTER PREDICTION MODE IS MERGE MODE?
NO
YES
274
CURRENT PU IS RESTRICTED TO UNI-DIRECTIONAL INTER PREDICTION?
NO
YES
276
GENERATE MERGE CANDIDATE LIST SUCH THAT MERGE CANDIDATE LIST DOES NOT INCLUDE BI-DIRECTIONAL MERGE CANDIDATES
278
GENERATE MERGE CANDIDATE LIST
280
DETERMINE SELECTED MERGE CANDIDATE IN MERGE CANDIDATE LIST
282
DETERMINE MOTION INFORMATION OF CURRENT PU BASED ON MOTION INFORMATION SPECIFIED BY SELECTED MERGE CANDIDATE
284
DETERMINE MOTION INFORMATION OF CURRENT PU USING AMVP MODE
286
GENERATE PREDICTIVE VIDEO BLOCK FOR CURRENT PU

FIG. 5

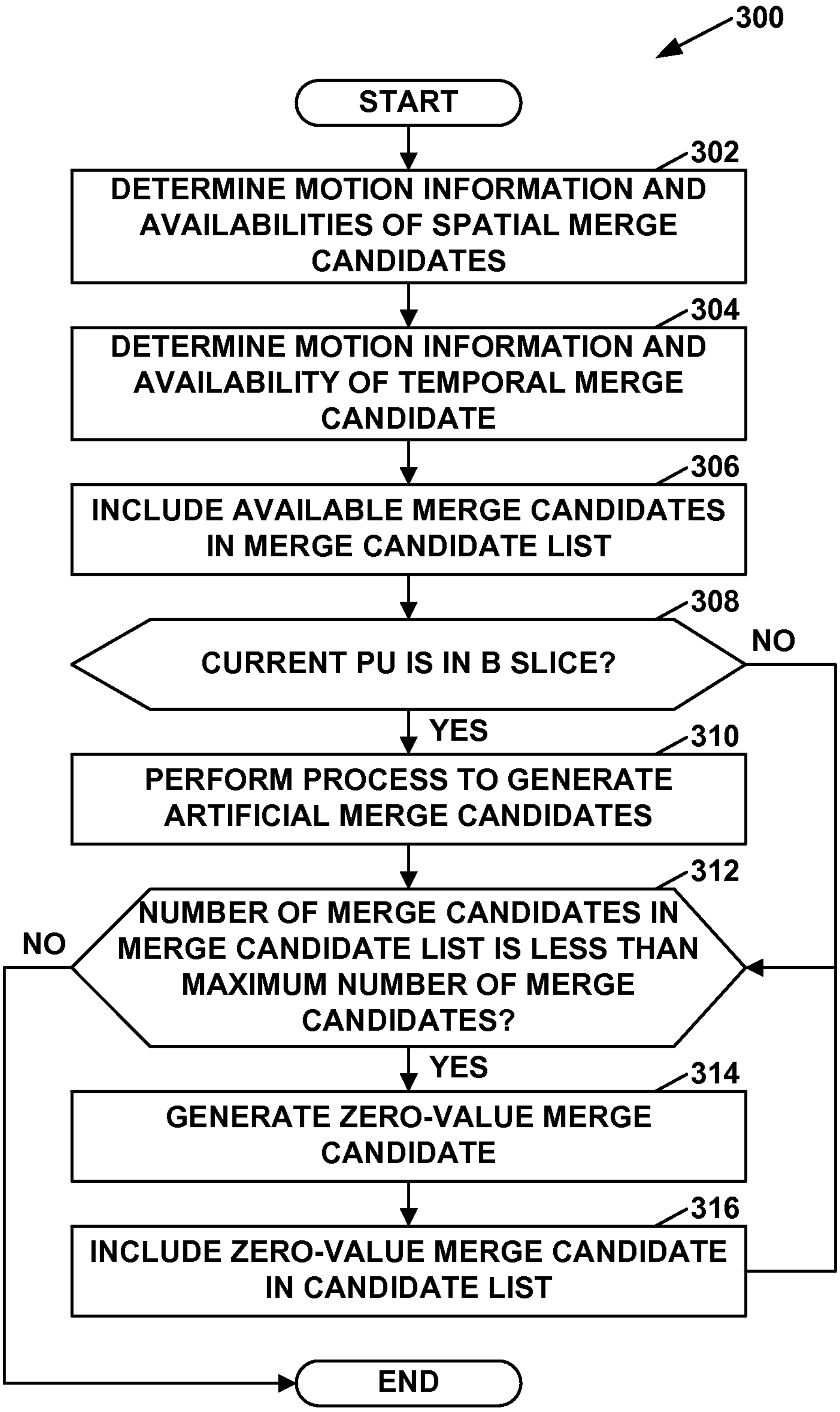
300
START
302
DETERMINE MOTION INFORMATION AND AVAILABILITIES OF SPATIAL MERGE CANDIDATES
304
DETERMINE MOTION INFORMATION AND AVAILABILITY OF TEMPORAL MERGE CANDIDATE
306
INCLUDE AVAILABLE MERGE CANDIDATES IN MERGE CANDIDATE LIST
308
CURRENT PU IS IN B SLICE?
NO
YES
310
PERFORM PROCESS TO GENERATE ARTIFICIAL MERGE CANDIDATES
312
NUMBER OF MERGE CANDIDATES IN MERGE CANDIDATE LIST IS LESS THAN MAXIMUM NUMBER OF MERGE CANDIDATES?
NO
YES
314
GENERATE ZERO-VALUE MERGE CANDIDATE
316
INCLUDE ZERO-VALUE MERGE CANDIDATE IN CANDIDATE LIST
END

FIG. 6

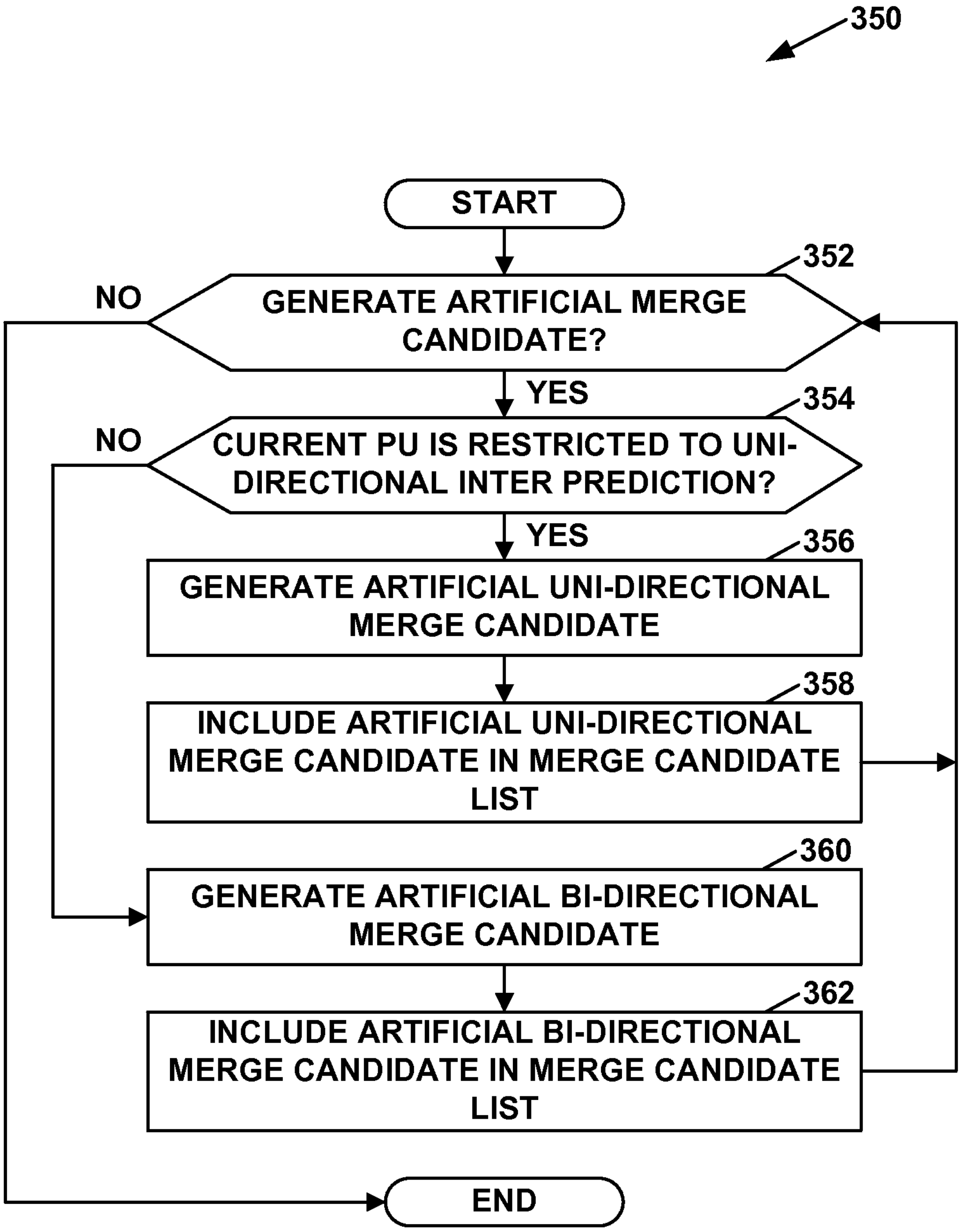
350
START
352
GENERATE ARTIFICIAL MERGE CANDIDATE?
NO
YES
354
CURRENT PU IS RESTRICTED TO UNI-DIRECTIONAL INTER PREDICTION?
NO
YES
356
GENERATE ARTIFICIAL UNI-DIRECTIONAL MERGE CANDIDATE
358
INCLUDE ARTIFICIAL UNI-DIRECTIONAL MERGE CANDIDATE IN MERGE CANDIDATE LIST
360
GENERATE ARTIFICIAL BI-DIRECTIONAL MERGE CANDIDATE
362
INCLUDE ARTIFICIAL BI-DIRECTIONAL MERGE CANDIDATE IN MERGE CANDIDATE LIST
END

FIG. 7

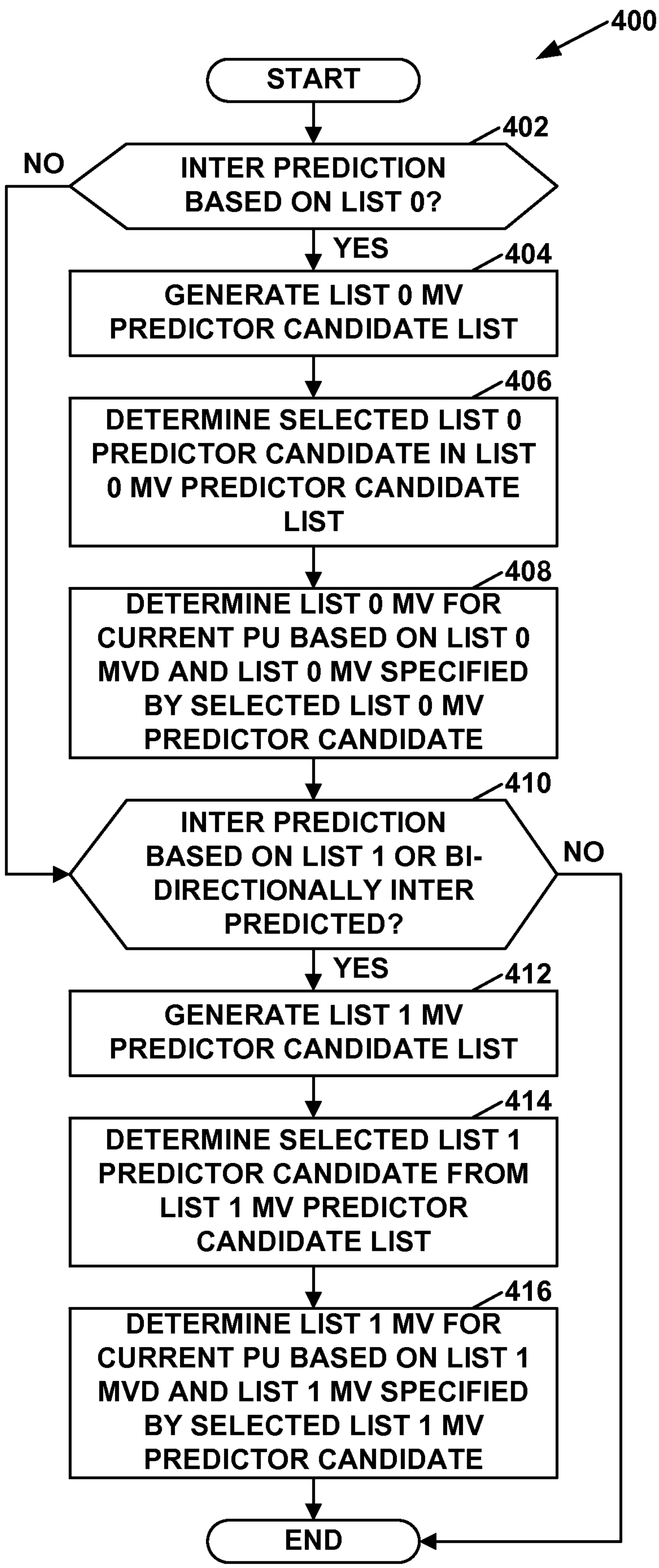
400
START
402
INTER PREDICTION BASED ON LIST 0?
NO
YES
404
GENERATE LIST 0 MV PREDICTOR CANDIDATE LIST
406
DETERMINE SELECTED LIST 0 PREDICTOR CANDIDATE IN LIST 0 MV PREDICTOR CANDIDATE LIST
408
DETERMINE LIST 0 MV FOR CURRENT PU BASED ON LIST 0 MVD AND LIST 0 MV SPECIFIED BY SELECTED LIST 0 MV PREDICTOR CANDIDATE
410
INTER PREDICTION BASED ON LIST 1 OR BI-DIRECTIONALLY INTER PREDICTED?
NO
YES
412
GENERATE LIST 1 MV PREDICTOR CANDIDATE LIST
414
DETERMINE SELECTED LIST 1 PREDICTOR CANDIDATE FROM LIST 1 MV PREDICTOR CANDIDATE LIST
416
DETERMINE LIST 1 MV FOR CURRENT PU BASED ON LIST 1 MVD AND LIST 1 MV SPECIFIED BY SELECTED LIST 1 MV PREDICTOR CANDIDATE
END

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/025153

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N7/36 H04N7/26
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	IKAI (SHARP) T: "AHG7: Controllable memory bandwidth reduction with bi-pred to uni-pred conversion", 8. JCT-VC MEETING; 99. MPEG MEETING; 1-2-2012 - 10-2-2012; SAN JOSE; (JOINT COLLABORATIVE TEAM ON VIDEO CODING OF ISO/IEC JTC1/SC29/WG11 AND ITU-T SG.16); URL: HTTP://WFTP3.ITU.INT/AV-ARCH/JCTVC-SITE/,, no. JCTVC-H0096, 20 January 2012 (2012-01-20), XP030111123, abstract table 1 section 1 "Introduction" section 2 "Proposed method" -----	1-50

-/--

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 April 2013	08/05/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Stoufs, Maryse

4

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KONDO K ET AL: "AHG7: Modification of merge candidate derivation to reduce MC memory bandwidth", 8. JCT-VC MEETING; 99. MPEG MEETING; 1-2-2012 - 10-2-2012; SAN JOSE; (JOINT COLLABORATIVE TEAM ON VIDEO CODING OF ISO/IEC JTC1/SC29/WG11 AND ITU-T SG.16); URL: HTTP://WFTP3.ITU.INT/AV-ARCH/JCTVC-SITE/,, no. JCTVC-H0221, 20 January 2012 (2012-01-20), XP030111248, abstract section 2.1 "Modification of merge candidate derivation" section 2.2 "Restriction for bi-prediction of small block" -----	1-6, 9-28, 31-50
X,P	FUKUSHIMA S ET AL: "AHG7: Bi-pred restriction for small PUs", 9. JCT-VC MEETING; 100. MPEG MEETING; 27-4-2012 - 7-5-2012; GENEVA; (JOINT COLLABORATIVE TEAM ON VIDEO CODING OF ISO/IEC JTC1/SC29/WG11 AND ITU-T SG.16); URL: HTTP://WFTP3.ITU.INT/AV-ARCH/JCTVC-SITE/,, no. JCTVC-I0297, 17 April 2012 (2012-04-17), XP030112060, figures 1-3 section 2.2 "Proposed algorithm" -----	1-50
X,P	ZHOU (TI) M: "AHG7: A combined study on JCTVC-I0216 and JCTVC-I0107", 9. JCT-VC MEETING; 100. MPEG MEETING; 27-4-2012 - 7-5-2012; GENEVA; (JOINT COLLABORATIVE TEAM ON VIDEO CODING OF ISO/IEC JTC1/SC29/WG11 AND ITU-T SG.16); URL: HTTP://WFTP3.ITU.INT/AV-ARCH/JCTVC-SITE/,, no. JCTVC-I0425, 17 April 2012 (2012-04-17), XP030112188, the whole document -----	1-6, 9-28, 31-50
A	MCCANN K ET AL: "High Efficiency Video Coding (HEVC) Test Model 5 (HM 5) Encoder Description", 7. JCT-VC MEETING; 98. MPEG MEETING; 21-11-2011 - 30-11-2011; GENEVA; (JOINT COLLABORATIVE TEAM ON VIDEO CODING OF ISO/IEC JTC1/SC29/WG11 AND ITU-T SG.16); URL: HTTP://WFTP3.ITU.INT/AV-ARCH/JCTVC-SITE/,, no. JCTVC-G1102, 30 January 2012 (2012-01-30), XP030111031, section 5.4 "Inter Prediction" section 6.9 "Derivation process for CU-level and PU-level coding parameters" -----	1-50

4

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13/628,562 2012.09.27 US

(85)PCT国际申请进入国家阶段日
2014.08.06

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WO2013/119816 EN 2013.08.15

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代理人 宋献涛

(51)Int.Cl.
H04N 19/577(2014.01)
H04N 19/52(2014.01)
H04N 19/176(2014.01)
H04N 19/159(2014.01)
H04N 19/109(2014.01)

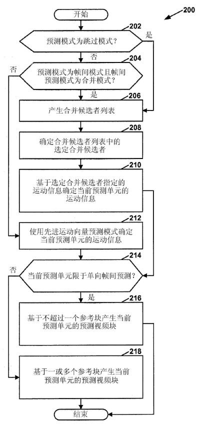
权利要求书5页 说明书27页 附图8页

(54)发明名称

B切片中的预测单元限于单向帧间预测

(57)摘要

一种计算装置确定B切片中的预测单元PU是否限于单向帧间预测。另外，所述计算装置产生所述PU的合并候选者列表且确定所述合并候选者列表中的选定合并候选者。如果所述PU限于单向帧间预测，那么所述计算装置基于与所述选定合并候选者指定的运动信息相关联的不超过一个参考块产生所述PU的预测视频块。如果所述PU不限于单向帧间预测，那么所述计算装置基于与所述选定合并候选者指定的所述运动信息相关联的一或多个参考块产生所述PU的所述预测视频块。



CN 104094605 A

1. 一种用于对视频数据进行译码的方法，所述方法包括：

确定 B 切片中的预测单元 PU 是否限于单向帧间预测；

产生所述 PU 的合并候选者列表；

确定所述合并候选者列表中的选定合并候选者；

如果所述 PU 限于单向帧间预测，那么基于与所述选定合并候选者指定的运动信息相关联的不超过一个参考块产生所述 PU 的预测视频块；以及

如果所述 PU 不限于单向帧间预测，那么基于与所述选定合并候选者指定的所述运动信息相关联的一或多个参考块产生所述 PU 的所述预测视频块。

2. 根据权利要求 1 所述的方法，其中确定所述 PU 是否限于单向预测包括：

如果所述 PU 的大小特性低于阈值，那么确定所述 PU 限于单向帧间预测；以及

如果所述 PU 的所述大小特性不低于所述阈值，那么确定所述 PU 不限于单向帧间预测。

3. 根据权利要求 2 所述的方法，其中在所述 PU 的所述大小特性低于所述阈值的情况下确定所述 PU 限于单向帧间预测包括在与所述 PU 相关联的视频块的高度或宽度低于所述阈值的情况下确定所述 PU 限于单向帧间预测。

4. 根据权利要求 2 所述的方法，其中在所述 PU 的所述大小特性低于所述阈值的情况下确定所述 PU 限于单向帧间预测包括在与所述 PU 相关联的视频块的第一尺寸小于阈值且与所述 PU 相关联的所述视频块的第二尺寸小于或等于所述阈值的情况下确定所述 PU 限于单向帧间预测。

