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(54) COMPANION DEVICE ASSISTED MULTI-VIEW VIDEO CODING

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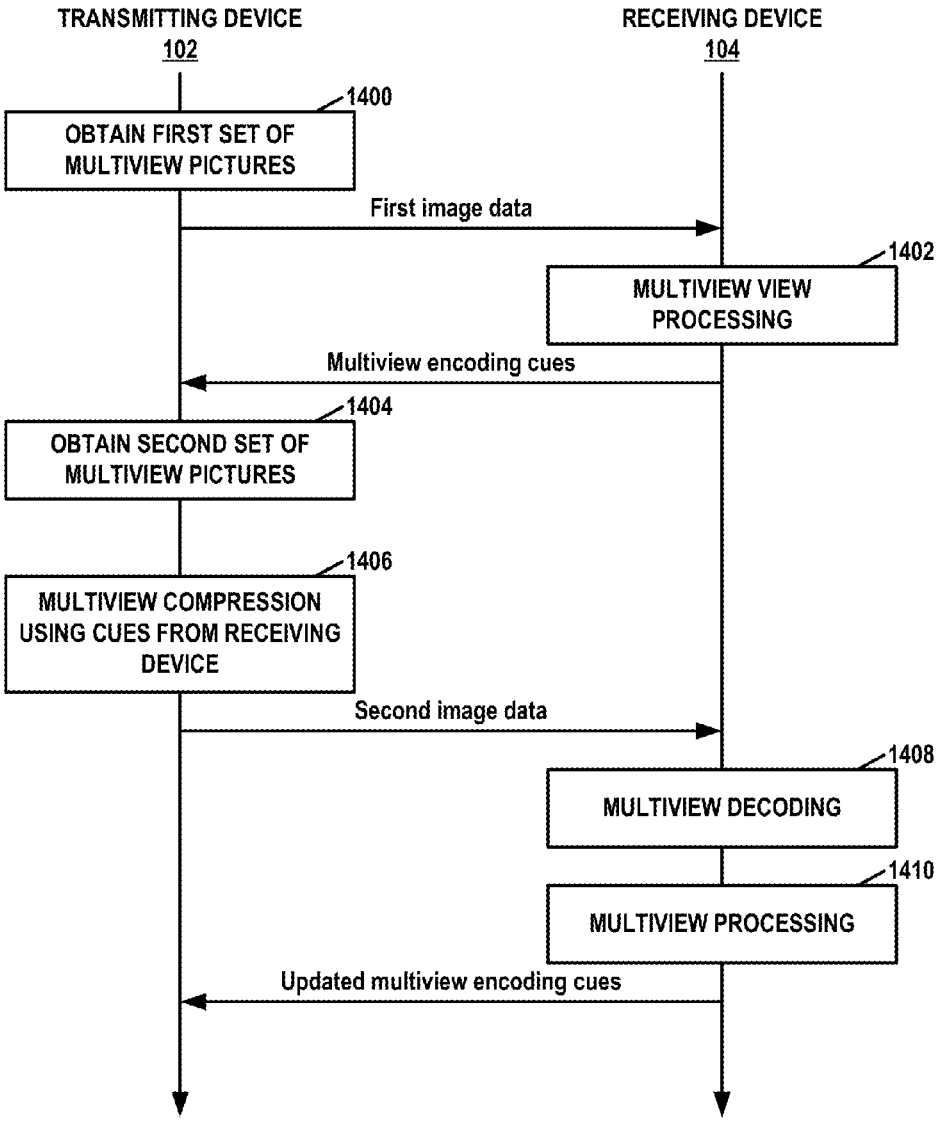
(52) **U.S. Cl.**
CPC *H04N 19/597* (2014.11)

(57) **ABSTRACT**

A device is configured obtain a first set of multiview pictures, wherein the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; transmit first encoded video data to a receiving device, wherein the first encoded video data is based on the first set of multiview pictures; receive multi-view encoding cues from the receiving device; obtain a second set of multiview pictures of the video data, wherein the second set of multiview pictures includes third pictures and fourth pictures, the third pictures being from the first viewpoint and the fourth pictures being from the second viewpoint; perform, based on the multiview encoding cues, a multiview encoding process on the second set of multiview pictures to generate second encoded video data; and transmit the second encoded video data to the receiving device.