5. 根据权利要求 2 所述的方法，其中在所述 PU 的所述大小特性低于所述阈值的情况下确定所述 PU 限于单向帧间预测包括在与所述 PU 相关联的视频块的第一尺寸小于第一阈值且与所述 PU 相关联的所述视频块的第二尺寸小于第二阈值的情况下确定所述 PU 限于单向帧间预测。

6. 根据权利要求 5 所述的方法，其中所述第一阈值与所述第二阈值相同。

7. 根据权利要求 2 所述的方法，其中确定所述 PU 是否限于单向预测包括：

如果与所述 PU 相关联的译码单元 CU 的大小特性小于或等于特定大小且所述 PU 的所述大小特性低于所述阈值，那么确定所述 PU 限于单向帧间预测，其中所述 CU 的所述大小特性是与所述 CU 相关联的视频块的高度或宽度；以及

如果所述 CU 的所述大小特性不等于所述特定大小且所述 PU 的所述大小特性不低于所述阈值，那么确定所述 PU 不限于单向帧间预测。

8. 根据权利要求 7 所述的方法，其中所述特定大小等于 8，且所述阈值等于 8。

9. 根据权利要求 1 所述的方法，其进一步包括：

在产生所述合并候选者列表之后，将所述合并候选者列表中的双向合并候选者转换为单向合并候选者；以及

将所述单向合并候选者代替于所述双向合并候选者包含在所述合并候选者列表中。

10. 根据权利要求 9 所述的方法，其中将所述双向合并候选者转换为所述单向合并候选者包括将所述双向合并候选者转换为所述单向合并候选者使得所述单向合并候选者与特定参考图片列表中的参考图片相关联，其中每当将双向合并候选者转换为单向合并候选者，所述单向合并候选者就与所述特定参考图片列表中的参考图片相关联。

11. 根据权利要求 1 所述的方法，其中产生所述合并候选者列表包括在所述 PU 限于单

向帧间预测的情况下产生所述合并候选者列表使得所述合并候选者列表仅包含单向合并候选者。

12. 根据权利要求 11 所述的方法，其中产生所述合并候选者列表使得所述合并候选者列表仅包含单向合并候选者包括 ：

将双向合并候选者转换为一或多个单向合并候选者 ；以及

将所述单向合并候选者的任一者或两者包含在所述合并候选者列表中。

13. 根据权利要求 12 所述的方法，其进一步包括在将所述双向合并候选者转换为所述一或多个单向合并候选者之前删除重复的合并候选者。

14. 根据权利要求 12 所述的方法，其进一步包括在将所述双向合并候选者转换为所述单向合并候选者之后删除重复的合并候选者。

15. 根据权利要求 12 所述的方法，其中将所述双向合并候选者转换为一或多个单向合并候选者包括将所述双向合并候选者转换为单一单向合并候选者，所述单一单向合并候选者指示列表 0 中的参考图片或列表 1 中的参考图片。

16. 根据权利要求 11 所述的方法，其中产生所述合并候选者列表使得所述合并候选者列表仅包含单向合并候选者包括 ：

产生人为单向合并候选者 ；以及

将所述人为单向合并候选者包含在所述合并候选者列表中。

17. 根据权利要求 16 所述的方法，其中 ：

所述合并候选者列表包含第一单向合并候选者和第二单向合并候选者，所述第一单向合并候选者指定第一运动向量，所述第二单向合并候选者指定第二运动向量 ；且

产生所述人为单向合并候选者包括基于所述第一单向合并候选者指定的参考图片与所述第二单向合并候选者指定的参考图片之间的时间差缩放所述第一运动向量。

18. 根据权利要求 16 所述的方法，其中产生所述人为单向合并候选者包括产生所述人为单向合并候选者使得所述人为单向合并候选者指定所述双向合并候选者指定的运动向量。

19. 根据权利要求 1 所述的方法，其中所述选定合并候选者是双向合并候选者。

20. 根据权利要求 1 所述的方法，其中确定所述选定合并候选者包括 ：

从位流解析指示所述选定合并候选者在所述合并候选者列表中的位置的语法元素 ；以及

确定所述选定合并候选者在所述合并候选者列表中的所述位置处的所述选定合并候选者。

21. 根据权利要求 1 所述的方法，其中所述方法包括产生包含指示所述选定合并候选者在所述合并候选者列表中的位置的经编码语法元素的位流。

22. 根据权利要求 1 所述的方法，其中所述方法在移动计算装置上执行。

23. 一种视频译码装置，其包括经配置以进行以下操作的一或多个处理器 ：

确定 B 切片中的预测单元 PU 是否限于单向帧间预测 ；

产生所述 PU 的合并候选者列表 ；

确定所述合并候选者列表中的选定合并候选者 ；

如果所述 PU 限于单向帧间预测，那么基于与所述选定合并候选者指定的运动信息相

关联的不超过一个参考块产生所述 PU 的预测视频块 ;以及

如果所述 PU 不限于单向帧间预测，那么基于与所述选定合并候选者指定的所述运动信息相关联的一或多个参考块产生所述 PU 的所述预测视频块。

24. 根据权利要求 23 所述的视频译码装置，其中所述一或多个处理器经配置以 :

在所述 PU 的大小特性低于阈值的情况下确定所述 PU 限于单向帧间预测 ;且

在所述 PU 的所述大小特性不低于所述阈值的情况下确定所述 PU 不限于单向帧间预测。

25. 根据权利要求 24 所述的视频译码装置，其中所述一或多个处理器经配置以在与所述 PU 相关联的视频块的高度或宽度低于所述阈值的情况下确定所述 PU 限于单向帧间预测。

26. 根据权利要求 24 所述的视频译码装置，其中所述一或多个处理器经配置以在与所述 PU 相关联的视频块的第一尺寸小于阈值且与所述 PU 相关联的所述视频块的第二尺寸小于或等于所述阈值的情况下确定所述 PU 限于单向帧间预测。

27. 根据权利要求 24 所述的视频译码装置，其中所述一或多个处理器经配置以在与所述 PU 相关联的视频块的第一尺寸小于第一阈值且与所述 PU 相关联的所述视频块的第二尺寸小于第二阈值的情况下确定所述 PU 限于单向帧间预测。

28. 根据权利要求 27 所述的视频译码装置，其中所述第一阈值与所述第二阈值相同。

29. 根据权利要求 24 所述的视频译码装置，其中所述一或多个处理器经配置以 :

在与所述 PU 相关联的译码单元 CU 的大小特性小于或等于特定大小且所述 PU 的所述大小特性低于所述阈值的情况下确定所述 PU 限于单向帧间预测 ;且

在所述 CU 的所述大小特性不等于所述特定大小且所述 PU 的所述大小特性不低于所述阈值的情况下确定所述 PU 不限于单向帧间预测。

30. 根据权利要求 29 所述的视频译码装置，其中所述特定大小等于 8，且所述阈值等于 8。

31. 根据权利要求 23 所述的视频译码装置，其中所述一或多个处理器进一步经配置以 :

在产生所述合并候选者列表之后，将所述合并候选者列表中的双向合并候选者转换为单向合并候选者 ;且

将所述单向合并候选者代替于所述双向合并候选者包含在所述合并候选者列表中。

32. 根据权利要求 31 所述的视频译码装置，其中所述一或多个处理器经配置以将所述双向合并候选者转换为所述单向合并候选者使得所述单向合并候选者与特定参考图片列表中的参考图片相关联，其中每当所述一或多个处理器将双向合并候选者转换为单向合并候选者，所述单向合并候选者就与所述特定参考图片列表中的参考图片相关联。

33. 根据权利要求 23 所述的视频译码装置，其中所述一或多个处理器经配置以产生所述合并候选者列表使得在所述 PU 限于单向帧间预测的情况下所述合并候选者列表仅包含单向合并候选者。

34. 根据权利要求 33 所述的视频译码装置，其中为产生所述合并候选者列表使得所述合并候选者列表仅包含单向合并候选者，所述一或多个处理器经配置以 :

将双向合并候选者转换为一或多个单向合并候选者 ;且

将所述单向合并候选者的任一者或两者包含在所述合并候选者列表中。

35. 根据权利要求 34 所述的视频译码装置，其中所述一或多个处理器进一步经配置以在将所述双向合并候选者转换为所述一或多个单向合并候选者之前删除重复的合并候选者。

36. 根据权利要求 34 所述的视频译码装置，其中所述一或多个处理器经配置以在将所述双向合并候选者转换为所述一或多个单向合并候选者之后删除重复的合并候选者。

37. 根据权利要求 34 所述的视频译码装置，其中所述一或多个处理器经配置以将所述双向合并候选者转换为单一单向合并候选者，所述单一单向合并候选者与列表 0 中的参考图片或列表 1 中的参考图片相关联。

38. 根据权利要求 33 所述的视频译码装置，其中为产生所述合并候选者列表使得所述合并候选者列表仅包含单向合并候选者，所述一或多个处理器经配置以：

产生人为单向合并候选者；且

将所述人为单向合并候选者包含在所述合并候选者列表中。

39. 根据权利要求 38 所述的视频译码装置，其中：

所述合并候选者列表包含第一单向合并候选者和第二单向合并候选者，所述第一单向合并候选者指定第一运动向量，所述第二单向合并候选者指定第二运动向量；且

为产生所述人为单向合并候选者，所述一或多个处理器经配置以基于所述第一单向合并候选者指定的参考图片与所述第二单向合并候选者指定的参考图片之间的时间差缩放所述第一运动向量。

40. 根据权利要求 38 所述的视频译码装置，其中所述一或多个处理器经配置以产生所述人为单向合并候选者使得所述人为单向合并候选者指定双向合并候选者指定的运动向量。

41. 根据权利要求 23 所述的视频译码装置，其中所述选定合并候选者是双向合并候选者。

42. 根据权利要求 23 所述的视频译码装置，其中所述视频译码装置对视频数据进行解码，且所述一或多个处理器经配置以基于指示所述选定合并候选者在所述合并候选者列表中的位置的语法元素确定所述选定合并候选者。

43. 根据权利要求 23 所述的视频译码装置，其中所述视频译码装置对视频数据进行编码，且所述一或多个处理器经配置以输出指示所述选定合并候选者在所述合并候选者列表中的位置的语法元素。

44. 根据权利要求 23 所述的视频译码装置，其中所述视频译码装置是移动计算装置。

45. 一种视频译码装置，其包括：

用于确定 B 切片中的预测单元 PU 是否限于单向帧间预测的装置；

用于产生所述 PU 的合并候选者列表的装置；

用于确定所述合并候选者列表中的选定合并候选者的装置；

用于在所述 PU 限于单向帧间预测的情况下基于与所述选定合并候选者指定的运动信息相关联的不超过一个参考块产生所述 PU 的预测视频块的装置；以及

用于在所述 PU 不限于单向帧间预测的情况下基于与所述选定合并候选者指定的所述运动信息相关联的一或多个参考块产生所述 PU 的所述预测视频块的装置。

46. 根据权利要求45所述的视频译码装置，其中所述用于确定所述PU是否限于单向预测的装置包括：

用于在所述PU的大小特性低于阈值的情况下确定所述PU限于单向帧间预测的装置；以及

用于在所述PU的所述大小特性不低于所述阈值的情况下确定所述PU不限于单向帧间预测的装置。

47. 根据权利要求45所述的视频译码装置，其中所述选定合并候选者是双向合并候选者。

48. 一种计算机程序产品，其包括存储指令的一或多个计算机可读存储媒体，所述指令当执行时配置一或多个处理器以：

确定B切片中的预测单元PU是否限于单向帧间预测；

产生所述PU的合并候选者列表；

确定所述合并候选者列表中的选定合并候选者；

在所述PU限于单向帧间预测的情况下，基于与选定合并候选者指定的运动信息相关联的不超过一个参考块产生所述PU的预测视频块；且

在所述PU不限于单向帧间预测的情况下，基于与所述选定合并候选者指定的所述运动信息相关联的一或多个参考块产生所述PU的所述预测视频块。

49. 根据权利要求48所述的计算机程序产品，其中所述指令配置所述一或多个处理器以：

确定所述PU是否限于单向预测包括：

在所述PU的大小特性低于阈值的情况下确定所述PU限于单向帧间预测；以及

在所述PU的所述大小特性不低于所述阈值的情况下确定所述PU不限于单向帧间预测。

50. 根据权利要求48所述的计算机程序产品，其中所述选定合并候选者是双向合并候选者。

B 切片中的预测单元限于单向帧间预测

[0001] 本申请案主张 2012 年 2 月 8 日申请的第 61/596,597 号美国临时专利申请案以及 2012 年 4 月 11 日申请的第 61/622,968 号美国临时专利申请案的权益，所述专利申请案的每一者的全部内容以引用的方式并入本文中。

技术领域

[0002] 本发明涉及视频译码，且特定来说涉及视频译码中的帧间预测。

背景技术

[0003] 数字视频能力可并入到广泛装置中，包含数字电视、数字直播系统、无线广播系统、个人数字助理 (PDA)、膝上型或台式计算机、平板计算机、电子书阅读器、数码相机、数字记录装置、数字媒体播放器、视频游戏装置、视频游戏控制台、蜂窝式或卫星无线电电话、所谓的“智能电话”、视频电信会议装置、视频串流装置等。数字视频装置实施视频压缩技术，例如 MPEG-2、MPEG-4、ITU-T H.263、ITU-T H.264/MPEG-4 第 10 部分、先进视频译码 (AVC)、当前开发中的高效视频译码 (HEVC) 标准所界定的标准以及此类标准的扩展中描述的技术。视频装置可通过实施此类视频压缩技术更有效地发射、接收、编码、解码和 / 或存储数字视频信息。

[0004] 视频压缩技术执行空间 (图片内) 预测和 / 或时间 (图片间) 预测以减少或移除视频序列中固有的冗余。对于基于块的视频译码，视频切片 (即，视频帧或视频帧的一部分) 可分割为视频块，其也可称为树块、译码单元 (CU) 和 / 或译码节点。使用空间预测相对于同一图片中的相邻块中的参考样本编码图片的帧内译码 (I) 切片中的视频块。图片的帧间译码 (P 或 B) 切片中的视频块可使用相对于同一图片中的相邻块中的参考样本的空间预测，或相对于其它参考图片中的参考样本的时间预测。图片可称为帧，且参考图片可称为参考帧。

[0005] 空间或时间预测结果产生待译码的块的预测视频块。残余数据表示待译码的原始块与预测视频块之间的像素差。帧间译码块根据指向形成预测视频块的参考样本的块的运动向量以及指示经译码块与预测视频块之间的差的残余数据而编码。帧内译码块根据帧内译码模式和残余数据而编码。为了进一步压缩，残余数据可从像素域变换到变换域，从而产生残余变换系数，残余变换系数接着可量化。初始布置在二维阵列中的经量化变换系数可经扫描以便产生变换系数的一维向量，且可应用熵译码来实现更多压缩。

发明内容

[0006] 大体来说，本发明描述用于视频译码过程中的帧间预测的技术。视频译码器确定 B 切片中的预测单元 (PU) 是否限于单向帧间预测。另外，视频译码器产生 PU 的合并候选者列表且确定合并候选者列表中的选定合并候选者。如果 PU 限于单向帧间预测，那么视频译码器基于与选定合并候选者指定的运动信息相关联的不超过一个参考块产生 PU 的预测视频块。如果 PU 不限于单向帧间预测，那么视频译码器基于与选定合并候选者指定的运动信

息相关联的一或多个参考块产生 PU 的预测视频块。

[0007] 在一个方面中，本发明描述一种用于对视频数据进行译码的方法。所述方法包括确定 B 切片中的 PU 是否限于单向帧间预测。所述方法还包括产生 PU 的合并候选者列表。另外，所述方法包括确定合并候选者列表中的选定合并候选者。另外，所述方法包括在 PU 限于单向帧间预测的情况下基于与选定合并候选者指定的运动信息相关联的不超过一个参考块产生 PU 的预测视频块。所述方法还包括在 PU 不限于单向帧间预测的情况下基于与选定合并候选者指定的运动信息相关联的一或多个参考块产生 PU 的预测视频块。

[0008] 在另一方面中，本发明描述一种视频译码装置，其包括经配置以确定 B 切片中的 PU 是否限于单向帧间预测的一或多个处理器。所述一或多个处理器还经配置以产生 PU 的合并候选者列表且确定合并候选者列表中的选定合并候选者。所述一或多个处理器经配置使得如果 PU 限于单向帧间预测，那么所述一或多个处理器基于与选定合并候选者指定的运动信息相关联的不超过一个参考块产生 PU 的预测视频块。此外，所述一或多个处理器经配置使得如果 PU 不限于单向帧间预测，那么所述一或多个处理器基于与选定合并候选者指定的运动信息相关联的一或多个参考块产生 PU 的预测视频块。

[0009] 在另一方面中，本发明描述一种视频译码装置，其包括用于确定 B 切片中的 PU 是否限于单向帧间预测的装置。所述视频译码装置还包括用于产生 PU 的合并候选者列表的装置。另外，所述视频译码装置包括用于确定合并候选者列表中的选定合并候选者的装置。所述视频译码装置还包括用于在 PU 限于单向帧间预测的情况下基于与选定合并候选者指定的运动信息相关联的不超过一个参考块产生 PU 的预测视频块的装置。所述视频译码装置还包括用于在 PU 不限于单向帧间预测的情况下基于与选定合并候选者指定的运动信息相关联的一或多个参考块产生 PU 的预测视频块的装置。

[0010] 在另一方面中，本发明描述一种计算机程序产品，其包括存储指令的一或多个计算机可读存储媒体，所述指令当执行时配置一或多个处理器以确定 B 切片中的 PU 是否限于单向帧间预测。所述指令还配置所述一或多个处理器以产生 PU 的合并候选者列表，且确定合并候选者列表中的选定合并候选者。如果 PU 限于单向帧间预测，那么所述指令配置所述一或多个处理器以基于与选定合并候选者指定的运动信息相关联的不超过一个参考块产生 PU 的预测视频块。如果 PU 不限于单向帧间预测，那么所述指令配置所述一或多个处理器以基于与选定合并候选者指定的运动信息相关联的一或多个参考块产生 PU 的预测视频块。

[0011] 一或多个实例的细节在附图和以下描述中陈述。从描述内容和图式并从权利要求书将明白其它特征、目的和优点。

附图说明

[0012] 图 1 是说明可利用本发明中描述的技术的实例视频译码系统的框图。

[0013] 图 2 是说明经配置以实施本发明中描述的技术的实例视频编码器的框图。

[0014] 图 3 是说明经配置以实施本发明中描述的技术的实例视频解码器的框图。

[0015] 图 4 是说明实例运动补偿操作的流程图。

[0016] 图 5 是说明另一实例运动补偿操作的流程图。

[0017] 图 6 是说明用于产生合并候选者列表的实例操作的流程图。

[0018] 图 7 是说明用于产生人为合并候选者的实例过程的流程图。

[0019] 图 8 是说明用于使用先进运动向量预测模式确定预测单元的运动信息的实例操作的流程图。

具体实施方式

[0020] 如下文描述，图片可划分为一或多个切片。切片的每一者可包含整数数目的译码单元(CU)。每一 CU 可具有一或多个预测单元(PU)。切片可为 I 切片、P 切片或 B 切片。在 I 切片中，所有 PU 经帧内预测。视频编码器可对 P 切片中的 PU 执行帧内预测或单向帧间预测。当视频编码器对 P 切片中的 PU 执行单向帧间预测时，视频编码器可识别或合成参考图片的第一列表(“列表 0”)中列举的参考图片中的参考样本。参考块可为参考图片内的参考样本的块。参考样本可对应于参考块中的实际像素，或例如通过使用实际像素进行内插而合成的像素。视频编码器可接着基于 PU 的参考块产生 PU 的预测视频块。

[0021] 视频编码器可对 B 切片中的 PU 执行列表 0 单向帧间预测、列表 1 单向帧间预测或双向帧间预测。当视频编码器对 PU 执行列表 0 单向帧间预测时，视频编码器可识别列表 0 中列举的参考图片中的参考块或基于列表 0 中列举的参考图片中的参考样本合成参考块。视频编码器可接着基于参考块产生 PU 的预测视频块。当视频编码器对 PU 执行列表 1 单向帧间预测时，视频编码器可识别第二参考图片列表(“列表 1”)中列举的参考图片中的参考块或可基于列表 1 中列举的参考图片中的参考样本合成参考块。视频编码器可接着基于参考块产生 PU 的预测视频块。当视频编码器对 PU 执行双向帧间预测时，视频编码器可识别列表 0 中列举的参考图片中的参考块或基于列表 0 中列举的参考图片中的参考样本合成参考块。另外，当视频编码器对 PU 执行双向帧间预测时，视频编码器可识别列表 1 中列举的参考图片中的参考块或基于列表 1 中列举的参考图片中的参考样本合成参考块。视频编码器可接着基于两个参考块产生 PU 的预测视频块。

[0022] 视频编码器可信令 PU 的运动信息以使视频解码器能够识别或合成视频编码器用于产生 PU 的预测视频块的参考块。PU 的运动信息可包含一或多个运动向量、参考图片索引，和指示帧间预测是否基于列表 0 和 / 或列表 1 的旗标。在一些例子中，视频编码器可使用合并模式信令 PU 的运动信息。当视频编码器使用合并模式信令 PU 的运动信息时，视频编码器可产生 PU 的合并候选者列表。合并候选者列表可包含多个合并候选者，其每一者指定运动信息的集合。

[0023] 如果合并候选者指定识别列表 0 或列表 1 中列举的参考图片中的单一位置的运动信息，那么合并候选者可为单向合并候选者。如果参考块中的样本基于运动信息识别的参考图片中的运动信息所识别的位置处的样本来确定，那么参考块可与运动信息的集合相关联。举例来说，如果参考块中的样本与运动信息识别的参考图片中的运动信息所识别的位置处的视频块中的样本相同，那么参考块可与运动信息的集合相关联。如果参考块中的样本从运动信息识别的参考帧中的运动信息所识别的位置处的视频块中的样本合成(例如，内插)，那么参考块也可与运动信息的集合相关联。

[0024] 如果合并候选者指定识别列表 0 中列举的参考图片中的位置和列表 1 中列举的参考图片中的位置的运动信息，那么合并候选者可为双向合并候选者。视频编码器可基于空间上与不同图片中的当前 PU 和 / 或协同定位 PU 相邻的 PU 的运动信息产生合并候选者指

定的运动信息。在产生当前 PU 的合并列表之后，视频编码器可选择合并候选者列表中的合并候选者的一者，且信令选定合并候选者的合并候选者列表内的位置。视频解码器可基于选定合并候选者指定的运动信息确定当前 PU 的运动信息。

[0025]　依据操作和所需存储器带宽，基于两个参考块产生 PU 的预测视频块可比基于单一参考块产生 PU 的预测视频块要复杂。与基于两个参考块产生预测视频块相关联的复杂性可随 B 切片中的双向帧间预测 PU 的数目增加而增加。当小双向帧间预测 PU 的数目增加时，可能尤其如此。因此，可有利地将 B 切片中的一些 PU 限于单向帧间预测。

[0026]　视频编码器可通过仅从 PU 的合并候选者列表选择单向合并候选者而将 B 切片中的 PU 限于单向帧间预测。然而，在一些例子中，合并候选者列表可不包含任何单向合并候选者。在此类例子中，视频编码器可不能使用合并模式信令 PU 的运动信息。这可减小译码性能。此外，即使合并候选者列表包含至少一个单向合并候选者，如果与单向合并候选者指定的运动信息相关联的参考块不充分类似于与 PU 相关联的视频块，那么译码效率也可减小。

[0027]　根据本发明的技术，视频译码器（例如，视频编码器或视频解码器）可确定 B 切片中的 PU 是否限于单向帧间预测。举例来说，视频译码器可确定在 PU 的大小特性小于特定阈值的情况下 PU 限于单向帧间预测。PU 的大小特性可为与 PU 相关联的视频块的大小的特性，例如与 PU 相关联的视频块的高度、宽度、对角长度等。另外，视频译码器可产生 PU 的合并候选者列表且确定合并候选者列表中的选定合并候选者。如果 PU 限于单向帧间预测，那么视频译码器可基于与选定合并候选者指定的运动信息相关联的不超过一个参考块产生 PU 的预测视频块。如果 PU 不限于单向帧间预测，那么视频译码器可基于与选定合并候选者指定的运动信息相关联的一或多个参考块产生 PU 的预测视频块。通过以此方式将一些 PU 限于单向帧间预测，视频译码器可减小与基于多个参考块产生预测视频块相关联的复杂性。这可增加视频译码器能够对视频数据进行译码的速度且可减小数据带宽要求。

[0028]　为便于阐释，本发明可将位置或视频块描述为具有与 CU 或 PU 的各种空间关系。此描述可解释为意味着位置或视频块具有与同 CU 或 PU 相关联的视频块的各种空间关系。此外，本发明可提到视频译码器当前正作为当前 PU 译码的 PU。本发明可提到视频译码器当前正作为当前 CU 译码的 CU。本发明可提到视频译码器当前正作为当前图片译码的图片。

[0029]　附图说明实例。附图中的参考数字指示的元件对应于以下描述中的相同参考数字指示的元件。本发明中，具有以序数词（例如，“第一”、“第二”、“第三”等）开始的名称的元件不一定暗示所述元件具有特定次序。而是，此类序数词仅用于指代相同或类似类型的不同元件。

[0030]　图 1 是说明可利用本发明的技术的实例视频译码系统 10 的框图。如本文所描述而使用，术语“视频译码器”一般指代视频编码器和视频解码器两者。在本发明中，术语“视频译码”或“译码”可一般指代视频编码或视频解码。

[0031]　如图 1 所示，视频译码系统 10 包含源装置 12 和目的地装置 14。源装置 12 产生经编码视频数据。因此，源装置 12 可称为视频编码装置或视频编码设备。目的地装置 14 可解码源装置 12 产生的经编码视频数据。因此，目的地装置 14 可称为视频解码装置或视频解码设备。源装置 12 和目的地装置 14 可为视频译码装置或视频译码设备的实例。

[0032]　源装置 12 和目的地装置 14 可包括广范围的装置，包含台式计算机、移动计算装

置、笔记本(例如,膝上型)计算机、平板计算机、机顶盒、例如所谓的“智能”电话等电话手持机、电视机、相机、显示装置、数字媒体播放器、视频游戏控制台、车载计算机等。在一些实例中,源装置 12 和目的地装置 14 可经装备用于无线通信。

[0033] 目的地装置 14 可经由信道 16 从源装置 12 接收经编码视频数据。信道 16 可包括能够将经编码视频数据从源装置 12 移动到目的地装置 14 的类型的媒体或装置。在一个实例中,信道 16 可包括使源装置 12 能够实时将经编码视频数据直接发射到目的地装置 14 的通信媒体。在此实例中,源装置 12 可根据例如无线通信协议等通信标准调制经编码视频数据,且可将经调制视频数据发射到目的地装置 14。通信媒体可包括无线或有线通信媒体,例如射频 (RF) 频谱或一或多个物理发射线路。通信媒体可形成基于包的网络的一部分,例如局域网、广域网或全球网络(例如,因特网)。通信媒体可包含路由器、开关、基站,或促进从源装置 12 到目的地装置 14 的通信的其它设备。

[0034] 在另一实例中,信道 16 可对应于存储源装置 12 产生的经编码视频数据的存储媒体。在此实例中,目的地装置 14 可经由磁盘存取或卡存取而存取存储媒体。存储媒体可包含多种本地存取的数据存储媒体,例如蓝光光盘、DVD、CD-ROM、快闪存储器,或用于存储经编码视频数据的其它适宜的数字存储媒体。在另一实例中,信道 16 可包含文件服务器或存储源装置 12 产生的经编码视频的另一中间存储装置。在此实例中,目的地装置 14 可经由串流或下载存取存储在文件服务器或其它中间存储装置处的经编码视频数据。文件服务器可为能够存储经编码视频数据且将经编码视频数据发射到目的地装置 14 的类型的服务器。实例文件服务器包含网络服务器(例如,针对网站)、文件传送协议 (FTP) 服务器、网络附接存储 (NAS) 装置和本地磁盘驱动器。目的地装置 14 可经由标准数据连接(包含因特网连接)存取经编码视频数据。数据连接的实例类型可包含无线信道(例如,Wi-Fi 连接)、有线连接(例如,DSL、电缆调制解调器等),或适于存取存储在文件服务器上的经编码视频数据的两者的组合。经编码视频数据从文件服务器的发射可为串流发射、下载发射,或两者的组合。

[0035] 本发明的技术不限于无线应用或设置。所述技术可应用于视频译码以支持多种多媒体应用的任一者,例如空中电视广播、电缆电视发射、卫星电视发射、串流视频发射(例如,经由因特网)、编码数字视频以供存储在数据存储媒体上、解码存储在数据存储媒体上的数字视频,或其它应用。在一些实例中,视频译码系统 10 可经配置以支持单向或双向视频发射以支持例如视频串流、视频重放、视频广播和/或视频电话等应用。

[0036] 在图 1 的实例中,源装置 12 包含视频源 18、视频编码器 20 和输出接口 22。在一些情况下,输出接口 22 可包含调制器/解调器(调制解调器)和/或发射器。在源装置 12 中,视频源 18 可包含例如视频俘获装置(例如,视频相机)、含有先前俘获的视频数据的视频档案、用以从视频内容提供者接收视频数据的视频馈送接口,和/或用于产生视频数据的计算机图形系统等源,或此类源的组合。

[0037] 视频编码器 20 可编码所俘获、预先俘获或计算机产生的视频数据。经编码视频数据可经由源装置 12 的输出接口 22 直接发射到目的地装置 14。经编码视频数据还可存储到存储媒体或文件服务器上以供随后由目的地装置 14 存取用于解码和/或重放。

[0038] 在图 1 的实例中,目的地装置 14 包含输入接口 28、视频解码器 30 和显示装置 32。在一些情况下,输入接口 28 可包含接收器和/或调制解调器。目的地装置 14 的输入接口

28经由信道16接收经编码视频数据。经编码视频数据可包含视频编码器20产生的表示视频数据的多种语法元素。此类语法元素可与在通信媒体上发射、存储在存储媒体上或存储在文件服务器上的经编码视频数据一起包含。

[0039] 显示装置32可与目的地装置14集成或可在目的地装置14外部。在一些实例中，目的地装置14可包含集成显示装置，且还可经配置以与外部显示装置介接。在其它实例中，目的地装置14可为显示装置。一般来说，显示装置32向用户显示经解码视频数据。显示装置32可包括例如液晶显示器(LCD)、等离子体显示器、有机发光二极管(OLED)显示器或另一类型的显示装置等多种显示装置的任一者。

[0040] 视频编码器20和视频解码器30可根据例如当前在开发中的高效视频译码(HEVC)标准等视频压缩标准操作，且可遵循HEVC测试模式(HM)。称为“HEVC工作草案7”或“WD7”的即将到来的HEVC标准的最近草案在Bross等人的文献JCTVC-I1003_d54“高效视频译码(HEVC)文本规范草案7”中描述，ITU-T SG16 WP3和ISO/IEC JTC1/SC29/WG11的视频译码联合协作团队(JCT-VC)，第九次会议:瑞典日内瓦，2012年5月，其截至2012年7月19日可从http://phenix.int-evry.fr/jct/doc_end_user/documents/9_Geneva/wg11/JCTVC-I1003-v6.zip下载，其全部内容以引用的方式并入本文中。或者，视频编码器20和视频解码器30可根据其它专有或工业标准操作，例如ITU-T H.264标准，或者称为MPEG-4，第10部分，先进视频译码(AVC)，或此类标准的扩展。然而，本发明的技术不限于任何特定译码标准或技术。视频压缩标准和技术的其它实例包含MPEG-2、ITU-T H.263和专有或开放源压缩格式(例如，VP8和相关格式)。

[0041] 尽管图1的实例中未图示，但视频编码器20和视频解码器30可各自与音频编码器和解码器集成，且可包含适当MUX-DEMUX单元，或其它硬件和软件来处置共同数据流或单独数据流中音频和视频两者的编码。如果适用，那么在一些实例中，MUX-DEMUX单元可遵循ITU H.223多路复用器协议，或例如用户数据报协议(UDP)等其它协议。

[0042] 再次，图1仅为实例，且本发明的技术可适用于不必包含编码与解码装置之间的任何数据通信的视频译码设置(例如，视频编码或视频解码)。在其它实例中，数据可从本地存储器检索、经由网络串流等。编码装置可编码数据并将数据存储到存储器，且/或解码装置可从存储器检索和解码数据。在许多实例中，编码和解码由不彼此通信而是仅将数据编码到存储器和/或从存储器检索和解码数据的装置执行。

[0043] 视频编码器20和视频解码器30各自可实施为多种适宜电路的任一者，例如一或多个微处理器、数字信号处理器(DSP)、专用集成电路(ASIC)、现场可编程门阵列(FPGA)、离散逻辑、硬件，或其任何组合。当所述技术部分实施在软件中时，装置可将软件的指令存储在适宜的非暂时性计算机额可读存储媒体中且可使用一或多个处理器执行硬件中的指令以执行本发明的技术。以上各项(包含硬件、软件、硬件与软件的组合等)的任一者可视为一或多个处理器。视频编码器20和视频解码器30的每一者可包含在一或多个编码器或解码器中，其任一者可作为组合式编码器/解码器(CODEC)的一部分集成在相应装置中。

[0044] 本发明可一般提及视频编码器20向例如视频解码器30等另一装置“信令”特定信息。然而应理解，视频编码器20可通过使特定语法元素与视频数据的各种经编码部分相关联而信令信息。即，视频编码器20可通过将特定语法元素存储到视频数据的各种经编码部分的标头而“信令”数据。在一些情况下，此类语法元素可在由视频解码器30接收和解

码之前编码和存储（例如，在存储系统中）。因此，术语“信令”可一般指代用于解码经压缩视频数据的语法或其它数据的通信。此通信可实时或近实时发生。或者，此通信可在一时间跨度上发生，例如可能当编码时将语法元素在经编码位流中存储到媒介时发生，所述语法元素接着可由解码装置在存储到此媒介之后的任何时间检索。

[0045] 如上文简要提及，视频编码器 20 编码视频数据。视频数据可包括一或多个图片，图片的每一者可为形成视频的一部分的静止图像。在一些例子中，图片可称为视频“帧”。当视频编码器 20 编码视频数据时，视频编码器 20 可产生位流。位流可包含形成视频数据的经译码表示的位的序列。位流可包含经译码图片和相关联数据。经译码图片是图片的经译码表示。

[0046] 为产生位流，视频编码器 20 可对视频数据中的每一图片执行编码操作。当视频编码器 20 对图片执行编码操作时，视频编码器 20 可产生一系列经译码图片和相关联数据。相关联数据可包含序列参数集、图片参数集、调适参数集和其它语法结构。序列参数集（SPS）可含有适用于零个或多个图片序列的参数。图片参数集（PPS）可含有适用于零个或多个图片的参数。调适参数集（APS）可含有适用于零个或多个图片的参数。APS 中的参数可为比 PPS 中的参数更可能改变的参数。

[0047] 为产生经译码图片，视频编码器 20 可将图片分割为相等大小的视频块。视频块可为样本的二维阵列。视频块的每一者与树块（treeblock）相关联。在一些例子中，树块可称为最大译码单元（LCU）或“译码树块”。HEVC 的树块可广义上类似于例如 H.264/AVC 等先前标准的宏块。然而，树块不必限于特定大小且可包含一或多个译码单元（CU）。视频编码器 20 可使用四叉树分割将树块的视频块分割为与 CU 相关联的视频块，因此称为“树块”。

[0048] 在一些实例中，视频编码器 20 可将图片分割为多个切片。切片的每一者可包含整数数目的 CU。在一些例子中，切片包括整数数目的树块。在其它例子中，切片的边界可在树块内。

[0049] 作为对图片执行编码操作的一部分，视频编码器 20 可对图片的每一切片执行编码操作。当视频编码器 20 对切片执行编码操作时，视频编码器 20 可产生与切片相关联的经编码数据。与切片相关联的经编码数据可称为“经译码切片”。

[0050] 为产生经译码切片，视频编码器 20 可对切片中的每一树块执行编码操作。当视频编码器 20 对树块执行编码操作时，视频编码器 20 可产生经译码树块。经译码树块可包括树块的经编码表示。

[0051] 当视频编码器 20 产生经译码切片时，视频编码器 20 可根据光栅扫描次序对切片中的树块（其在此情况下表示最大译码单元）执行编码操作（即，编码）。换句话说，视频编码器 20 可以在切片中的树块的最顶部行上从左向右接着从树块的下一较低行上从左向右以此类推直到视频编码器 20 已对切片中的树块的每一者编码的次序对切片的树块编码。

[0052] 由于根据光栅扫描次序对树块编码，所以给定树块上方以及左侧的树块可已编码，但给定树块下方以及右侧的树块尚未编码。因此，视频编码器 20 可能够存取通过在编码给定树块时编码给定树块上方以及左侧的树块产生的信息。然而，视频编码器 20 可不能存取通过在编码给定树块时编码给定树块下方以及右侧的树块产生的信息。

[0053] 为产生经译码树块，视频编码器 20 可对树块的视频块递归执行四叉树分割以将视频块分割为逐渐变小的视频块。较小视频块的每一者可与不同 CU 相关联。举例来说，视

频编码器 20 可将树块的视频块分割为四个相等大小的子块，将子块的一或多者分割为四个相等大小的子子块，以此类推。经分割 CU 可为视频块分割为与其它 CU 相关联的视频块的 CU。未分割 CU 可为视频块未分割为与其它 CU 相关联的视频块的 CU。

[0054] 位流中的一或多个语法元素可指示视频编码器 20 可分割树块的视频块的最大次数。CU 的视频块可为正方形形状。CU 的视频块的大小（即，CU 的大小）范围可从 8x8 像素到树块的视频块的大小（即，树块的大小），最大 64x64 像素或更大。

[0055] 视频编码器 20 可根据 z 扫描次序对树块的每一 CU 执行编码操作（即，编码）。换句话说，视频编码器 20 可以所述次序编码左上 CU、右上 CU、左下 CU 且接着右下 CU。当视频编码器 20 对经分割 CU 执行编码操作时，视频编码器 20 可根据 z 扫描次序对与经分割 CU 的视频块的子块相关联的 CU 进行编码。换句话说，视频编码器 20 可以所述次序编码与左上子块相关联的 CU、与右上子块相关联的 CU、与左下子块相关联的 CU，且接着与右下子块相关联的 CU。

[0056] 由于根据 z 扫描次序对树块的 CU 编码，给定 CU 的上方、上方以及左侧、上方以及右侧、左侧和下方以及左侧的 CU 可已经编码。给定 CU 的下方或右侧的 CU 尚未编码。因此，视频编码器 20 可能够存取通过当编码给定 CU 时编码与给定 CU 相邻的一些 CU 而产生的信息。然而，视频编码器 20 可不能存取通过当编码给定 CU 时编码与给定 CU 相邻的其它 CU 而产生的信息。

[0057] 当视频编码器 20 编码未经分割 CU 时，视频编码器 20 可产生 CU 的一或多个预测单元 (PU)。CU 的 PU 的每一者可与 CU 的视频块内的不同视频块相关联。视频编码器 20 可产生 CU 的每一 PU 的预测视频块。PU 的预测视频块可为样本的块。视频编码器 20 可使用帧内预测或帧间预测来产生 PU 的预测视频块。

[0058] 当视频编码器 20 使用帧内预测产生 PU 的预测视频块时，视频编码器 20 可基于与 PU 相关联的图片的经解码样本产生 PU 的预测视频块。如果视频编码器 20 使用帧内预测产生 CU 的 PU 的预测视频块，那么 CU 为经帧内预测的 CU。

[0059] 当视频编码器 20 使用帧间预测产生 PU 的预测视频块时，视频编码器 20 可基于除与 PU 相关联的图片的一或多个图片的经解码样本产生 PU 的预测视频块。如果视频编码器 20 使用帧间预测产生 CU 的 PU 的预测视频块，那么 CU 为经帧间预测的 CU。

[0060] 此外，当视频编码器 20 使用帧间预测产生 PU 的预测视频块时，视频编码器 20 可产生 PU 的运动信息。PU 的运动信息可指示 PU 的一或多个参考块。PU 的每一参考块可为参考图片内的视频块。参考图片可为除与 PU 相关联的图片以外的图片，在一些例子中，PU 的参考块也可称为 PU 的“参考样本”。视频编码器 20 可基于 PU 的参考块产生 PU 的预测视频块。

[0061] 如上文论述，切片可为 I 切片、P 切片或 B 切片。在 I 切片中，所有 PU 经帧内预测。在 P 切片和 B 切片中，PU 可经帧内预测或帧间预测。当视频编码器 20 对 P 切片中的 PU 执行帧间预测时，视频编码器 20 可产生识别单一参考图片中的位置的运动信息。换句话说，PU 可经单向帧间预测。运动信息可包含参考图片索引和运动向量。参考图片索引可指示参考图片在第一参考图片列表（“列表 0”）中的位置。运动向量可指示与 PU 相关联的视频块与参考图片内的参考块之间的空间位移。例如视频编码器 20 或视频解码器 30 的视频译码器可随后基于与 PU 的运动信息相关联的单一参考块产生 PU 的预测视频块。举例来说，