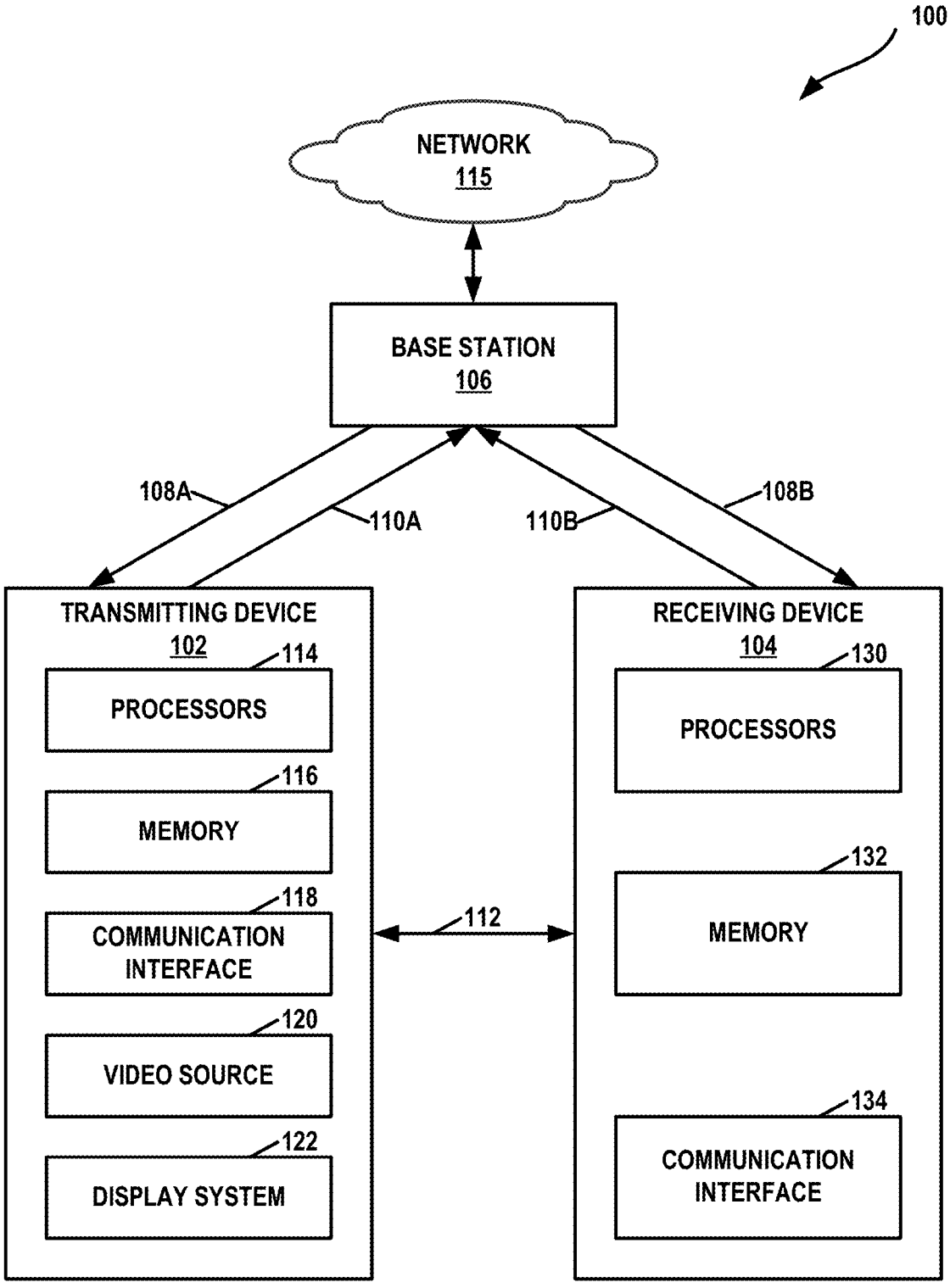

100
NETWORK
115
BASE STATION
106
108A
110A
110B
108B
TRANSMITTING DEVICE
102
114
PROCESSORS
116
MEMORY
118
COMMUNICATION INTERFACE
120
VIDEO SOURCE
122
DISPLAY SYSTEM
112
RECEIVING DEVICE
104
130
PROCESSORS
132
MEMORY
134
COMMUNICATION INTERFACE