视频译码器可产生 PU 的预测视频块使得所述预测视频块与参考块匹配。

[0062] B 切片中的 PU 可基于列表 0 单向帧间预测、基于第二参考图片列表（“列表 1”）单向帧间预测，或双向帧间预测。如果 B 切片中的 PU 基于列表 0 单向帧间预测，那么 PU 的运动信息可包含列表 0 参考图片索引和列表 0 运动向量。列表 0 参考图片索引可通过指示参考图片在列表 0 中的位置而识别参考图片。列表 0 运动向量可指示与 PU 相关联的视频块与参考图片内的参考块之间的空间位移。视频编码器 20 可基于与列表 0 运动向量相关联的参考块产生 PU 的预测视频块。换句话说，视频编码器 20 可基于列表 0 运动向量识别的参考样本的块产生 PU 的预测视频块，或可基于从列表 0 运动向量识别的参考样本的块合成（例如，内插）的参考样本的块产生 PU 的预测视频块。

[0063] 如果 B 切片中的 PU 基于列表 1 单向帧间预测，那么 PU 的运动信息可包含列表 1 参考图片索引和列表 1 运动向量。列表 1 参考图片索引可通过指示参考图片在列表 1 中的位置而识别参考图片。列表 1 运动向量可指示 PU 与参考图片内的参考块之间的空间位移。视频编码器 20 可基于与列表 1 运动向量相关联的参考样本的块产生 PU 的预测视频块。举例来说，视频编码器 20 可基于列表 1 运动向量识别的参考样本的块产生 PU 的预测视频块，或可基于从列表 1 运动向量识别的参考样本的块合成（例如，内插）的参考样本的块产生 PU 的预测视频块。

[0064] 如果 B 切片中的 PU 双向帧间预测，那么 PU 的运动信息可包含列表 0 参考图片索引、列表 0 运动向量、列表 1 参考图片索引和列表 1 运动向量。在一些例子中，列表 0 和列表 1 参考图片索引可识别同一图片。视频编码器 20 可基于与列表 0 和列表 1 运动向量相关联的参考块产生 PU 的预测视频块。在一些实例中，视频编码器 20 可通过从与列表 0 运动向量相关联的参考块中的样本和与列表 1 运动向量相关联的参考块中的样本内插预测视频块而产生 PU 的预测视频块。

[0065] 在视频编码器 20 产生 CU 的一或多个 PU 的预测视频块之后，视频编码器 20 可基于 CU 的 PU 的预测视频块产生 CU 的残余数据。CU 的残余数据可指示 CU 的 PU 的预测视频块与 CU 的原始视频块中的样本之间的差异。

[0066] 此外，作为对未经分割 CU 执行编码操作的一部分，视频编码器 20 可对 CU 的残余数据执递归行四叉树分割以将 CU 的残余数据分割为与 CU 的变换单元 (TU) 相关联的残余数据的一或多个块（即，残余数据块）。

[0067] 视频译码器 20 可将一或多个变换应用于同 TU 相关联的残余视频块以产生与 TU 相关联的变换系数块（即，变换系数的块）。概念上，变换系数块可为变换系数的二维 (2D) 矩阵。

[0068] 在产生变换系数块之后，视频编码器 20 可对变换系数块执行量化过程。量化通常指代变换系数经量化以可能减少用于表示变换系数的数据量从而提供进一步压缩的过程。量化过程可减小与一些或所有变换系数相关联的位深度。举例来说，n 位变换系数可在量化期间下舍入到 m 位变换系数，其中 n 大于 m。

[0069] 视频编码器 20 可使每一 CU 与量化参数 (QP) 值相关联。与 CU 相关联的 QP 值可确定视频编码器 20 如何量化与 CU 相关联的变换系数块。视频编码器 20 可通过调整与 CU 相关联的 QP 值而调整施加到与 CU 相关联的变换系数块的量化程度。

[0070] 在视频编码器 20 量化变换系数块之后，视频编码器 20 可产生表示经量化变换系

数块中的变换系数的语法元素的集合。视频编码器 20 可向这些语法元素中的一些应用熵编码操作，例如上下文自适应二进制算术译码 (CABAC) 操作。

[0071] 视频编码器 20 产生的位流可包含一系列网络抽象层 (NAL) 单元。NAL 单元的每一者可为含有 NAL 单元中数据的类型和含有所述数据的字节的指示的语法结构。举例来说，NAL 单元可含有表示序列参数集、图片参数集、经译码切片、补充增强信息 (SEI)、存取单元限定符、填充数据，或另一类型的数据的数据。NAL 单元中的数据可包含各种语法结构。

[0072] 视频解码器 30 可接收视频编码器 20 产生的位流。位流可包含由视频编码器 20 编码的视频数据的经译码表示。当视频解码器 30 接收位流时，视频解码器 30 可对位流执行解析操作。当视频解码器 30 执行解析操作时，视频解码器 30 可从位流提取语法元素。视频解码器 30 可基于从位流提取的语法元素重建视频数据的图片。基于语法元素重建视频数据的过程可通常与由视频编码器 20 执行以产生语法元素的过程互逆。

[0073] 在视频解码器 30 提取与 CU 相关联的语法元素之后，视频解码器 30 可基于语法元素产生 CU 的 PU 的预测视频块。另外，视频解码器 30 可反向量化与 CU 的 TU 相关联的变换系数块。视频解码器 30 可对变换系数块执行反向变换以重建与 CU 的 TU 相关联的残余视频块。在产生预测视频块且重建残余视频块之后，视频解码器 30 可基于预测视频块和残余视频块重建 CU 的视频块。以此方式，视频解码器 30 可基于位流中的语法元素重建 CU 的视频块。

[0074] 如上文描述，视频编码器 20 可使用帧间预测产生与 CU 的 PU 的运动信息相关联的预测视频块。在许多例子中，给定 PU 的运动信息可能与一或多个附近 PU(即，视频块在空间或时间上在给定 PU 的视频块附近的 PU) 的运动信息相同或类似。因为附近 PU 频繁地具有类似运动信息，所以视频编码器 20 可参考一或多个附近 PU 的运动信息编码给定 PU 的运动信息。参考所述一或多个附近 PU 的运动信息编码给定 PU 的运动信息可减少位流中指示给定 PU 的运动信息所需的位的数目。

[0075] 视频编码器 20 可以各种方式参考一或多个附近 PU 的运动信息编码给定 PU 的运动信息。举例来说，视频编码器 20 可使用合并模式或先进运动向量预测 (AMVP) 模式编码给定 PU 的运动信息。为使用合并模式编码 PU 的运动信息，视频编码器 20 可产生 PU 的合并候选者列表。合并候选者列表可包含一或多个合并候选者。合并候选者的一者指定运动信息的集合。视频编码器 20 可基于空间上与同一图片中的 PU 相邻的 PU 所指定的运动信息 (其可称为空间合并候选者) 或基于另一图片中协同定位的 PU(其可称为时间合并候选者) 产生合并候选者的一或多者。如果合并候选者指定的运动信息与两个参考块相关联，那么合并候选者可在本文中称为双向合并候选者或双向的合并候选者。否则，如果合并候选者指定的运动信息与仅单一参考块相关联，那么合并候选者可在本文中称为单向合并候选者或单向的合并候选者。视频编码器 20 可从合并候选者列表选择合并候选者的一者，且信令 PU 的候选者索引值。候选者索引值可指示选定合并候选者在合并候选者列表中的位置。

[0076] 当视频编码器 20 使用合并模式编码 PU 的运动信息时，视频解码器 30 可产生与视频编码器 20 针对 PU 产生的相同的 PU 的合并候选者列表。视频解码器 30 可接着基于 PU 的候选者索引值确定合并候选者列表中的合并候选者的哪一者由视频编码器 20 选择。视频解码器 30 可接着采用选定合并候选者指定的运动信息作为 PU 的运动信息。选定候选者

指定的运动信息可包含一或多个运动向量和一或多个参考图片索引。

[0077]　当视频编码器 20 使用 AMVP 信令 PU 的运动信息时，视频编码器 20 可在 PU 基于列表 0 单向帧间预测的情况下或在 PU 基于列表 0 和列表 1 中的参考图片双向帧间预测的情况下产生 PU 的列表 0MV 预测器候选者列表。列表 0MV 预测器候选者列表可包含一或多个 MV 预测器候选者。MV 预测器候选者的每一者指定运动信息的集合。视频编码器 20 可从列表 0 MV 预测器候选者列表选择列表 0 MV 预测器候选者。视频编码器 20 可信令指示选定列表 0MV 预测器候选者在列表 0 MV 预测器候选者列表中的位置的列表 0MV 预测器旗标。列表 0MV 预测器旗标可表示为“mvp_10_flag”。

[0078]　另外，当视频编码器 20 使用 AMVP 信令 PU 的运动信息时，视频编码器 20 可在 PU 基于列表 1 单向帧间预测的情况下或在 PU 双向帧间预测的情况下产生 PU 的列表 1MV 预测器候选者列表。列表 1MV 预测器候选者列表可包含一或多个 MV 预测器候选者。MV 预测器候选者的每一者指定运动信息的集合。视频编码器 20 可接着从列表 1 MV 预测器候选者列表选择列表 1MV 预测器候选者。视频编码器 20 可信令指示选定列表 1MV 预测器候选者在列表 1MV 预测器候选者列表中的位置的列表 1MV 预测器旗标。列表 1MV 预测器旗标可表示为“mvp_11_flag”。

[0079]　另外，当视频编码器 20 使用 AMVP 信令 PU 的运动信息时，视频编码器 20 可在 PU 基于列表 0 单向帧间预测的情况下或在 PU 双向帧间预测的情况下计算 PU 的列表 0 运动向量差 (MVD)。列表 0 MVD 指示 PU 的列表 0 运动向量与选定列表 0 MV 预测器候选者指定的列表 0 运动向量之间的差。另外，视频编码器 20 可在 PU 基于列表 1 单向帧间预测的情况下或在 PU 双向帧间预测的情况下输出 PU 的列表 1MVD。列表 1MVD 指示 PU 的列表 1 运动向量与选定列表 1MV 预测器候选者指定的列表 1 运动向量之间的差。视频编码器 20 可信令列表 0MVD 和／或列表 1MVD。

[0080]　当视频编码器 20 使用 AMVP 模式信令 PU 的运动信息时，视频解码器 30 可独立地产生视频编码器 20 产生的相同列表 0 和／或列表 1MV 预测器候选者列表。在其它实例中，视频编码器 20 可编码指定列表 0 和列表 1MV 预测器候选者列表的语法元素。如果 PU 基于列表 0 单向帧间预测或如果 PU 双向帧间预测，那么视频解码器 30 可从列表 0 MV 预测器候选者列表确定选定列表 0 MV 预测器候选者。视频解码器 30 可接着基于 PU 的选定列表 0 MV 预测器候选者和列表 0 MVD 确定 PU 的列表 0 运动向量。举例来说，视频解码器 30 可通过将选定列表 0MV 预测器候选者和列表 0 MVD 指定的列表 0 运动向量相加而确定 PU 的列表 0 运动向量。如果 PU 基于列表 1 单向帧间预测或如果 PU 双向帧间预测，那么视频解码器 30 可从列表 1MV 预测器候选者列表确定选定列表 1MV 预测器候选者。视频解码器 30 可接着基于选定列表 1MV 候选者和列表 1MVD 指定的列表 1 运动向量确定 PU 的列表 1 运动向量。举例来说，视频解码器 30 可通过将选定列表 1MV 候选者和列表 1MVD 指定的列表 1 运动向量相加而确定 PU 的列表 1 运动向量。

[0081]　如上文简要论述，当视频编码器 20 对 B 切片中的 PU 执行帧间预测时，视频编码器 20 可产生与 PU 的一个或两个参考块相关联的运动信息。例如视频编码器 20 或视频解码器 30 等视频译码器可接着基于与 PU 的运动信息相关联的参考块产生 PU 的预测视频块。为基于两个参考块产生预测视频块，视频译码器可从存储器检索参考块的两者。因为存储器带宽（即，数据可从存储器转移的速率）可能有限，所以可能与从存储器检索单一参考块将花

费的时间相比花费较长时间从存储器检索两个参考块。因此，如果 B 切片包含许多小双向帧间预测 PU，那么检索 PU 的每一者的两个参考块所需的额外时间可减缓视频译码器能够产生 B 切片中的 PU 的预测视频块的速度。

[0082] 根据本发明的技术的各个实例，例如视频编码器 20 或视频解码器 30 等视频译码器可确定 B 切片中的 PU 是否限于单向帧间预测。在一些实例中，视频译码器可基于 PU 的大小特性或某一参数确定 PU 限于单向帧间预测。另外，视频译码器可产生 PU 的合并候选者列表且确定合并候选者列表中的选定合并候选者。如果 PU 限于单向帧间预测，那么视频译码器可基于与选定合并候选者指定的运动信息相关联的不超过一个参考块产生 PU 的预测视频块。另一方面，如果 PU 不限于单向帧间预测，那么视频译码器可基于与选定合并候选者指定的运动信息相关联的一或多个参考块产生 PU 的预测视频块。因为视频译码器在基于单一参考块产生预测视频块时比在基于两个参考块产生预测视频块时从存储器转移更少数据，所以由视频编码器和解码器将 B 切片中的特定 PU 限于单向帧间预测可增加视频编码器和解码器能够产生 B 切片中的 PU 的预测视频块的速度。

[0083] 视频译码器（即，视频编码器或视频解码器）可基于各种准则确定 B 切片中的 PU 限于单向帧间预测。举例来说，如果 PU 的大小特性低于特定阈值，那么视频译码器可确定 B 切片中的 PU 限于单向帧间预测。在此实例中，如果 PU 的大小特性不低于特定阈值，那么视频译码器可确定 PU 不限于单向帧间预测。举例来说，在此实例中，如果与 PU 相关联的视频块的高度或宽度低于阈值，那么视频译码器可确定 PU 限于单向帧间预测。举例来说，如果与 PU 相关联的视频块的高度和 / 或宽度小于 N（例如，N ＝ 8）像素，那么视频译码器可确定 PU 限于单向帧间预测。

[0084] 在另一实例中，如果与 PU 相关联的视频块的第一尺寸小于阈值且与 PU 相关联的视频块的第二尺寸小于或等于所述阈值，那么视频译码器可确定 B 切片中的 PU 限于单向帧间预测。视频块的尺寸可为视频块的宽度或高度。举例来说，如果阈值等于 8，那么在视频块的宽度等于 4 但视频块的高度等于 16 的情况下，视频译码器可确定 PU 不限于单向帧间预测。然而，如果阈值等于 8，那么在视频块的宽度等于 4 但视频块的高度等于 8 的情况下，视频译码器可确定 PU 限于单向帧间预测。

[0085] 在另一实例中，如果与 PU 相关联的视频块的第一尺寸小于第一阈值且与 PU 相关联的视频块的第二尺寸小于第二阈值，那么视频译码器可确定 B 切片中的 PU 限于单向帧间预测。举例来说，如果视频块的宽度小于 8 且视频块的高度小于 16，那么视频译码器可确定 PU 限于单向帧间预测。在一些例子中，第一阈值可与第二阈值相同。

[0086] 在另一实例中，如果与 PU 相关联的 CU（例如，当前 CU）的大小特性等于特定大小且 PU 的大小特性低于阈值，那么视频译码器可确定 PU 限于单向帧间预测。在此实例中，如果 CU 的大小特性不等于特定大小或 PU 的大小特性不低于阈值，那么视频译码器可确定 PU 不限于单向帧间预测。在此实例中，特定大小可等于 N（例如，N ＝ 8）像素，且阈值也可等于 N（例如，N ＝ 8）像素。在此实例中，对于具有 8x8 大小的 CU，CU 的具有小于 8x8 的大小的任何 PU 可被抑制进行双向帧间预测。

[0087] 在另一实例中，如果参数指示 B 切片中的 PU 将限于单向帧间预测，那么视频译码器可确定 B 切片中的 PU 限于单向帧间预测。

[0088] 视频译码器可以各种方式将 B 切片中的 PU 限于单向帧间预测。举例来说，视频译

码器可忽略与PU的运动信息相关联的参考块的一者且基于与PU的运动信息相关联的参考块的另一者产生PU的预测视频块。举例来说，视频译码器可产生合并候选者列表，且如果选定合并候选者是双向合并候选者，那么视频译码器可基于与选定合并候选者的列表0参考图片索引以及选定合并候选者的列表0运动向量相关联的参考块产生PU的预测视频块。在类似实例中，视频译码器可基于与选定合并候选者的列表1参考图片索引以及选定合并候选者的列表1运动向量相关联的参考块产生PU的预测视频块。

[0089] 在关于视频译码器可如何将B切片中的PU限于单向帧间预测的另一实例中，视频译码器可在PU的合并候选者列表中包含单向合并候选者，而不在PU的合并候选者列表中包含双向合并候选者。在此实例中，视频译码器不将双向合并候选者转换为单向合并候选者。在此实例中，如果可用单向合并候选者的数目不足以填充合并候选者列表，那么视频译码器可在合并候选者列表中包含人为单向合并候选者。人为合并候选者可为基于一或多个PU的运动信息产生但不指定所述一或多个PU的运动信息的合并候选者。

[0090] 在关于视频译码器可如何将B切片中的PU限于单向帧间预测的另一实例中，视频译码器可将双向合并候选者转换为一或多个单向合并候选者，且在合并候选者列表中包含所述一或多个单向合并候选者。在一些此类实例中，视频译码器可将双向合并候选者转换为与列表0中的参考图片或列表1中的参考图片相关联的单一单向合并候选者。在一些此类情况下，不论何时视频译码器将双向合并候选者转换为单向合并候选者，所述单向合并候选者均与特定参考列表中的参考图片相关联。举例来说，视频译码器可仅将双向合并候选者转换为与列表0中的参考图片相关联的单一单向合并候选者。或者，视频译码器可仅将双向合并候选者转换为与列表1中的参考图片相关联的单一单向合并候选者。在其它此类实例中，视频译码器可将双向合并候选者转换为两个单向合并候选者，其中一者与列表0中的参考图片相关联且其中另一者与列表1中的参考图片相关联。因此，在一些实例中，在产生合并候选者列表之后，视频译码器可将合并候选者列表中的双向合并候选者转换为单向合并候选者，且将所述单向合并候选者包含在合并候选者列表中代替双向合并候选者。

[0091] 在一些实例中，视频译码器可在将双向合并候选者转换为单向合并候选者之前从合并候选者列表移除复制的合并候选者。在其它实例中，视频译码器可在将双向合并候选者转换为单向合并候选者之后从合并候选者列表移除复制的合并候选者。

[0092] 当视频编码器20使用AMVP编码B切片中的PU的运动信息时，视频编码器20可产生、熵编码和输出PU的帧间预测模式指示符。所述帧间预测模式指示符可表示为“inter_pred_idc”。所述帧间预测模式指示符可指示PU基于列表0单向帧间预测、基于列表1单向帧间预测，还是双向帧间预测。视频解码器30可在对PU执行帧间预测时使用帧间预测模式指示符。因为帧间预测模式指示符具有三个可能值，所以帧间预测模式指示符可常规行使用两个位表示。

[0093] 然而，如果B切片中的PU限于单向帧间预测，那么帧间预测模式指示符可具有两个可能值：基于列表0的单向帧间预测和基于列表1的单向帧间预测。因此，根据本发明的技术，如果B切片中的PU限于单向帧间预测，那么帧间预测模式指示符可使用单一位表示。否则，如果PU不限于单向帧间预测，那么帧间预测模式指示符可使用两个位表示。当PU限于单向帧间预测时使用单一位表示帧间预测模式指示符可增加译码效率。

[0094] 此外，可在PU限于单向帧间预测的情况下使用与PU不限于单向帧间预测的情况

下不同的上下文对 B 切片中的 PU 的帧间预测模式指示符进行熵译码。这可进一步增加译码效率。

[0095]　图 2 是说明经配置以实施本发明的技术的实例视频编码器 20 的框图。图 2 出于阐释的目的而提供且不应视为限制如本发明广义上例证且描述的技术。出于阐释的目的，本发明在 HEVC 译码的上下文中描述视频编码器 20。然而，本发明的技术可适用于其它译码标准或方法。

[0096]　在图 2 的实例中，视频编码器 20 包含多个功能组件。视频编码器 20 的功能组件包含预测模块 100、残余产生模块 102、变换模块 104、量化模块 106、反向量化模块 108、反向变换模块 110、重建模块 112、滤波器模块 113、经解码图片缓冲器 114，和熵编码模块 116。预测模块 100 包含帧内预测模块 121、运动估计模块 122、运动补偿模块 124 和帧内预测模块 126。在其它实例中，视频编码器 20 可包含更多、更少或不同功能组件。此外，运动估计模块 122 和运动补偿模块 124 可高度集成，但在图 2 的实例中出于阐释的目的单独表示。

[0097]　视频编码器 20 可接收视频数据。视频编码器 20 可从各个源接收视频数据。举例来说，视频编码器 20 可从视频源 18(图 1) 或另一源接收视频数据。视频数据可表示一系列图片。为编码视频数据，视频编码器 20 可对图片的每一者执行编码操作。作为对图片执行编码操作的一部分，视频编码器 20 可对图片的每一切片执行编码操作。作为对切片执行编码操作的一部分，视频编码器 20 可对切片中的树块执行编码操作。

[0098]　作为对树块执行编码操作的一部分，预测模块 100 可对树块的视频块执行四叉树分割以将视频块划分为逐渐变小的视频块。较小视频块的每一者可与不同 CU 相关联。举例来说，预测模块 100 可将树块的视频块分割为相等大小的子块，将子块的一或多者分割为相等大小的子子块，以此类推。

[0099]　与 CU 相关联的视频块的大小范围可从 8x8 样本到具有最大 64x64 样本或更大的树块的大小。在本发明中，“NxN”和“N 乘 N”可互换使用以指代在垂直和水平尺寸方面视频块的样本尺寸（例如，16x16 样本或 16 乘 16 样本）。一般来说，16x16 视频块具有垂直方向上 $(y = 16)$ 十六个样本且水平方向上 $(x = 16)$ 十六个样本。同样，N 乘 N 块通常具有垂直方向上 N 个样本以及水平方向上 N 个样本，其中 N 表示非负整数值。

[0100]　此外，作为对树块执行编码操作的一部分，预测模块 100 可产生树块的层级四叉树数据结构。举例来说，树块可对应于四叉树数据结构的根节点。如果预测模块 100 将树块的视频块分割为四个子块，那么根节点具有四叉树数据结构中的四个子节点。子节点的每一者对应于与子块的一者相关联的 CU。如果预测模块 100 将子块的一者分割为四个子子块，那么对应于与子块相关联的 CU 的节点可具有四个子节点，其每一者对应于与子子块的一者相关联的 CU。

[0101]　四叉树数据结构的每一节点可含有对应树块或 CU 的语法数据（例如，语法元素）。举例来说，四叉树中的节点可包含分离旗标，其指示对应于节点的 CU 的视频块是否分割（即，分离）为四个子块。CU 的语法元素递归地界定，且可取决于 CU 的视频块是否分离为子块。视频块不分割的 CU 可对应于四叉树数据结构中的叶节点。经译码树块可包含对应树块的基于四叉树数据结构的数据。

[0102]　视频编码器 20 可对树块的每一未经分割 CU 执行编码操作。当视频编码器 20 对未经分割 CU 执行编码操作时，视频编码器 20 可产生未经分割 CU 的经编码表示。

[0103] 作为对 CU 执行编码操作的一部分，预测模块 100 可在 CU 的一或多个 PU 之间分割 CU 的视频块。视频编码器 20 和视频解码器 30 可支持各种 PU 大小。假定特定 CU 的大小为 2Nx2N，视频编码器 20 和视频解码器 30 可支持用于帧内预测的 2Nx2N 或 NxN 的 PU 大小，以及用于帧间预测的 2Nx2N、2NxN、Nx2N、NxN 或类似的对称 PU 大小。视频编码器 20 和视频解码器 30 还可支持用于帧间预测的 2NxnU、2NxnD、nLx2N 和 nRx2N 的 PU 大小的非对称分割。在一些实例中，预测模块 100 可执行几何分割以沿着不以直角与 CU 的视频块的侧边相遇的边界在 CU 的 PU 之间分割 CU 的视频块。

[0104] 帧间预测模块 121 可对 CU 的 PU 的每一者执行帧间预测。帧间预测可提供时间压缩。当帧间预测模块 121 对 PU 执行帧间预测时，帧间预测模块 121 可产生 PU 的预测数据。PU 的预测数据可包含对应于 PU 和 PU 的运动信息的预测视频块。运动估计模块 122 可产生 PU 的运动信息。在一些例子中，运动估计模块 122 可使用合并模式或 AMVP 模式来信令 PU 的运动信息。运动补偿模块 124 可基于除当前图片（即，参考图片）外的一或多个图片的样本产生 PU 的预测视频块。

[0105] 切片可为 I 切片、P 切片或 B 切片。运动估计模块 122 和运动补偿模块 124 可依据 PU 在 I 切片、P 切片还是 B 切片中而执行 CU 的 PU 的不同操作。在 I 切片中，所有 PU 经帧内预测。因此，如果 PU 在 I 切片中，那么运动估计模块 122 和运动补偿模块 124 不对 PU 执行帧间预测。

[0106] 如果 PU 在 P 切片中，那么含有 PU 的图片与称为“列表 0”的参考图片的列表相关联。在一些实例中，列表 0 中列举的每一参考图片在显示次序中的当前图片之前发生。列表 0 中参考图片的每一者含有可用于其它图片的帧间预测的样本。当运动估计模块 122 相对于 P 切片中的 PU 执行运动估计操作时，运动估计模块 122 可搜索列表 0 中的参考图片以寻找 PU 的参考块。PU 的参考块可为样本的集合，例如最紧密对应于 PU 的视频块中的样本的样本的块。运动估计模块 122 可使用多种量度来确定参考图片中的样本的集合与 PU 的视频块中的样本对应的紧密程度。举例来说，运动估计模块 122 可通过绝对差之和 (SAD)、均方差之和 (SSD) 或其它差值量度确定参考图片中的样本的集合与 PU 的视频块中的样本对应的紧密程度。

[0107] 在识别或合成 P 切片中的 PU 的参考块之后，运动估计模块 122 可产生指示含有参考块的列表 0 中的参考图片的参考图片索引，和指示 PU 与参考块之间的空间位移的运动向量。运动估计模块 122 可产生不同精度的运动向量。举例来说，运动估计模块 122 可产生四分之一样本精度、八分之一样本精度或其它分数样本精度的运动向量。在分数样本精度的情况下，参考块值可从参考图片中的整数位置样本值内插。运动估计模块 122 可输出参考图片索引和运动向量作为 PU 的运动信息。运动补偿模块 124 可基于与 PU 的运动信息相关联的参考块产生 PU 的预测视频块。

[0108] 如果 PU 在 B 切片中，那么含有 PU 的图片可与参考图片的两个列表相关联，称为“列表 0”和“列表 1”。在一些实例中，含有 B 切片的图片可与作为列表 0 与列表 1 的组合的列表组合相关联。在一些实例中，列表 1 中列举的每一参考图片在显示次序中的当前图片之后发生。

[0109] 此外，如果 PU 在 B 切片中，那么运动估计模块 122 可执行 PU 的单向帧间预测或双向帧间预测。当运动估计模块 122 执行 PU 的单向帧间预测时，运动估计模块 122 可搜索列

表 0 或列表 1 的参考图片以寻找 PU 的参考块。运动估计模块 122 可接着产生指示含有参考块的列表 0 或列表 1 中的参考图片的参考图片索引，和指示 PU 与参考块之间的空间位移的运动向量。

[0110] 当运动估计模块 122 执行 PU 的双向帧间预测时，运动估计模块 122 可搜索列表 0 的参考图片以寻找 PU 的参考块，且还可搜索列表 1 的参考图片以寻找 PU 的另一参考块。运动估计模块 122 可接着产生指示含有参考块的列表 0 和列表 1 中的参考图片的参考图片索引，和指示参考块与 PU 之间的空间位移的运动向量。PU 的运动信息可包含参考图片索引和 PU 的运动向量。运动补偿模块 124 可基于 PU 的运动信息指示的参考块产生 PU 的预测视频块。

[0111] 运动补偿模块 124 可基于与 PU 的运动信息相关联的一或多个参考块产生 PU 的预测视频块。根据本发明的技术，运动补偿模块 124 可确定 PU 是否限于单向帧间预测。另外，运动补偿模块 124 可产生 PU 的合并候选者列表，且确定合并候选者列表中的选定合并候选者。如果 PU 限于单向帧间预测，那么运动补偿模块 124 可基于与选定合并候选者指定的运动信息相关联的不超过一个参考块产生 PU 的预测视频块。如果 PU 不限于单向帧间预测，那么运动补偿模块 124 可基于与选定合并候选者指定的运动信息相关联的一或多个参考块产生 PU 的预测视频块。

[0112] 作为对 CU 执行编码操作的一部分，帧内预测模块 126 可对 CU 的 PU 执行帧内预测。帧内预测可提供空间压缩。当帧内预测模块 126 对 PU 执行帧内预测时，帧内预测模块 126 可基于同一图片中其它 PU 的经解码样本产生 PU 的预测数据。PU 的预测数据可包含预测视频块和各种语法元素。帧内预测模块 126 可对 I 切片、P 切片和 B 切片中的 PU 执行帧内预测。

[0113] 为对 PU 执行帧内预测，帧内预测模块 126 可使用多个帧内预测模式来产生 PU 的预测数据的多个集合。当帧内预测模块 126 使用帧内预测模式来产生 PU 的预测数据的集合时，帧内预测模块 126 可在与帧内预测模式相关联的方向和 / 或梯度上在 PU 的视频块上延伸来自相邻 PU 的视频块的样本。相邻 PU 可在所述 PU 上方、上方以及右侧、上方以及左侧，或左侧，假定 PU、CU 和树块的从左向右、自顶向下编码次序。帧内预测模块 126 可使用各种数目的帧内预测模式，例如 33 个定向帧内预测模式。在一些实例中，帧内预测模式的数目可取决于 PU 的大小。

[0114] 预测模块 100 可从运动补偿模块 124 针对 PU 产生的预测数据或帧内预测模块 126 针对 PU 产生的预测数据中选择 PU 的预测数据。在一些实例中，预测模块 100 基于预测数据的集合的速率 / 失真量度选择 PU 的预测数据。

[0115] 如果预测模块 100 选择帧内预测模块 126 产生的预测数据，那么预测模块 100 可信令用于产生 PU 的预测数据的帧内预测模式，即选定帧内预测模式。预测模块 100 可以各种方式信令选定帧内预测模式。举例来说，有可能选定帧内预测模式与相邻 PU 的帧内预测模式相同。换句话说，相邻 PU 的帧内预测模式可为当前 PU 的最可能模式。因此，预测模块 100 可产生语法元素以指示选定帧内预测模式与相邻 PU 的帧内预测模式相同。

[0116] 在预测模块 100 选择 CU 的 PU 的预测数据之后，残余产生模块 102 可通过从 CU 的视频块减去 CU 的 PU 的预测视频块而产生 CU 的残余数据。CU 的残余数据可包含对应于 CU 的视频块中的样本的不同样本组件的 2D 残余视频块。举例来说，残余数据可包含对应于 CU

的PU的预测视频块中的样本的亮度组件与CU的原始视频块中的样本的亮度组件之间的差的残余视频块。另外,CU的残余数据可包含对应于CU的PU的预测视频块中的样本的色度组件与CU的原始视频块中的样本的色度组件之间的差的残余视频块。

[0117] 预测模块100可执行四叉树分割以将CU的残余视频块分割为子块。每一未划分残余视频块可与CU的不同TU相关联。与CU的TU相关联的残余视频块的大小和位置可或可不基于与CU的PU相关联的视频块的大小和位置。称为“残余四叉树”(RQT)的四叉树结构可包含与残余视频块的每一者相关联的节点。CU的TU可对应于RQT的页节点。

[0118] 变换模块104可通过将一或多个变换应用于与TU相关联的残余视频块而产生CU的每一TU的一或多个变换系数块。变换系数块的每一者可为变换系数的2D矩阵。变换模块104可将各种变换应用于与TU相关联的残余视频块。举例来说,变换模块104可将离散余弦变换(DCT)、定向变换或概念上类似的变换应用于与TU相关联的残余视频块。

[0119] 在变换模块104产生与TU相关联的变换系数块之后,量化模块106可量化变换系数块中的变换系数。量化模块106可基于与CU相关联的QP值量化与CU的TU相关联的变换系数块。

[0120] 视频编码器20可以各种方式使QP值与CU相关联。举例来说,视频编码器20可对与CU相关联的树块执行速率-失真分析。在速率-失真分析中,视频编码器20可通过对树块执行编码操作多次而产生树块的多个经译码表示。当视频编码器20产生树块的不同经编码表示时,视频编码器20可使不同QP值与CU相关联。当给定QP值与树块的经译码表示中具有最低位速率和失真量度的CU相关联时,视频编码器20可信令给定QP值与CU相关联。

[0121] 反向量化模块108和反向变换模块110可分别将反向量化和反向变换应用于变换系数块以从变换系数块重建残余视频块。重建模块112可将经重建残余视频块与来自预测模块100产生的一或多个预测视频块的对应样本相加以产生与TU相关联的经重建视频块。通过以此方式重建CU的每一TU的视频块,视频编码器20可重建CU的视频块。

[0122] 在重建模块112(表示为加法器)重建CU的视频块之后,滤波器模块113可执行解块操作以减少与CU相关联的视频块中的成块假影。在执行所述一或多个解块操作之后,滤波器模块113可将CU的经重建视频块存储在经解码图片缓冲器114中。运动估计模块122和运动补偿模块124可使用含有经重建视频块的参考图片对后续图片的PU执行帧间预测。另外,帧内预测模块126可使用经解码图片缓冲器114中的经重建视频块对与CU相同图片中的其它PU执行帧内预测。

[0123] 熵编码模块116可从视频编码器20的其它功能组件接收数据。举例来说,熵编码模块116可从量化模块106接收变换系数块且可从预测模块100接收语法元素。当熵编码模块116接收数据时,熵编码模块116可执行一或多个熵编码操作以产生经熵编码数据。举例来说,视频编码器20可对数据执行上下文自适应可变长度译码(CAVLC)操作、CABAC操作、变量到变量(V2V)长度译码操作、基于语法的上下文自适应二进制算术译码(SBAC)操作、概率间隔分割熵(PIPE)译码操作,或另一类型的熵编码操作。熵编码模块116可输出包含经熵编码数据的位流。

[0124] 作为对数据执行熵编码操作的一部分,熵编码模块116可选择上下文模式。如果熵编码模块116正执行CABAC操作,那么上下文模式可指示具有特定值的特定bin的概率

的估计值。在 CABAC 的上下文中，术语“bin”用于指代语法元素的二值化 (binarized) 版本的位。

[0125] 图 3 是说明经配置以实施本发明的技术的实例视频解码器 30 的框图。图 3 出于阐释的目的而提供且不限制如本发明广义上例证且描述的技术。出于阐释的目的，本发明在 HEVC 译码的上下文中描述视频解码器 30。然而，本发明的技术可适用于其它译码标准或方法。

[0126] 在图 3 的实例中，视频解码器 30 包含多个功能组件。视频解码器 30 的功能组件包含熵解码模块 150、预测模块 152、反向量化模块 154、反向变换模块 156、重建模块 158、滤波器模块 159 和经解码图片缓冲器 160。预测模块 152 包含运动补偿模块 162 和帧内预测模块 164。在一些实例中，视频解码器 30 可执行通常与相对于图 2 的视频编码器 20 描述的编码遍次互逆的解码遍次。在其它实例中，视频解码器 30 可包含更多、更少或不同功能组件。

[0127] 视频解码器 30 可接收包括经编码视频数据的位流。所述位流可包含多个语法元素。当视频解码器 30 接收位流时，熵解码模块 150 可对位流执行解析操作。作为对位流执行解析操作的结果，熵解码模块 150 可从位流提取语法元素。作为执行解析操作的一部分，熵解码模块 150 可对位流中的经熵编码语法元素进行熵解码。预测模块 152、反向量化模块 154、反向变换模块 156、重建模块 158 和滤波器模块 159 可执行重建操作，其基于从位流提取的语法元素产生经解码视频数据。

[0128] 如上文论述，位流可包括一系列 NAL 单元。位流的 NAL 单元可包含序列参数集 NAL 单元、图片参数集 NAL 单元、SEI NAL 单元等。作为对位流执行解析操作的一部分，熵解码模块 150 可执行解析操作，其从序列参数集 NAL 单元提取序列参数集，从图片参数集 NAL 单元提取图片参数集且从 SEI NAL 单元提取 SEI 数据，并对所述序列参数集、图片参数集和 SEI 数据进行熵解码。

[0129] 另外，位流的 NAL 单元可包含经译码切片 NAL 单元。作为对位流执行解析操作的一部分，熵解码模块 150 可执行解析操作，其从经译码切片 NAL 单元提取经译码切片并对所述经译码切片进行熵解码。经译码切片的每一者可包含切片标头和切片数据。切片标头可含有关于切片的语法元素。切片标头中的语法元素可包含识别与含有切片的图片相关联的图片参数集的语法元素。熵解码模块 150 可对经译码切片标头中的语法元素执行熵解码操作（例如，CABAC 解码操作）以恢复切片标头。

[0130] 作为从经译码切片 NAL 单元提取切片数据的一部分，熵解码模块 150 可执行解析操作，其从切片数据中的经译码 CU 提取语法元素。所提取的语法元素可包含与变换系数块相关联的语法元素。熵解码模块 150 可接着对一些语法元素执行 CABAC 解码操作。

[0131] 在熵解码模块 150 对未经分割 CU 执行解析操作之后，视频解码器 30 可对未经分割 CU 执行重建操作。为对未经分割 CU 执行重建操作，视频解码器 30 可对 CU 的每一 TU 执行重建操作。通过对 CU 的每一 TU 执行重建操作，视频解码器 30 可重建与 CU 相关联的残余视频块。

[0132] 作为对 TU 执行重建操作的一部分，反向量化模块 154 可对与 TU 相关联的变换系数块进行反向量化，即解量化。反向量化模块 154 可以与针对 HEVC 所提议或由 H.264 解码标准界定的反向量化过程类似的方式对变换系数块进行反向量化。反向量化模块 154 可使

用视频编码器 20 针对变换系数块的 CU 计算的量化参数 QP 来确定量化程度以及同样反向量化模块 154 应用的反向量化程度。

[0133] 在反向量化模块 154 对变换系数块进行反向量化之后，反向变换模块 156 可产生与变换系数块相关联的 TU 的残余视频块。反向变换模块 156 可对变换系数块应用反向变换以便产生 TU 的残余视频块。举例来说，反向变换模块 156 可对变换系数块应用反向 DCT、反向整数变换、反向卡洛 (Karhunen-Loeve) 变换 (KLT)、反向旋转变换、反向定向变换，或另一反向变换。

[0134] 在一些实例中，反向变换模块 156 可基于来自视频编码器 20 的信令确定应用于变换系数块的反向变换。在此类实例中，反向变换模块 156 可基于与变换系数块相关联的树块的四叉树的根节点处的所信令变换确定反向变换。在其它实例中，反向变换模块 156 可从例如块大小、译码模式等一或多个译码特性推断反向变换。在一些实例中，反向变换模块 156 可应用级联反向变换。

[0135] 如果 PU 在跳过模式中编码或使用合并模式编码 PU 的运动信息，那么运动补偿模块 162 可产生 PU 的合并候选者列表。运动补偿模块 162 可接着识别合并候选者列表中的选定合并候选者。在识别合并候选者列表中的选定合并候选者之后，运动补偿模块 162 可基于与选定合并候选者指定的运动信息相关联的所述一或多个参考块产生 PU 的预测视频块。

[0136] 根据本发明的技术，运动补偿模块 162 可确定 PU 是否限于单向帧间预测。此外，运动补偿模块 162 可产生 PU 的合并候选者列表，且确定合并候选者列表中的选定合并候选者。如果 PU 限于单向帧间预测，那么运动补偿模块 162 可基于与选定合并候选者指定的运动信息相关联的不超过一个参考块产生 PU 的预测视频块。否则，如果 PU 不限于单向帧间预测，那么运动补偿模块 162 可基于与选定合并候选者指定的运动信息相关联的一或多个参考块产生 PU 的预测视频块。

[0137] 如果使用 AMVP 模式对 PU 的运动信息进行编码，那么运动补偿模块 162 可产生列表 0MV 预测器候选者列表和 / 或列表 1MV 预测器候选者列表。运动补偿模块 162 可接着确定选定列表 0MV 预测器候选者和 / 或选定列表 1MV 预测器候选者。接下来，运动补偿模块 162 可基于列表 0MVD、列表 1MVD、选定列表 0MV 预测器候选者指定的列表 0 运动向量和 / 或选定列表 1MV 预测器候选者指定的列表 1 运动向量确定 PU 的列表 0 运动向量和 / 或 PU 的列表 1 运动向量。运动补偿模块 162 可接着基于与列表 0 运动向量和列表 0 参考图片索引以及 / 或列表 1 运动向量和列表 1 参考图片索引相关联的参考块产生 PU 的预测视频块。