FIG. 1

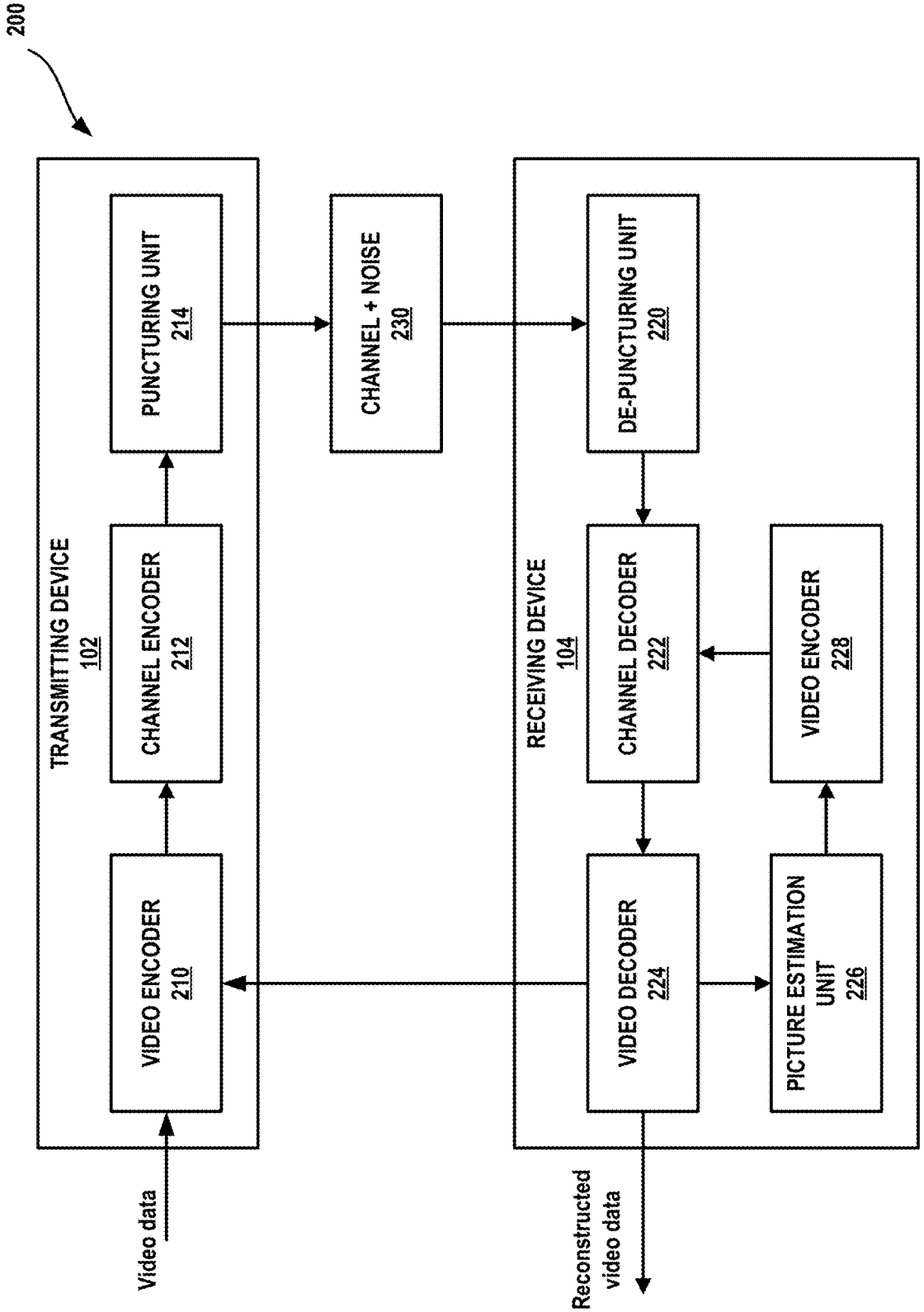

200
TRANSMITTING DEVICE
102
VIDEO ENCODER
210
CHANNEL ENCODER
212
PUNCTURING UNIT
214
CHANNEL + NOISE
230
RECEIVING DEVICE
104
VIDEO DECODER
224
CHANNEL DECODER
222
DE-PUNCTURING UNIT
220
PICTURE ESTIMATION UNIT
226
VIDEO ENCODER
228
Video data
Reconstructed video data

FIG. 2

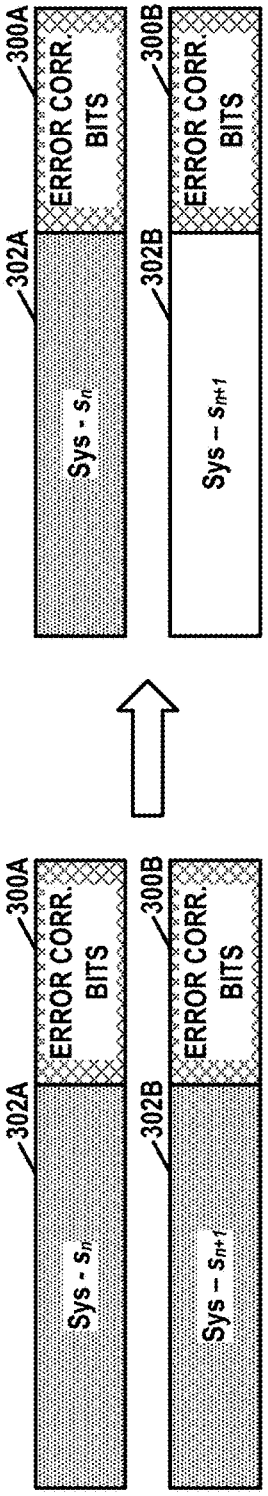

Picture n
Picture n+1
302A
300A
ERROR CORR. BITS
Sys - s_n
302B
300B
ERROR CORR. BITS
Sys – s_{n+1}