[0138] 在一些实例中，运动补偿模块 162 可通过基于内插滤波器执行内插而改善 PU 的预测视频块。待用于具有子样本精度的运动补偿的内插滤波器的识别符可包含在语法元素中。运动补偿模块 162 可使用与视频编码器 20 在产生 PU 的预测视频块期间使用的相同的内插滤波器来计算参考块的子整数样本的内插值。运动补偿模块 162 可根据所接收的语法信息确定视频编码器 20 使用的内插滤波器，且使用所述内插滤波器产生预测视频块。

[0139] 如果使用帧内预测对 PU 进行编码，那么帧内预测模块 164 可执行帧内预测以产生 PU 的预测视频块。举例来说，帧内预测模块 164 可基于位流中的语法元素确定 PU 的帧内预测模式。位流可包含帧内预测模块 164 可用于确定 PU 的帧内预测模式的语法元素。

[0140] 在一些例子中，语法元素可指示帧内预测模块 164 将使用另一 PU 的帧内预测模式

来确定当前 PU 的帧内预测模式。举例来说，有可能当前 PU 的帧内预测模式与相邻 PU 的帧内预测模式相同。换句话说，相邻 PU 的帧内预测模式可为当前 PU 的最可能模式。因此，在此实例中，位流可包含指示 PU 的帧内预测模式与相邻 PU 的帧内预测模式相同的小语法元素。帧内预测模块 164 可接着使用帧内预测模式基于空间上相邻 PU 的视频块产生 PU 的预测数据（例如，预测样本）。

[0141] 重建模块 158 可使用与 CU 的 TU 相关联的残余视频块和 CU 的 PU 的预测视频块，即帧内预测数据或帧间预测数据（视需要），来重建 CU 的视频块。特定来说，重建模块 158 可将残余数据添加到预测数据以重建经译码视频数据。因此，视频解码器 30 可基于位流中的语法元素产生预测视频块和残余视频块，且可基于预测视频块和残余视频块产生视频块。

[0142] 在重建模块 158 重建 CU 的视频块之后，滤波器模块 159 可执行解块操作以减少与 CU 相关联的成块假影。在滤波器模块 159 执行解块操作以减少与 CU 相关联的成块假影之后，视频解码器 30 可将 CU 的视频块存储在经解码图片缓冲器 160 中。经解码图片缓冲器 160 可提供用于后续运动补偿、帧内预测和显示装置（例如，图 1 的显示装置 32）上的呈现的参考图片。举例来说，视频解码器 30 可基于经解码图片缓冲器 160 中的视频块对其它 CU 的 PU 执行帧内预测或帧间预测操作。

[0143] 图 4 是说明实例运动补偿操作 200 的流程图。例如视频编码器 20 或视频解码器 30 等视频译码器可执行运动补偿操作 200。视频译码器可执行运动补偿操作 200 以产生当前 PU 的预测视频块。

[0144] 在视频译码器开始运动补偿操作 200 之后，视频译码器可确定当前 PU 的预测模式是否为跳过模式 (202)。如果当前 PU 的预测模式不是跳过模式 (202 的“否”)，那么视频译码器可确定当前 PU 的预测模式为帧间模式且当前 PU 的帧间预测模式为合并模式 (204)。如果当前 PU 的预测模式是跳过模式 (202 的“是”)，或如果当前 PU 的预测模式为帧间模式且当前 PU 的帧间预测模式为合并模式 (204 的“是”)，那么视频译码器可产生当前 PU 的合并候选者列表 (206)。合并候选者列表可包含多个合并候选者。合并候选者的每一者指定运动信息的集合，例如一或多个运动向量、一或多个参考图片索引、列表 0 预测旗标和列表 1 预测旗标。合并候选者列表可包含一或多个单向合并候选者或双向合并候选者。在一些实例中，视频译码器可执行下文参看图 6 描述的实例操作以产生合并候选者列表。

[0145] 在产生合并候选者列表之后，视频译码器可确定合并候选者列表中的选定合并候选者 (208)。如果视频译码器是视频编码器，那么视频译码器可基于速率 - 失真分析从合并候选者列表选择合并候选者。如果视频译码器是视频解码器，那么视频译码器可基于识别合并候选者列表中的选定合并候选者的位置的语法元素（例如，merge_idx）选择合并候选者。

[0146] 视频译码器可接着基于选定合并候选者指定的运动信息确定当前 PU 的运动信息 (210)。运动信息可包含一或多个运动向量和参考图片索引。视频译码器可以各种方式基于选定合并候选者指定的运动信息确定当前 PU 的运动信息。举例来说，视频译码器可确定当前 PU 的运动信息与选定合并候选者指定的运动信息相同。

[0147] 如果当前 PU 的帧间预测模式不是合并模式 (204 的“否”)，那么视频译码器可使用 AMVP 模式确定当前 PU 的运动信息 (212)。下文详细描述的图 8 是说明用于使用 AMVP 模式确定 PU 的运动信息的实例操作。

[0148] 在确定当前 PU 的运动信息之后，视频译码器可确定当前 PU 是否限于单向帧间预测 (214)。视频译码器可以各种方式确定当前 PU 是否限于单向帧间预测。举例来说，如果当前 PU 的大小特性小于阈值，那么视频译码器可确定当前 PU 限于单向帧间预测。在此实例中，如果 PU 的大小为或 8x4、4x8 或更小，那么视频译码器可确定当前 PU 限于单向帧间预测。在另一实例中，如果视频译码器为视频解码器，那么视频解码器可基于所接收位流中的语法元素确定当前 PU 限于单向帧间预测。

[0149] 响应于确定当前 PU 限于单向帧间预测 (214 的“是”)，视频译码器可基于与当前 PU 的运动信息相关联的不超过一个参考块产生当前 PU 的预测视频块 (216)。如上文指示，参考块可由选定合并候选者指定的运动信息识别或从选定合并候选者指定的运动信息所识别的参考样本合成。

[0150] 另一方面，响应于确定当前 PU 不限于单向帧间预测 (214 的“否”)，视频译码器可基于与当前 PU 的运动信息相关联的一或多个参考块产生当前 PU 的预测视频块 (218)。如上文指示，所述一或多个参考块可由选定合并候选者指定的运动信息识别和 / 或从选定合并候选者指定的运动信息所识别的参考样本合成。

[0151] 图 5 是说明另一实例运动补偿操作 270 的流程图。例如视频编码器 20 或视频解码器 30 等视频译码器可执行运动补偿操作 270 以产生当前 PU 的预测视频块。视频译码器可执行运动补偿操作 270 作为执行运动补偿操作 200 的替代。

[0152] 在视频译码器开始运动操作 270 之后，视频译码器可确定当前 PU 的预测模式是否为跳过模式 (272)。如果当前 PU 的预测模式不是跳过模式 (272 的“否”)，那么视频译码器可确定当前 PU 的预测模式为帧间模式且当前 PU 的帧间预测模式为合并模式 (273)。如果当前 PU 的预测模式为跳过模式 (272 的“是”) 或如果当前 PU 的预测模式为帧间模式且当前 PU 的帧间预测模式为合并模式 (273 的“是”)，那么视频译码器可确定当前 PU 是否限于单向帧间预测 (274)。如果当前 PU 限于单向帧间预测 (274 的“是”)，那么视频译码器可产生当前PU的合并候选者列表使得合并候选者列表不包含双向合并候选者 (276)。视频译码器可使用图 6 中说明的实例操作产生当前 PU 的合并候选者列表。

[0153] 另一方面，如果当前 PU 不限于单向帧间预测 (274 的“否”)，那么视频译码器可产生可包含单向和双向合并候选者的合并候选者列表 (278)。在一些实例中，视频译码器可执行下文参看图 6 描述的实例操作以产生合并候选者列表。因此，如果当前 PU 不限于单向帧间预测，那么合并候选者列表可包含单向合并候选者和双向合并候选者。

[0154] 在产生当前 PU 的合并候选者列表之后，视频译码器可确定合并候选者列表中的选定合并候选者 (280)。如果视频译码器是视频编码器，那么视频译码器可基于速率 - 失真分析从合并候选者列表选择合并候选者。如果视频译码器是视频解码器，那么视频译码器可基于识别合并候选者列表中的选定合并候选者的位置的语法元素 (例如，merge_idx) 选择合并候选者。

[0155] 视频译码器可接着基于选定合并候选者指定的运动信息确定当前 PU 的运动信息 (282)。选定合并候选者指定的运动信息可指定一或多个运动向量和一或多个参考图片索引。视频译码器可以各种方式基于选定合并候选者指定的运动信息确定当前 PU 的运动信息。举例来说，视频译码器可确定当前PU 的运动信息与选定合并候选者指定的运动信息相同。

[0156] 如果当前 PU 的帧间预测模式不是合并模式 (273 的“否”),那么视频译码器可使用 AMVP 模式确定当前 PU 的运动信息 (284)。下文详细描述的图 8 是说明用于使用 AMVP 模式确定 PU 的运动信息的实例操作。

[0157] 在确定当前 PU 的运动信息之后,视频译码器可产生当前 PU 的预测视频块 (286)。因为在当前 PU 限于单向帧间预测的情况下合并候选者列表仅包含单向合并候选者,所以选定合并候选者仅与单一参考块相关联。因此,如果当前 PU 在 B 切片中且限于单向帧间预测,那么当前 PU 的预测视频块可基于与选定合并候选者指定的运动信息相关联的不超过一个参考块。

[0158] 另一方面,如果当前 PU 不限于单向帧间预测,那么合并候选者列表可包含单向合并候选者和双向合并候选者。因为合并候选者列表可包含单向合并候选者和双向合并候选者,所以选定合并候选者可与一个或两个参考块相关联。因此,如果当前 PU 在 B 切片中且不限于单向帧间预测,那么当前 PU 的预测视频块可基于与选定合并候选者相关联的一或多个参考块。

[0159] 图 6 是说明用于产生合并候选者列表的实例操作 300 的流程图。例如视频编码器 20 或视频解码器 30 等视频译码器可执行操作 300 以产生当前 PU 的合并候选者列表。视频译码器可在当前 PU 的预测模式为跳过模式时或当当前 PU 的预测模式为帧间模式且当前 PU 的帧间预测模式为合并模式时执行操作 300。

[0160] 在视频译码器开始操作 300 之后,视频译码器可确定空间合并候选者的运动信息和可用性 (302)。视频译码器可基于覆盖空间上与当前 PU 相邻的位置的 PU 的运动信息确定空间合并候选者的运动信息。举例来说,视频译码器可基于覆盖当前 PU 的左侧、左下侧、左上侧和右上侧的 PU 的运动信息确定空间合并候选者的运动信息。

[0161] 视频译码器可以各种方式确定空间合并候选者的可用性。举例来说,如果空间合并候选者对应于经帧内预测的位于当前帧外部或位于当前切片外部的 PU,那么视频译码器可确定空间合并候选者不可用。此外,如果空间合并候选者的运动信息与另一空间合并候选者的运动信息相同,那么视频译码器可确定所述空间合并候选者不可用。

[0162] 另外,视频译码器可确定时间合并候选者的运动信息和可用性 (304)。时间合并候选者可指定与当前 PU 搭配但在与当前 PU 不同的图片中的 PU 的运动信息。视频译码器可以各种方式确定时间合并候选者的可用性。举例来说,如果时间合并候选者对应于经帧内预测的 PU,那么视频译码器可确定所述时间合并候选者不可用。

[0163] 在产生空间合并候选者和时间合并候选者之后,视频译码器可将空间合并候选者和时间合并候选者的可用者包含在当前 PU 的合并候选者列表中 (306)。如果合并候选者可用,那么视频译码器可将空间或时间合并候选者包含在合并候选者列表中,且如果合并候选者不可用,那么视频译码器可从合并候选者列表排除所述合并候选者。通过从合并候选者列表排除不可用合并候选者,视频译码器可实际上执行从合并候选者列表删除(例如,省略)不可用合并候选者的删除过程。

[0164] 在一些实例中,视频译码器产生合并候选者列表使得合并候选者列表仅包含单向合并候选者。在一些此类实例中,视频译码器可确定双向合并候选者不可用。即,如果合并候选者指定列表 0 运动向量和列表 1 运动向量,那么视频译码器可确定合并候选者不可用。因此,如果当前 PU 限于单向预测,那么视频译码器可确定单向合并候选者可用,而双向合

并候选者不可用。因为视频译码器不可将不可用合并候选者包含在合并候选者列表中，所以合并候选者列表可在一些实例中仅包含单向合并候选者。在此实例中，视频译码器可实际上执行从合并列表删除双向合并候选者的删除过程。

[0165] 在其中视频译码器产生合并候选者列表使得合并候选者列表仅包含单向合并候选者的其它实例中，视频译码器可将双向合并候选者转换为单向合并候选者，且接着将单向合并候选者的可用者包含在合并候选者列表中。在此类实例中，如果单向合并候选者与已添加到合并候选者列表的单向合并候选者相同，那么视频译码器可不将所述单向合并候选者添加到合并候选者列表。以此方式，视频译码器可从合并候选者列表删除复制的单向合并候选者。通过在从合并候选者列表删除复制的单向合并候选者之前将双向合并候选者转换为单向合并候选者，视频译码器可能够在删除之后避免合并候选者列表中的冗余合并候选者。在删除复制的单向合并候选者之前将双向合并候选者转换为单向合并候选者可增加视频译码器的硬件复杂性。另外，视频译码器可将相同的多个双向合并候选者转换为单向合并候选者。

[0166] 在其它实例中，视频译码器可初始将可用双向合并候选者包含在当前 PU 的合并候选者列表中。视频译码器可接着从合并候选者列表删除复制的合并候选者。在视频译码器已产生合并候选者列表之后，视频译码器可从合并候选者列表确定选定合并候选者，并在选定合并候选者为双向合并候选者的情况下将选定合并候选者转换为单向合并候选者。在此实例中，视频译码器可通过仅使用列表 0 运动向量或列表 1 运动向量指示的参考块产生当前 PU 的预测视频块而将选定双向合并候选者转换为单向合并候选者。

[0167] 与在从合并候选者列表删除复制的合并候选者之前将双向合并候选者转换为单向合并候选者相比，在从合并候选者列表删除复制的合并候选者之后将选定双向合并候选者转换为单向合并候选者可仅涉及单一转换，与多次转换形成对比。举例来说，如果转换在删除复制的合并候选者之后发生，选定合并候选者是合并候选者列表中的第三合并候选者，且第三合并候选者是双向合并候选者，那么视频译码器可仅将第三合并候选者转换为单向合并候选者。在此实例中，如果转换在删除复制的合并候选者之前发生，选定合并候选者是合并候选者列表中的第三合并候选者，且第三合并候选者是双向合并候选者，那么视频译码器可归因于在转换之后执行删除操作而必须在视频译码器能够确定选定合并候选者之前转换三个双向合并候选者。

[0168] 视频译码器可依据视频译码器在从合并候选者列表删除复制的合并候选者之前还是之后将双向合并候选者转换为单向合并候选者而产生不同合并候选者列表。举例来说，视频译码器可通过取双向合并候选者的列表 0 运动向量并忽略双向合并候选者的列表 1 运动向量而将双向合并候选者转换为单向合并候选者。在此实例中，第一合并候选者可为单向的且可指定等于值 MV1 的列表 0 运动向量。在此实例中，第二合并候选者可为双向的且可指定等于值 MV1 的列表 0 运动向量和等于值 MV2 的列表 1 运动向量。第一和第二合并候选者可指定相同列表 0 参考图片索引。在此实例中，如果视频译码器在从合并候选者列表删除复制的合并候选者之前将第二合并候选者转换为单向合并候选者，那么可存在等于 MV1 的两个单向合并候选者。因此，视频译码器可删除从第二合并候选者产生的单向合并候选者，因为其在第一合并候选者上是冗余的。因此，视频译码器可将仅一个合并候选者（例如，第一合并候选者）包含在合并候选者列表中。

[0169] 然而,在前一段落的实例中,如果视频译码器在从合并候选者列表删除复制的合并候选者之后将第二合并候选者转换为单向合并候选者,那么视频译码器可将第一和第二合并候选者两者包含在合并候选者列表中。在将第一和第二合并候选者包含在合并候选者列表中之后,视频译码器可通过取(即,保持)第二合并候选者的列表 0 运动向量且忽略第二合并候选者的列表 1 运动向量而将第二合并候选者转换为单向合并候选者。因此,合并候选者列表可实际上包含两个合并候选者,其两者均指定等于 MV1 的列表 0 运动向量。

[0170] 在将可用合并候选者包含在合并候选者列表中之后,视频译码器可确定当前 PU 是否在 B 切片中 (308)。响应于确定当前 PU 在 B 切片中 (308 的“是”),视频译码器可执行产生零个或多个人为合并候选者且将人为合并候选者包含在合并候选者列表中的过程 (310)。下文详细描述的图 7 说明用于产生人为合并候选者的实例过程。

[0171] 响应于确定当前 PU 不在 B 切片中 (308 的“否”),或在执行产生人为合并候选者的过程之后,视频译码器可确定合并候选者列表中的合并候选者的数目小于合并候选者的最大数目 (312)。如果合并候选者列表中的合并候选者的数目不小于合并候选者的最大数目 (312 的“否”),那么视频译码器已完成合并候选者列表。

[0172] 然而,响应于确定合并候选者列表中的合并候选者的数目小于合并候选者的最大数目 (312 的“是”),视频译码器可产生零值合并候选者 (314)。如果当前 PU 在 P 切片中,那么零值合并候选者可指定具有等于零的量值的列表 0 运动向量。如果当前 PU 在 B 切片中且当前 PU 不限于单向帧间预测,那么零值合并候选者可指定具有等于零的量值的列表 0 运动向量和具有等于零的量值的列表 1 运动向量。在一些实例中,如果当前 PU 在 B 切片中且当前 PU 限于单向帧间预测,那么零值合并候选者可指定具有等于零的量值的列表 0 运动向量或列表 1 运动向量。视频译码器可接着将零值合并候选者包含在合并候选者列表中 (316)。

[0173] 在将零值合并候选者包含在合并候选者列表中之后,视频译码器可再次确定合并候选者列表中的合并候选者的数目是否小于合并候选者的最大数目 (312),且如果否,那么视频译码器可产生额外零值合并候选者。以此方式,视频译码器可继续产生零值合并候选者且将零值合并候选者包含在合并候选者列表中,直到合并候选者列表中的合并候选者的数目等于合并候选者的最大数目为止。

[0174] 图 7 是说明用于产生人为合并候选者的实例过程 350 的流程图。例如视频编码器 20 或视频解码器 30 等视频译码器可执行产生人为合并候选者以供包含在当前 PU 的合并候选者列表中的过程 350。

[0175] 在视频译码器开始过程 350 之后,视频译码器可确定是否产生人为合并候选者 (352)。视频译码器可以各种方式确定是否产生人为合并候选者。举例来说,视频译码器可确定合并候选者列表中的人为合并候选者的数目是否等于可基于合并候选者列表中的原始合并候选者产生的唯一人为候选者的总数目。原始合并候选者可为指定除当前 PU 以外的 PU 的运动信息的合并候选者。此外,在此实例中,视频译码器可确定合并候选者列表是否包含最大数目的合并候选者。在此实例中,如果这些条件两者均为假,那么视频译码器可作出产生人为合并候选者的确定。

[0176] 如果视频译码器作出产生人为合并候选者的确定 (352 的“是”),那么视频译码器可确定当前 PU 是否限于单向帧间预测 (354)。如上文描述,视频译码器可以各种方式确定

当前 PU 是否限于单向帧间预测。举例来说，视频译码器可基于当前 PU 的大小特性确定当前 PU 是否限于单向帧间预测。在另一实例中，视频译码器可基于当前树块、当前 CU 或当前 PU 的语法元素中或切片标头、PPS、APS、SPS 中或另一参数集中指示的参数确定当前 PU 是否限于单向帧间预测。在一些实例中，树块中的参数可指定与树块相关联的所有 PU 限于单向帧间预测。在一些实例中，CU 中的参数可指定与 CU 相关联的所有 PU 限于单向帧间预测。在一些实例中，PPS 中的参数可指定与 PPS 相关联的所有 PU 限于单向帧间预测。在一些实例中，APS 中的参数可指定与 APS 相关联的所有 PU 限于单向帧间预测。在一些实例中，SPS 中的参数可指定与同 SPS 相关联的序列中的图片相关联的所有 PU 限于单向帧间预测。

[0177] 响应于确定当前 PU 限于单向帧间预测 (354 的“是”)，视频译码器可产生人为单向合并候选者 (356)。在产生人为单向合并候选者之后，视频译码器可将人为单向合并候选者包含在合并候选者列表中 (358)。在将人为单向合并候选者包含在合并候选者列表中之后，视频译码器可确定是否产生另一人为合并候选者 (352)，且如果是，那么产生另一人为合并候选者。

[0178] 视频译码器可以各种方式产生人为单向合并候选者。举例来说，视频译码器可通过首先取已在候选者列表中的一对单向合并候选者而产生人为单向合并候选者。第一和第二单向合并候选者可分别指定运动向量 MV1 和 MV2。在此实例中，视频译码器可接着根据第一单向合并候选者指定的参考帧与第二单向合并候选者指定的参考帧之间的时间差缩放 MV2。在此实例中，视频译码器可产生指定 MV2 的经缩放版本的人为单向合并候选者。举例来说，在此实例中，与第一单向合并候选者相关联的参考图片可在当前图片之后一个图片发生，且与第二单向合并候选者相关联的参考图片可在当前图片之后四个图片发生。在此实例中，视频译码器可将 MV2 的水平和垂直分量两者除以四且使用此经缩放 MV2 与对应于 MV1 的参考图片索引一起作为人为候选者。可基于 MV2 对 MV1 执行类似缩放。

[0179] 在另一实例中，视频译码器可产生指定双向合并候选者指定的运动向量的一者的人为单向合并候选者。举例来说，双向合并候选者可指定列表 0 运动向量和列表 1 运动向量。在此实例中，视频译码器可产生指定列表 0 运动向量但不指定列表 1 运动向量的人为单向合并候选者。在此实例中，视频译码器可产生指定列表 1 运动向量但不指定列表 0 运动向量的另一人为单向合并候选者。以此方式，视频译码器可通过将双向合并候选者分离为两个单向合并候选者（一个来自列表 0 运动向量且另一个来自列表 1 运动向量）而从双向空间或时间合并候选者产生单向人为合并候选者。视频译码器可将单向合并候选者的任一者或两者包含在合并候选者列表中。换句话说，视频译码器可产生人为单向合并候选者使得人为单向合并候选者指定双向合并候选者指定的运动向量。

[0180] 在其中视频译码器基于双向合并候选者指定的运动向量产生人为单向合并候选者的实例中，视频译码器可根据各种次序将人为单向合并候选者添加到合并候选者列表。举例来说，视频译码器可基于第一双向合并候选者的列表 0 运动向量添加人为单向合并候选者，接着基于第一双向合并候选者的列表 1 运动向量添加人为单向合并候选者，接着基于第二双向合并候选者的列表 0 运动向量添加人为单向合并候选者，接着基于第二双向合并候选者的列表 1 运动向量添加人为单向合并候选者。以此类推。

[0181] 如果当前 PU 不限于单向帧间预测 (354 的“否”)，那么视频译码器可产生人为双向合并候选者 (360)。如上文提及，视频译码器可基于例如 PU 的大小特性、参数等各种因

素确定当前PU是否限于单向帧间预测。视频译码器可以各种方式产生人为双向合并候选者。举例来说,视频译码器可选择合并候选者列表中的两个合并候选者的组合。在此实例中,视频译码器可确定是否选定合并候选者的第一者指定列表0中的参考图片,是否选定合并候选者的第二者指定列表1中的参考图片,以及是否所指定参考图片具有不同图片次序计数。如果这些条件的每一者为真,那么视频译码器可产生指定组合中的第一合并候选者的列表0运动向量和组合中的第二合并候选者的列表1运动向量的人为双向合并候选者。在一些实例中,例如图4的实例中,其中合并候选者列表可包含单向合并候选者和双向合并候选者,过程350不包含动作354、356和358。而是,视频译码器可产生B切片中的PU的合并候选者列表中的人为双向合并候选者。

[0182] 在产生人为双向合并候选者之后,视频译码器可将人为双向合并候选者包含在当前PU的合并候选者列表中(362)。视频译码器可接着确定是否产生另一人为合并候选者(352),等等。

[0183] 图8是说明用于使用AMVP模式确定PU的运动信息的实例操作400的流程图。例如视频编码器20或视频解码器30等视频译码器可执行操作400以使用AMVP模式确定PU的运动信息。

[0184] 在视频译码器开始操作400之后,视频译码器可确定当前PU的帧间预测是否基于列表0(402)。如果当前PU的帧间预测基于列表0(402的“是”),那么视频译码器可产生当前PU的列表0MV预测器候选者列表(404)。列表0MV预测器候选者列表可包含两个列表0MV预测器候选者。列表0MV预测器候选者的每一者可指定列表0运动向量。

[0185] 在产生列表0MV预测器候选者列表之后,视频译码器可确定列表0MV预测器候选者列表中的选定列表0MV预测器候选者(406)。视频译码器可基于列表0MV预测器旗标(“mvp_10_flag”)确定选定列表0MV预测器候选者。视频译码器可接着基于当前PU的列表0MVD以及选定列表0MV预测器候选者指定的列表0运动向量确定当前PU的列表0运动向量(408)。

[0186] 此外,在确定当前PU的帧间预测不基于列表0(402的“否”)之后,或在确定当前PU的列表0运动向量(408)之后,视频译码器可确定当前PU的帧间预测是否基于列表1或PU是否经双向帧间预测(410)。如果当前PU的帧间预测不基于列表1且当前PU未经双向帧间预测(410的“否”),那么视频译码器已完成使用AMVP模式确定当前PU的运动信息。响应于确定当前PU的帧间预测基于列表1或当前PU经双向帧间预测(410的“是”),视频译码器可产生当前PU的列表1MV预测器候选者列表(412)。列表1MV预测器候选者列表可包含两个列表1MV预测器候选者。列表0MV预测器候选者的每一者可指定列表1运动向量。

[0187] 在产生列表1MV预测器候选者列表之后,视频译码器可确定列表1MV预测器候选者列表中的选定列表1MV预测器候选者(414)。视频译码器可基于列表1MV预测器旗标(“mvp_11_flag”)确定选定列表1MV预测器候选者。视频译码器可接着基于当前PU的列表1MVD以及选定列表1MV预测器候选者指定的列表1运动向量确定当前PU的列表1运动向量(416)。

[0188] 在一些实例中,视频译码器可不将双向MV预测器候选者添加到列表0和列表1MV预测器候选者列表。换句话说,如果MV预测器候选者指定列表0运动向量和列表1运动向

量，那么视频译码器可从列表 0 和列表 1MV 预测器候选者列表排除 MV 预测器候选者。而是，视频译码器可仅将单向 MV 预测器候选者添加到列表 0 和列表 1MV 预测器候选者列表。视频译码器可通过检查每一可能且可用 MV 预测器候选者均为单向的且仅将单向 MV 预测器候选者包含在 MV 预测器候选者列表中而实现此目的。

[0189] 在一或多个实例中，所描述的功能可以硬件、软件、固件或其任何组合来实施。如果实施在软件中，那么所述功能可作为一或多个指令或代码存储在计算机可读媒体上或经由计算机可读媒体发射，且由基于硬件的处理单元执行。计算机可读媒体可包含对应于例如数据存储媒体等有形媒体的计算机可读存储媒体，或包含促进将计算机程序从一处转移到另一处（例如，根据通信协议）的任何媒体的通信媒体。以此方式，计算机可读媒体通常可对应于 (1) 非暂时性有形计算机可读存储媒体，或 (2) 例如信号或载波等通信媒体。数据存储媒体可为可由一或多个计算机或一或多个处理器存取以检索指令、代码和 / 或数据结构以用于实施本发明中描述的技术的任何可用媒体。计算机程序产品可包含计算机可读媒体。

[0190] 借助实例而非限制，此类计算机可读存储媒体可包括 RAM、ROM、EEPROM、CD-ROM 或其它光盘存储装置、磁盘存储装置，或其它磁性存储装置、快闪存储器，或可用于存储指令或数据结构的形式的所要程序代码且可由计算机存取的任何其它媒体。同样，恰当地将任何连接称作计算机可读媒体。举例来说，如果使用同轴电缆、光纤电缆、双绞线、数字订户线 (DSL) 或例如红外线、无线电和微波等无线技术从网站、服务器或其它远程源发射指令，那么同轴电缆、光纤电缆、双绞线、DSL 或例如红外线、无线电和微波等无线技术包含在媒体的定义中。然而，应理解，计算机可读存储媒体和数据存储媒体不包含连接、载波、信号或其它暂时性媒体，而是针对非暂时性有形存储媒体。如本文中所使用，磁盘和光盘包含紧密光盘 (CD)、激光光盘、光学光盘、数字多功能光盘 (DVD)、软磁盘和蓝光光盘，其中磁盘通常以磁性方式再现数据，而光盘使用激光以光学方式再现数据。上文的组合也应包含在计算机可读媒体的范围内。

[0191] 指令可由例如一或多个数字信号处理器 (DSP)、通用微处理器、专用集成电路 (ASIC)、现场可编程逻辑阵列 (FPGA)，或其它等效集成或离散逻辑电路等一或多个处理器执行。因此，如本文中所使用的术语“处理器”可指代上述结构或适于实施本文中所描述的技术的任一其它结构中的任一者。另外，在一些方面中，本文描述的功能性可提供在经配置用于编码和解码的专门硬件和 / 或软件模块内，或并入在组合式编解码器中。并且，可将所述技术完全实施于一或多个电路或逻辑元件中。

[0192] 本发明的技术可实施在广泛多种装置或设备中，包含无线手持机、集成电路 (IC) 或 IC 组（例如，芯片组）。本发明中描述各个组件、模块或单元以强调经配置以执行所揭示的技术的装置的功能方面，且不一定要求由不同硬件或软件单元实现。而是，如上所述，各个组件、模块和单元可组合在编解码器硬件单元中或由互操作硬件单元（包含如上文描述的一或多个处理器）结合适宜的软件和 / 或固件的集合提供。

[0193] 已描述各个实例。这些和其它实例均在所附权利要求书的范围内。

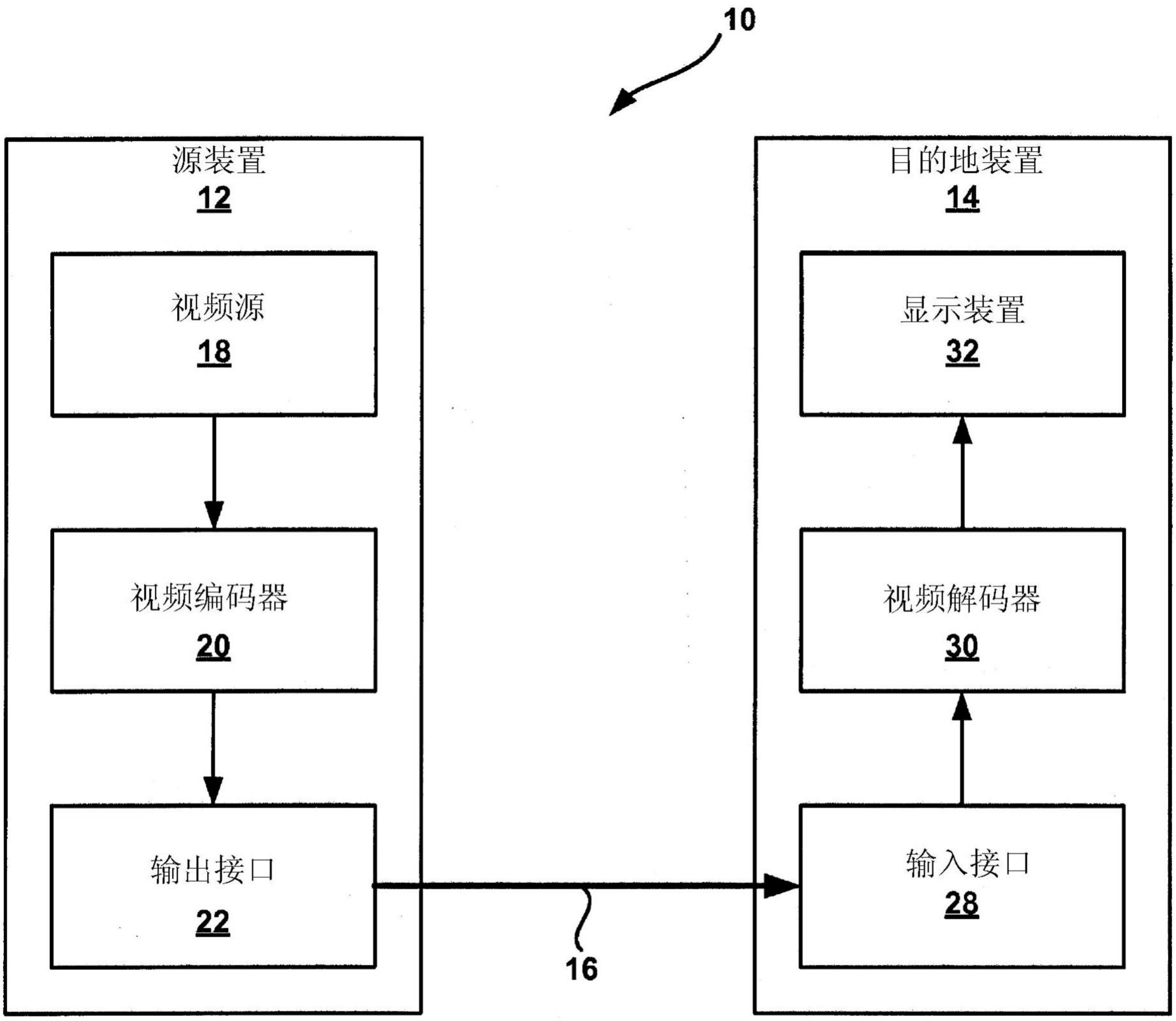

10
源装置
12
视频源
18
视频编码器
20
输出接口
22
16
目的地装置
14
显示装置
32
视频解码器
30
输入接口
28

图 1

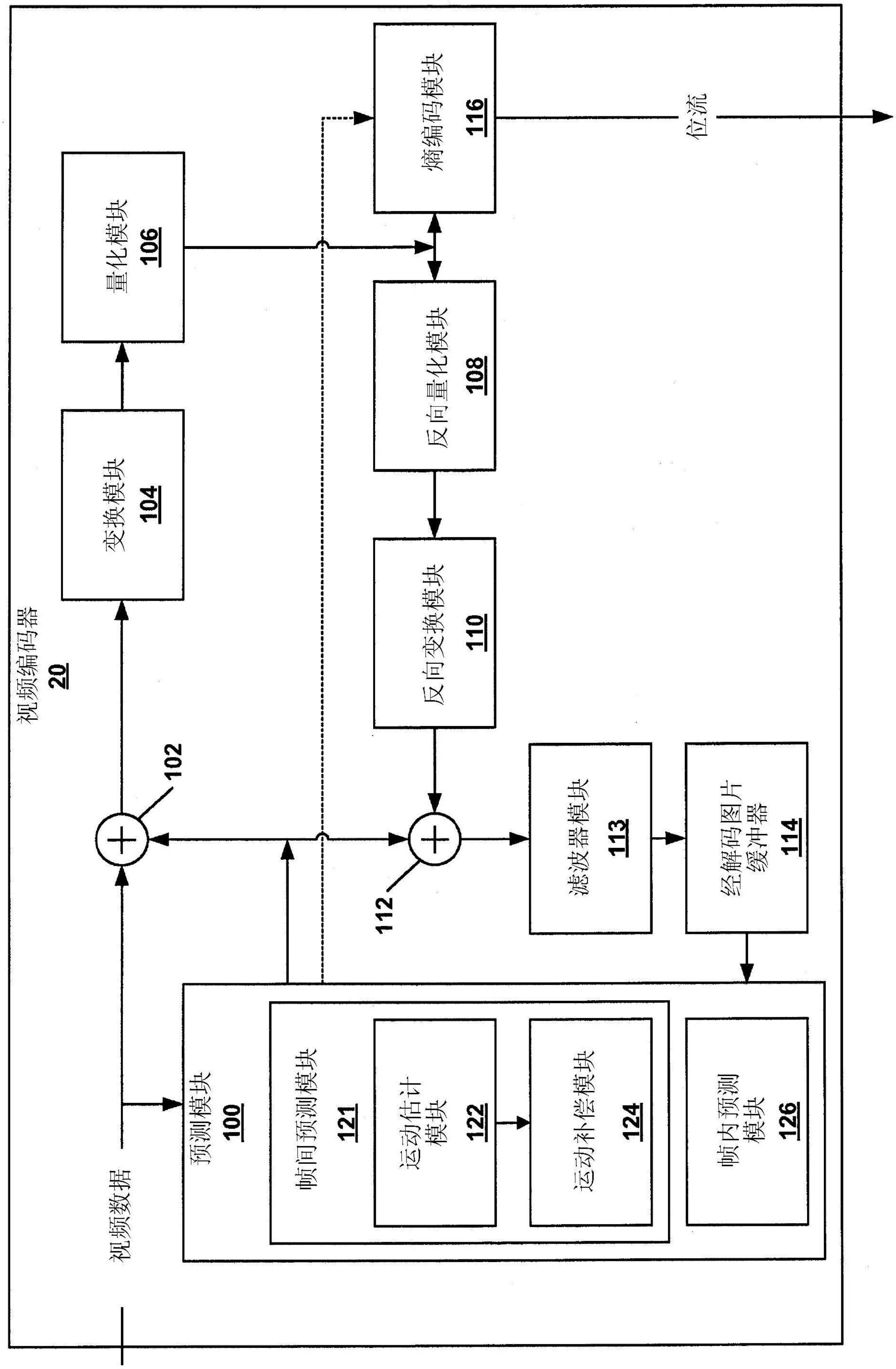

视频编码器
20
视频数据
预测模块
100
帧间预测模块
121
运动估计
模块
122
运动补偿模块
124
帧内预测
模块
126
102
变换模块
104
量化模块
106
熵编码模块
116
位流
反向量化模块
108
反向变换模块
110
112
滤波器模块
113
经解码图片
缓冲器
114

图 2

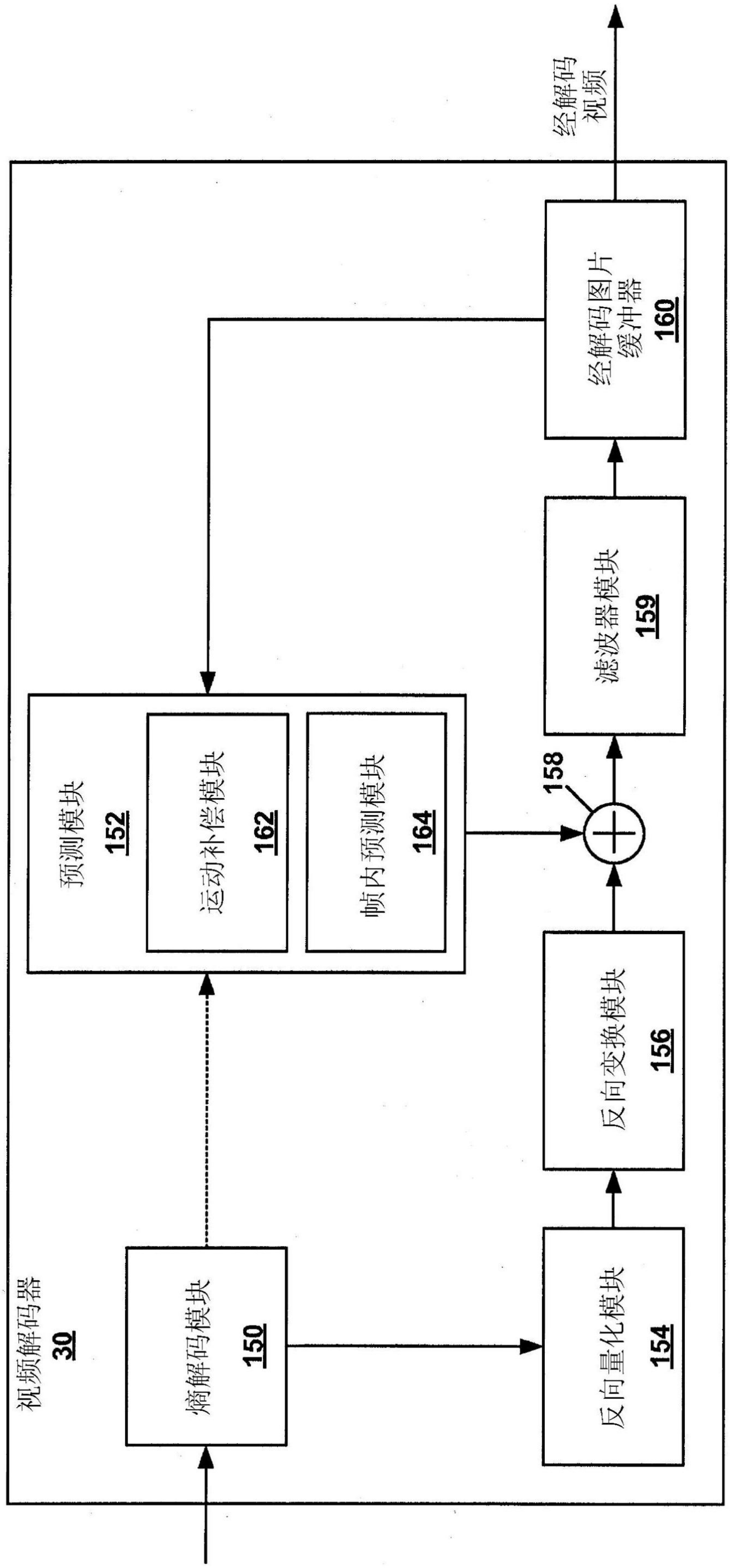

经解码视频
经解码图片缓冲器 160
滤波器模块 159
158
预测模块 152
运动补偿模块 162
帧内预测模块 164
反向变换模块 156
视频解码器 30
熵解码模块 150
反向量化模块 154