FIG. 3A

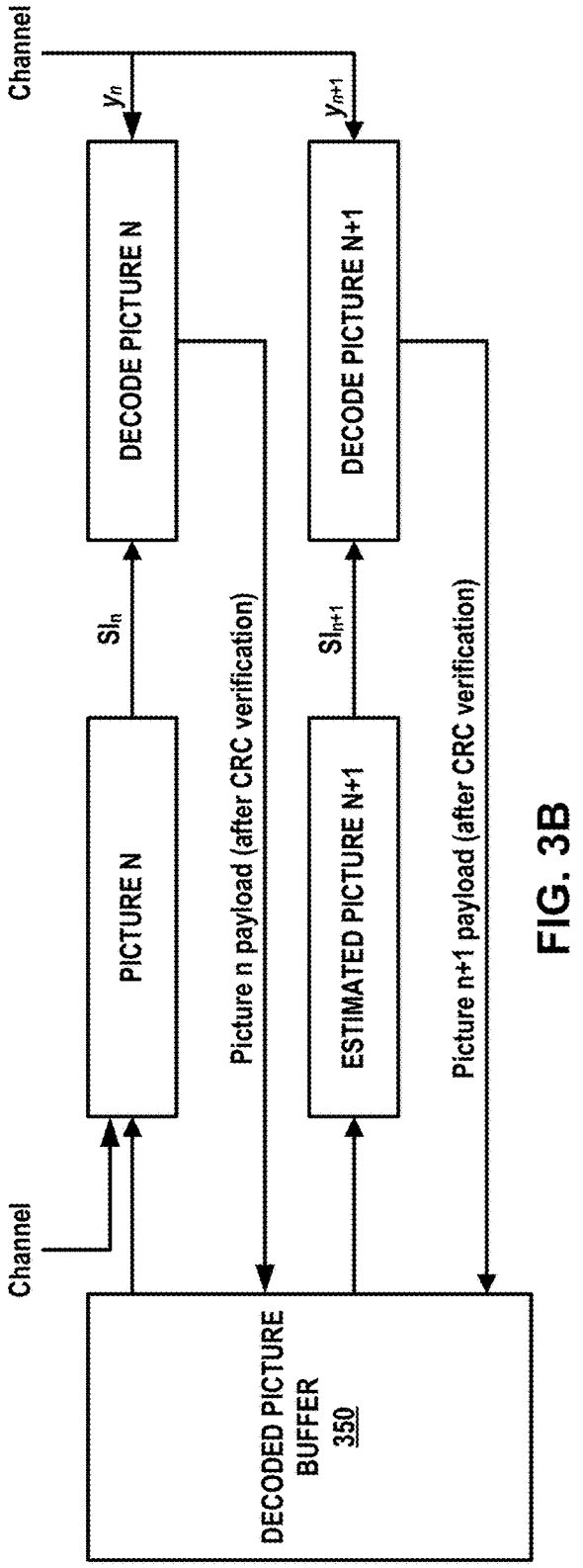

Channel
y_n
y_{n+1}
DECODE PICTURE N
DECODE PICTURE N+1
SI_n
SI_{n+1}
PICTURE N
ESTIMATED PICTURE N+1
Picture n payload (after CRC verification)
Picture n+1 payload (after CRC verification)
Channel
DECODED PICTURE BUFFER
350