图 3

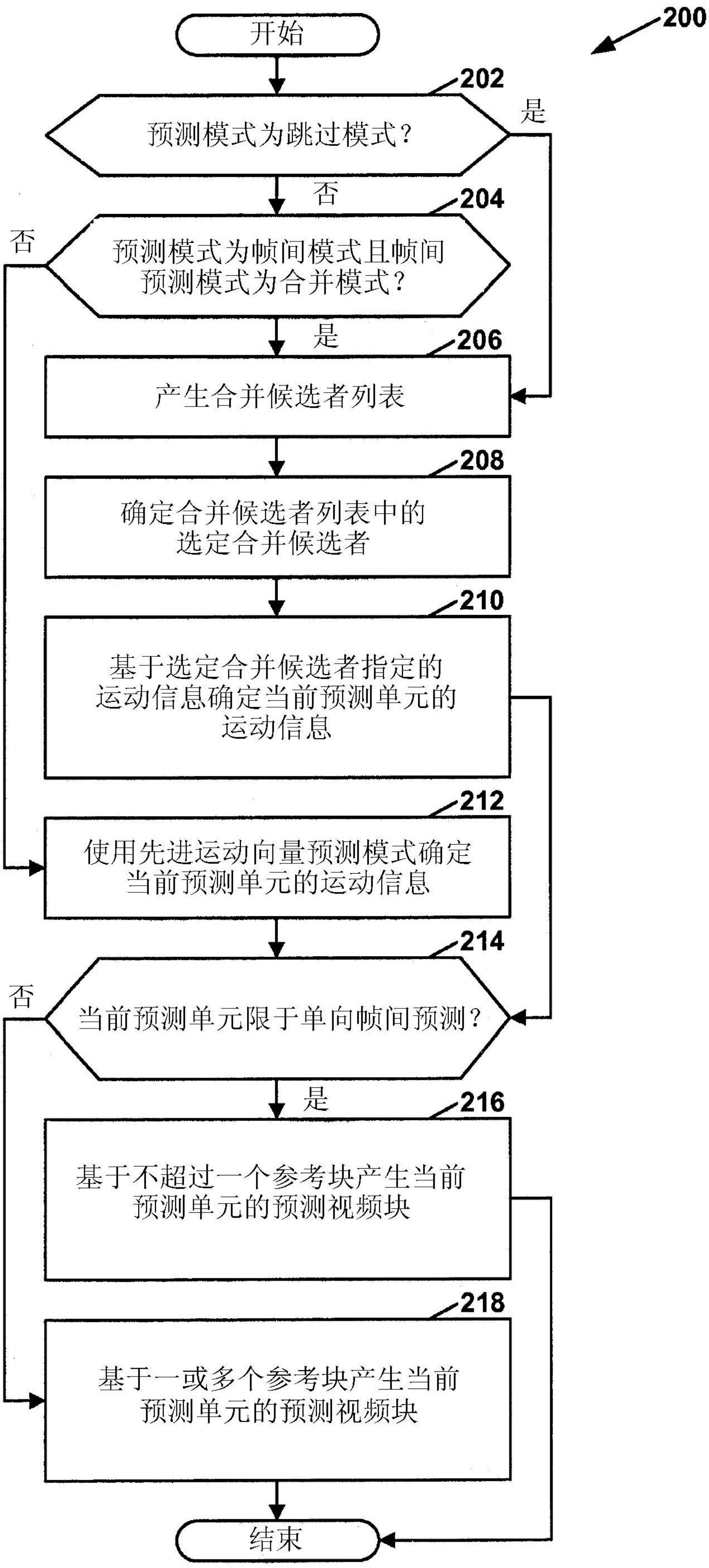

200
开始
202
预测模式为跳过模式？
是
否
204
否
预测模式为帧间模式且帧间预测模式为合并模式？
是
206
产生合并候选者列表
208
确定合并候选者列表中的选定合并候选者
210
基于选定合并候选者指定的运动信息确定当前预测单元的运动信息
212
使用先进运动向量预测模式确定当前预测单元的运动信息
214
否
当前预测单元限于单向帧间预测？
是
216
基于不超过一个参考块产生当前预测单元的预测视频块
218
基于一或多个参考块产生当前预测单元的预测视频块
结束

图 4

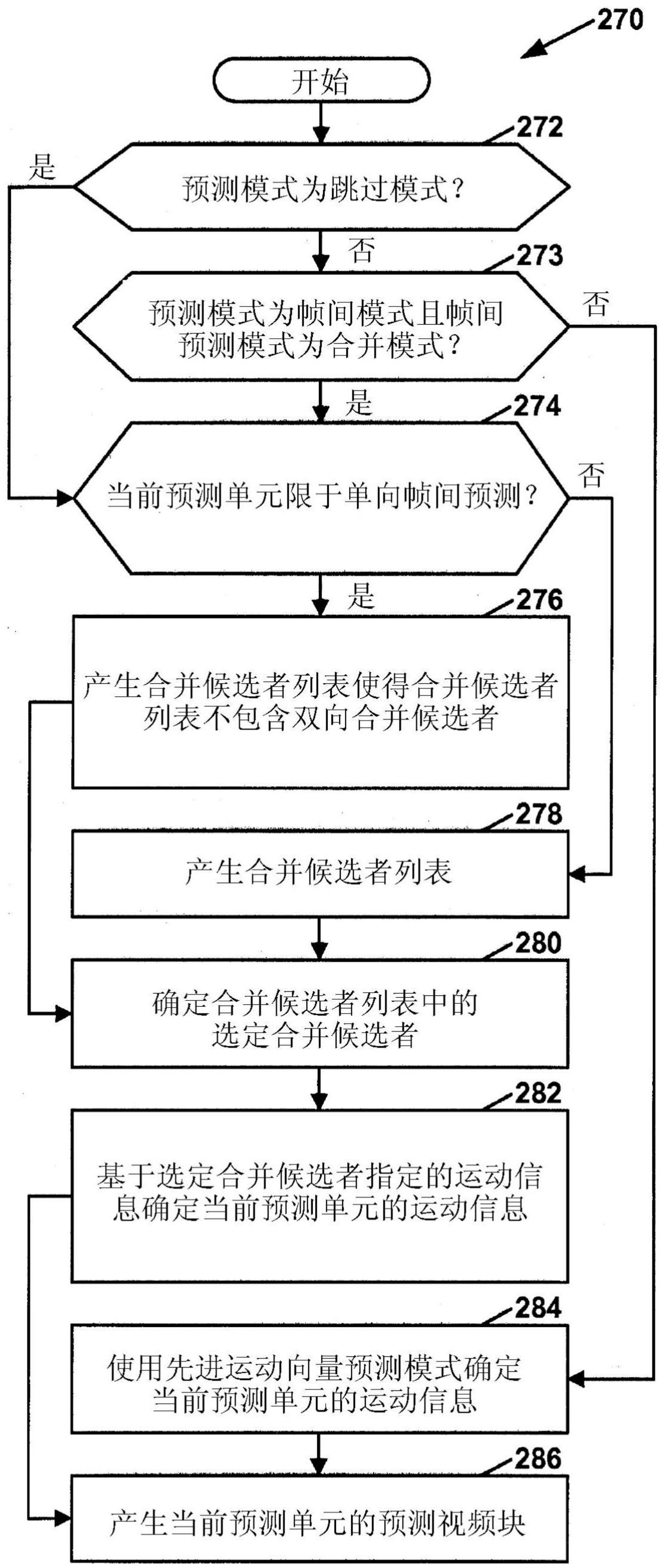

270
开始
272
预测模式为跳过模式？
是
否
273
预测模式为帧间模式且帧间预测模式为合并模式？
否
是
274
当前预测单元限于单向帧间预测？
否
是
276
产生合并候选者列表使得合并候选者列表不包含双向合并候选者
278
产生合并候选者列表
280
确定合并候选者列表中的选定合并候选者
282
基于选定合并候选者指定的运动信息确定当前预测单元的运动信息
284
使用先进运动向量预测模式确定当前预测单元的运动信息
286
产生当前预测单元的预测视频块

图 5

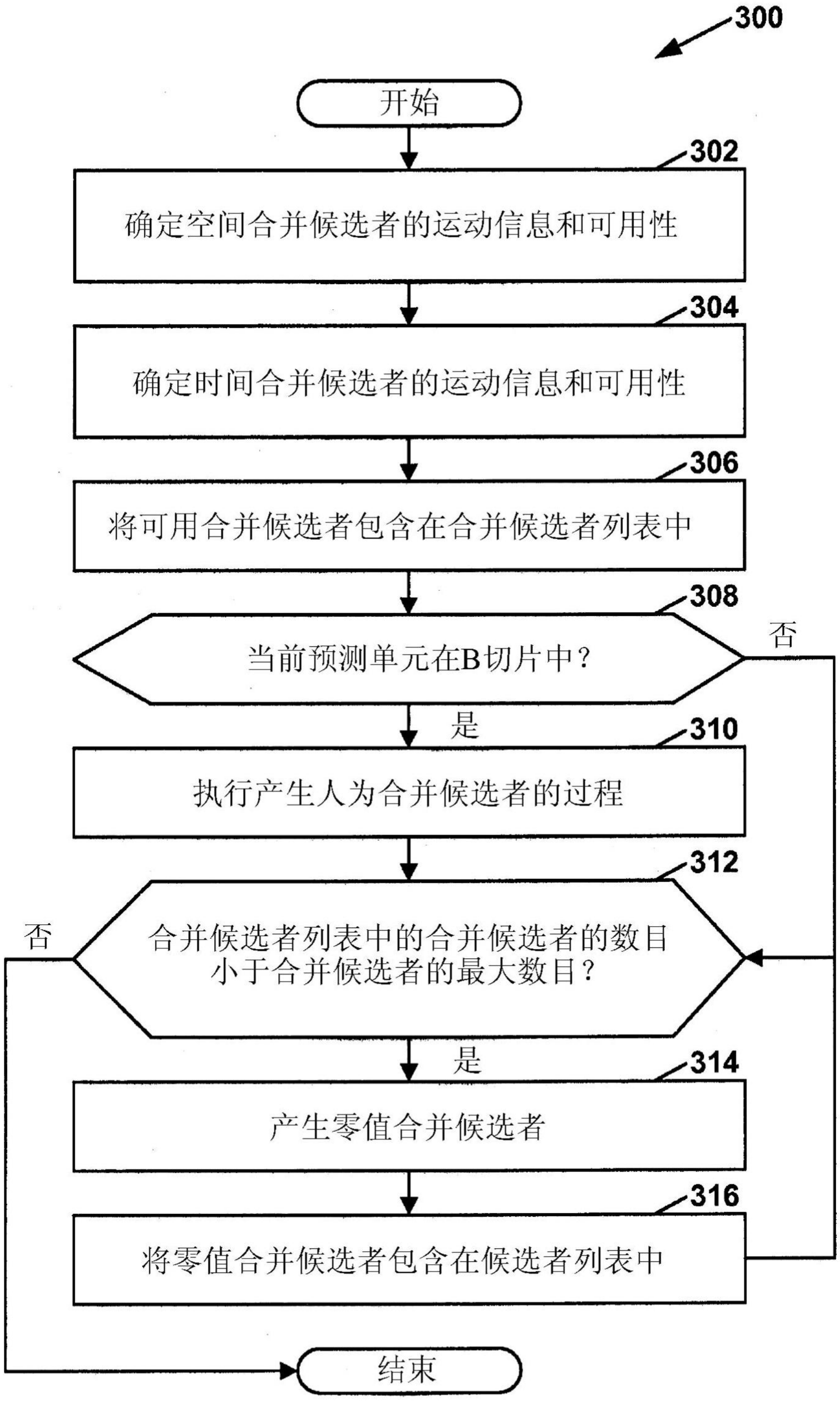

300
开始
302
确定空间合并候选者的运动信息和可用性
304
确定时间合并候选者的运动信息和可用性
306
将可用合并候选者包含在合并候选者列表中
308
当前预测单元在B切片中？
否
是
310
执行产生人为合并候选者的过程
312
合并候选者列表中的合并候选者的数目小于合并候选者的最大数目？
否
是
314
产生零值合并候选者
316
将零值合并候选者包含在候选者列表中
结束

图 6

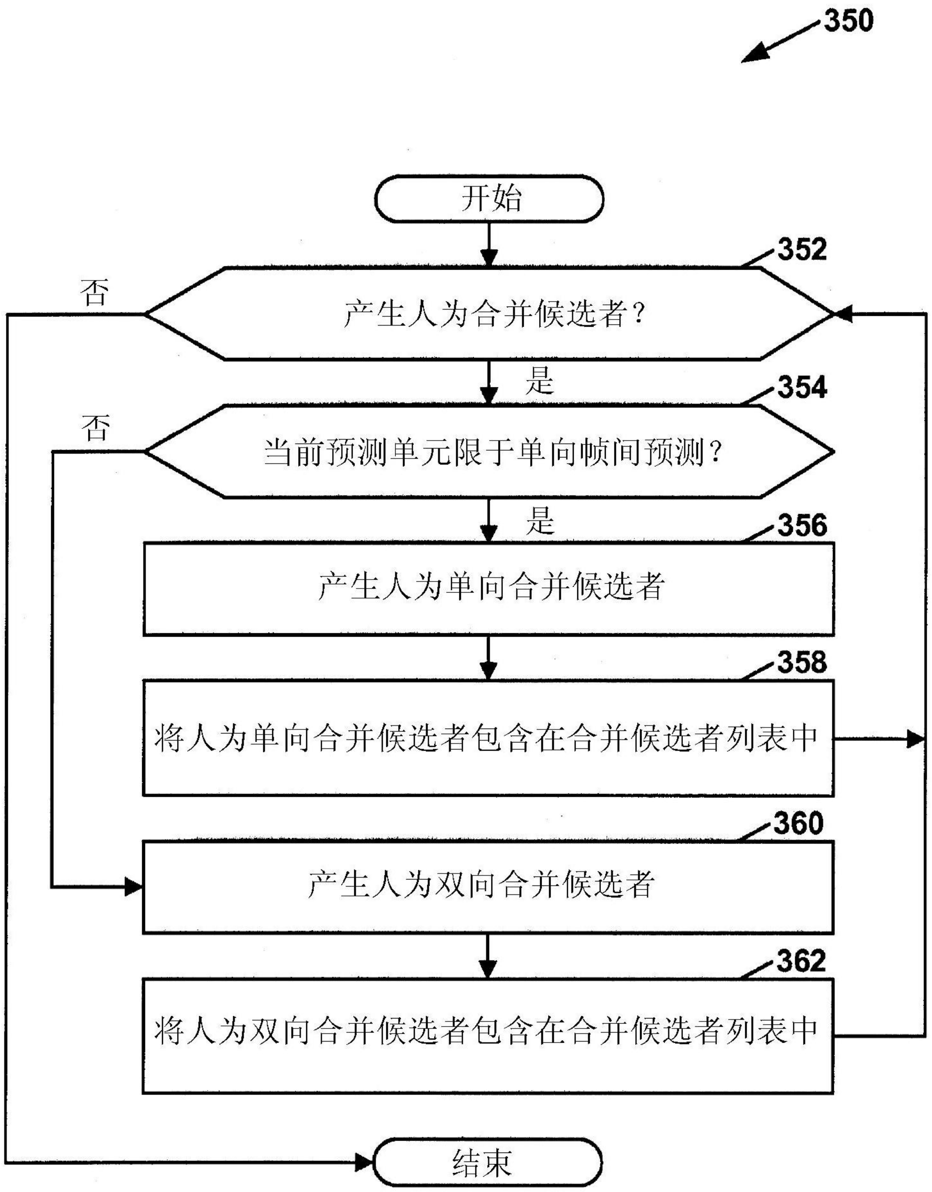

350
开始
352
否
产生人为合并候选者？
是
354
否
当前预测单元限于单向帧间预测？
是
356
产生人为单向合并候选者
358
将人为单向合并候选者包含在合并候选者列表中
360
产生人为双向合并候选者
362
将人为双向合并候选者包含在合并候选者列表中
结束

图 7

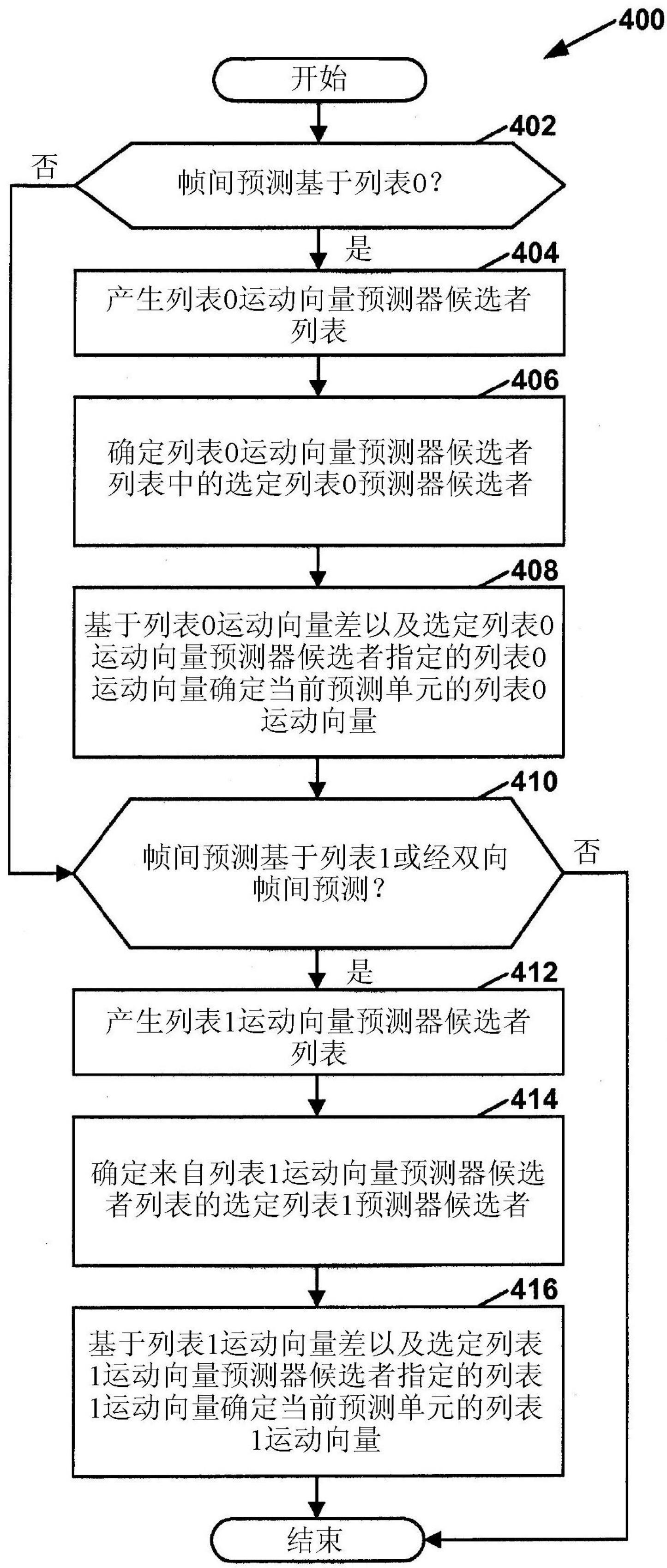

400
开始
402
帧间预测基于列表0？
否
是
404
产生列表0运动向量预测器候选者列表
406
确定列表0运动向量预测器候选者列表中的选定列表0预测器候选者
408
基于列表0运动向量差以及选定列表0运动向量预测器候选者指定的列表0运动向量确定当前预测单元的列表0运动向量
410
帧间预测基于列表1或经双向帧间预测？
否
是
412
产生列表1运动向量预测器候选者列表
414
确定来自列表1运动向量预测器候选者列表的选定列表1预测器候选者
416
基于列表1运动向量差以及选定列表1运动向量预测器候选者指定的列表1运动向量确定当前预测单元的列表1运动向量
结束

图 8