FIG. 3B

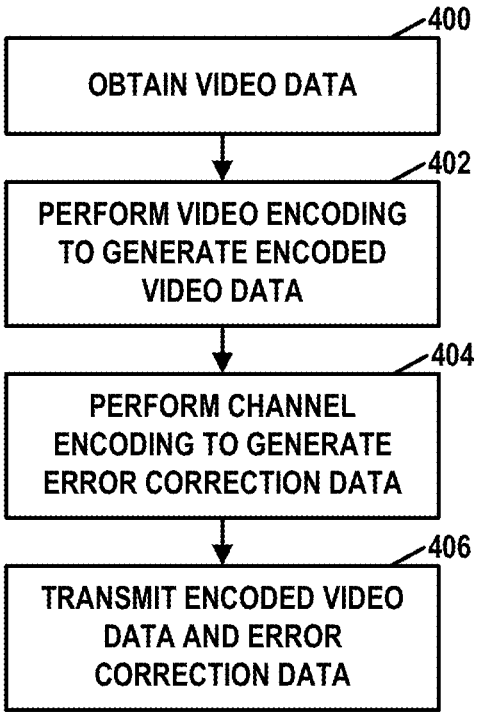

400
OBTAIN VIDEO DATA
402
PERFORM VIDEO ENCODING TO GENERATE ENCODED VIDEO DATA
404
PERFORM CHANNEL ENCODING TO GENERATE ERROR CORRECTION DATA
406
TRANSMIT ENCODED VIDEO DATA AND ERROR CORRECTION DATA

FIG. 4

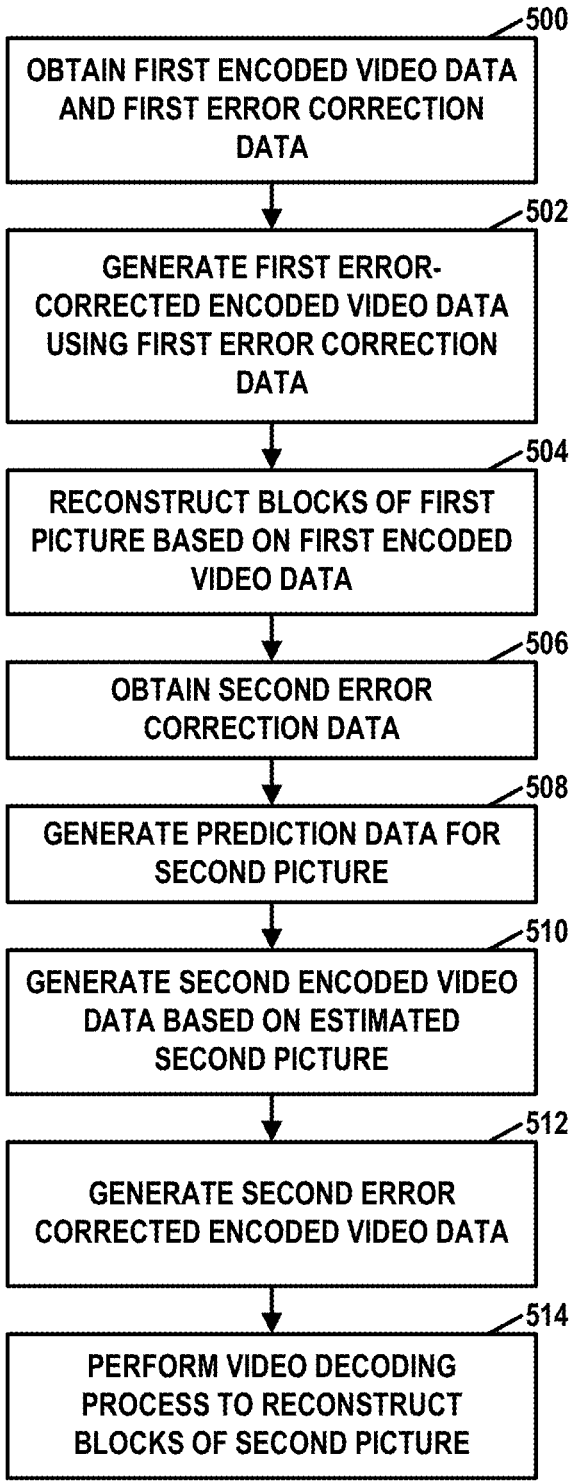

500
OBTAIN FIRST ENCODED VIDEO DATA AND FIRST ERROR CORRECTION DATA
502
GENERATE FIRST ERROR-CORRECTED ENCODED VIDEO DATA USING FIRST ERROR CORRECTION DATA
504
RECONSTRUCT BLOCKS OF FIRST PICTURE BASED ON FIRST ENCODED VIDEO DATA
506
OBTAIN SECOND ERROR CORRECTION DATA
508
GENERATE PREDICTION DATA FOR SECOND PICTURE
510
GENERATE SECOND ENCODED VIDEO DATA BASED ON ESTIMATED SECOND PICTURE
512
GENERATE SECOND ERROR CORRECTED ENCODED VIDEO DATA
514
PERFORM VIDEO DECODING PROCESS TO RECONSTRUCT BLOCKS OF SECOND PICTURE

FIG. 5

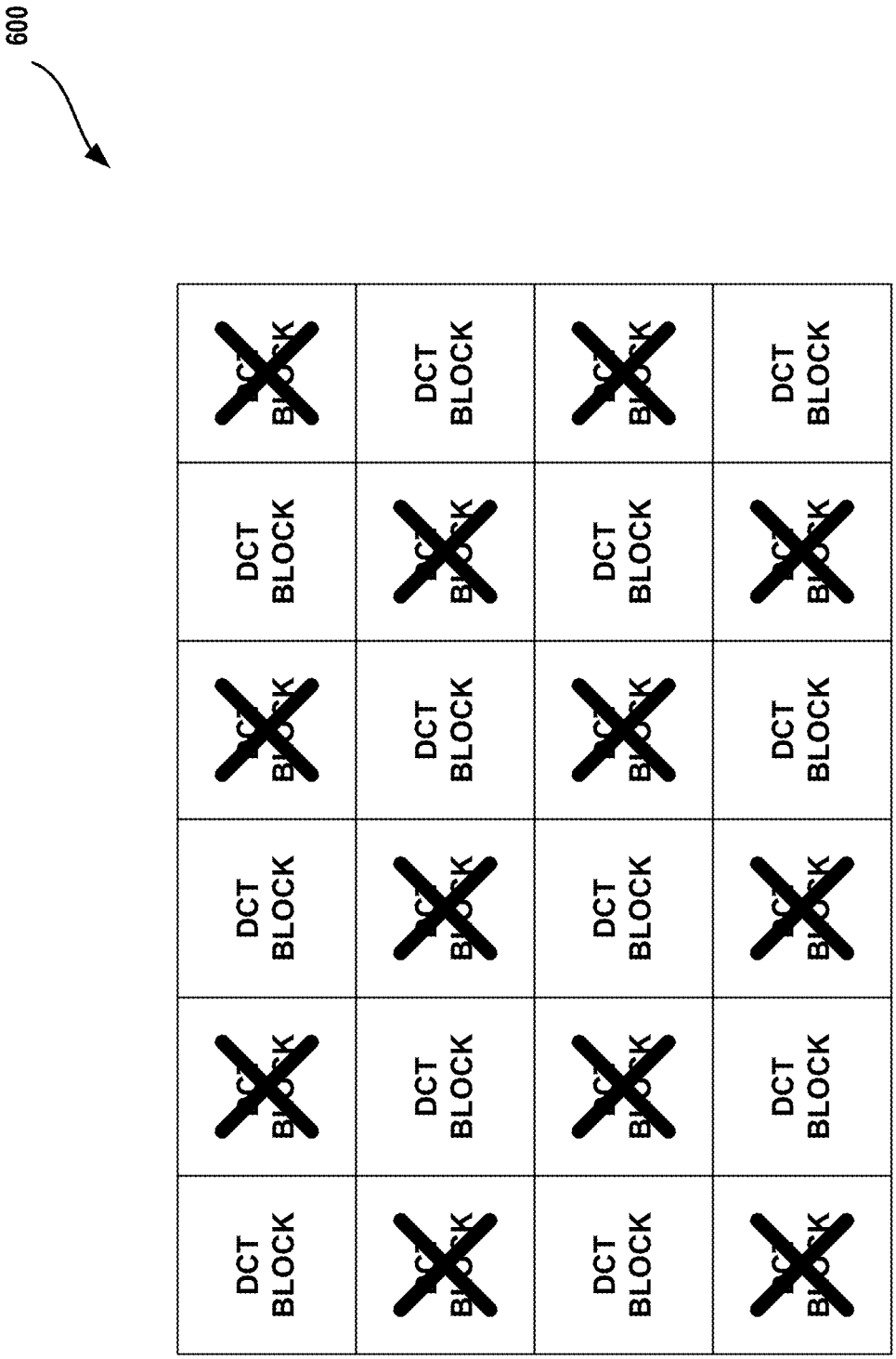


FIG. 6

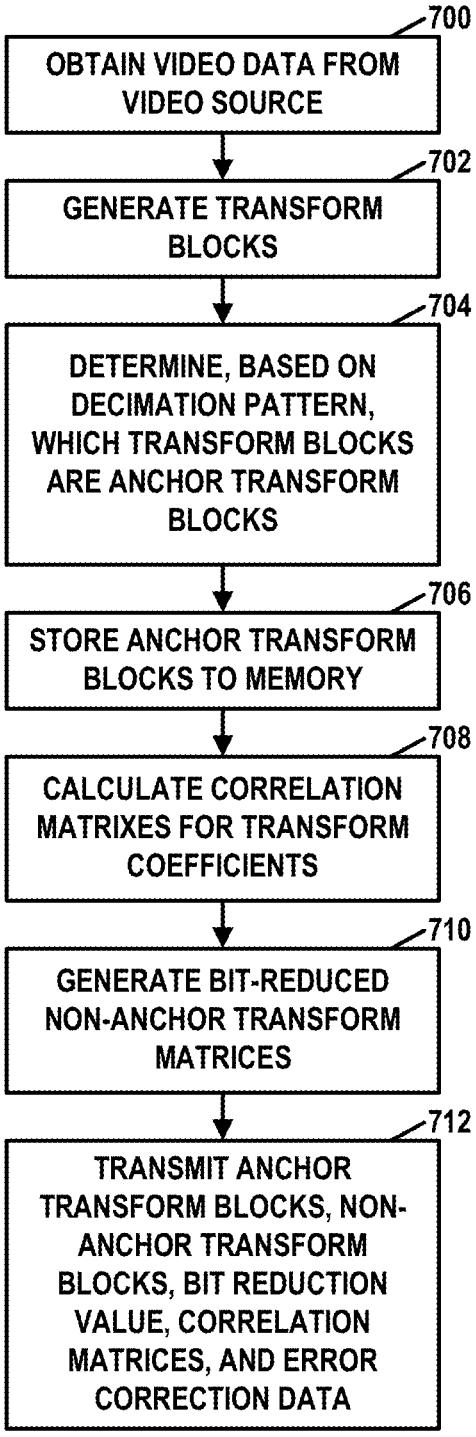

700
OBTAIN VIDEO DATA FROM VIDEO SOURCE
702
GENERATE TRANSFORM BLOCKS
704
DETERMINE, BASED ON DECIMATION PATTERN, WHICH TRANSFORM BLOCKS ARE ANCHOR TRANSFORM BLOCKS
706
STORE ANCHOR TRANSFORM BLOCKS TO MEMORY
708
CALCULATE CORRELATION MATRIXES FOR TRANSFORM COEFFICIENTS
710
GENERATE BIT-REDUCED NON-ANCHOR TRANSFORM MATRICES
712
TRANSMIT ANCHOR TRANSFORM BLOCKS, NON-ANCHOR TRANSFORM BLOCKS, BIT REDUCTION VALUE, CORRELATION MATRICES, AND ERROR CORRECTION DATA

FIG. 7

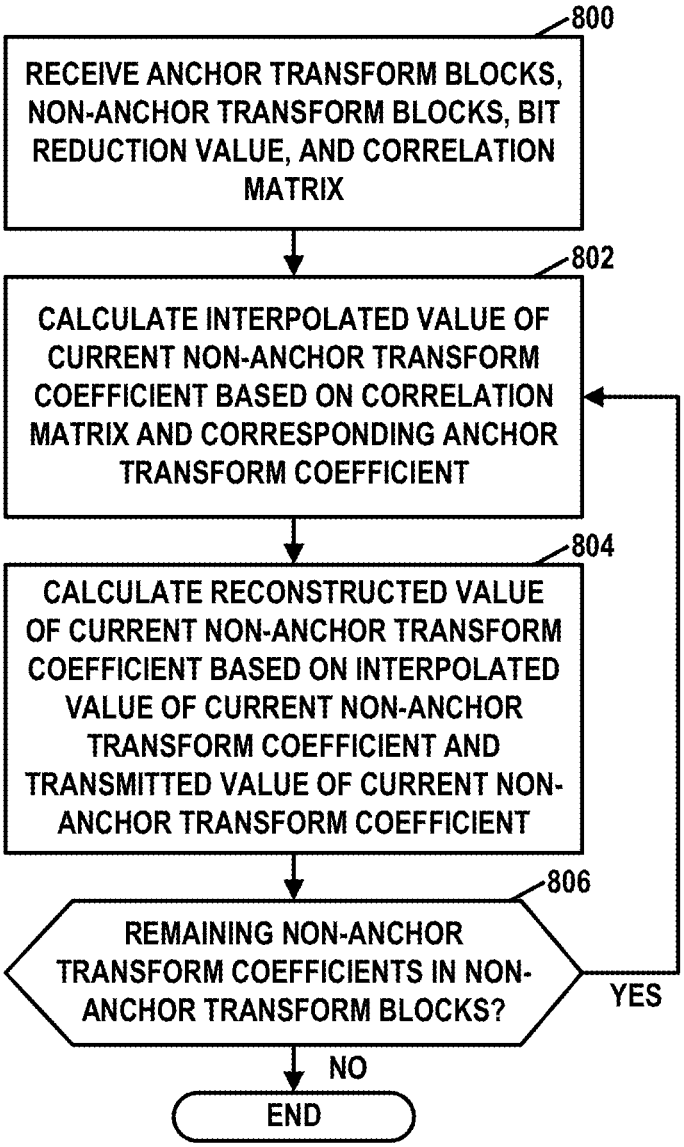

800
RECEIVE ANCHOR TRANSFORM BLOCKS, NON-ANCHOR TRANSFORM BLOCKS, BIT REDUCTION VALUE, AND CORRELATION MATRIX
802
CALCULATE INTERPOLATED VALUE OF CURRENT NON-ANCHOR TRANSFORM COEFFICIENT BASED ON CORRELATION MATRIX AND CORRESPONDING ANCHOR TRANSFORM COEFFICIENT
804
CALCULATE RECONSTRUCTED VALUE OF CURRENT NON-ANCHOR TRANSFORM COEFFICIENT BASED ON INTERPOLATED VALUE OF CURRENT NON-ANCHOR TRANSFORM COEFFICIENT AND TRANSMITTED VALUE OF CURRENT NON-ANCHOR TRANSFORM COEFFICIENT
806
REMAINING NON-ANCHOR TRANSFORM COEFFICIENTS IN NON-ANCHOR TRANSFORM BLOCKS?
YES
NO
END

FIG. 8

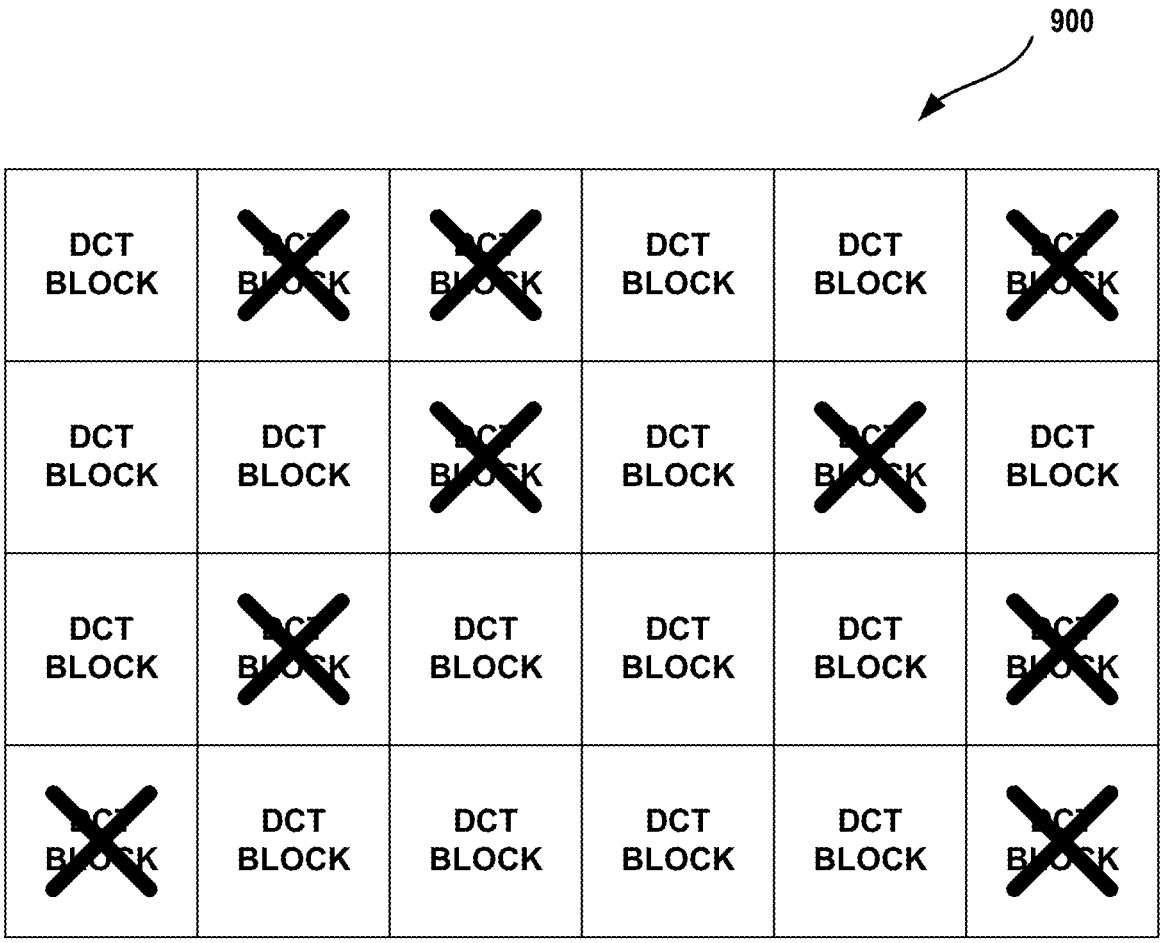


FIG. 9

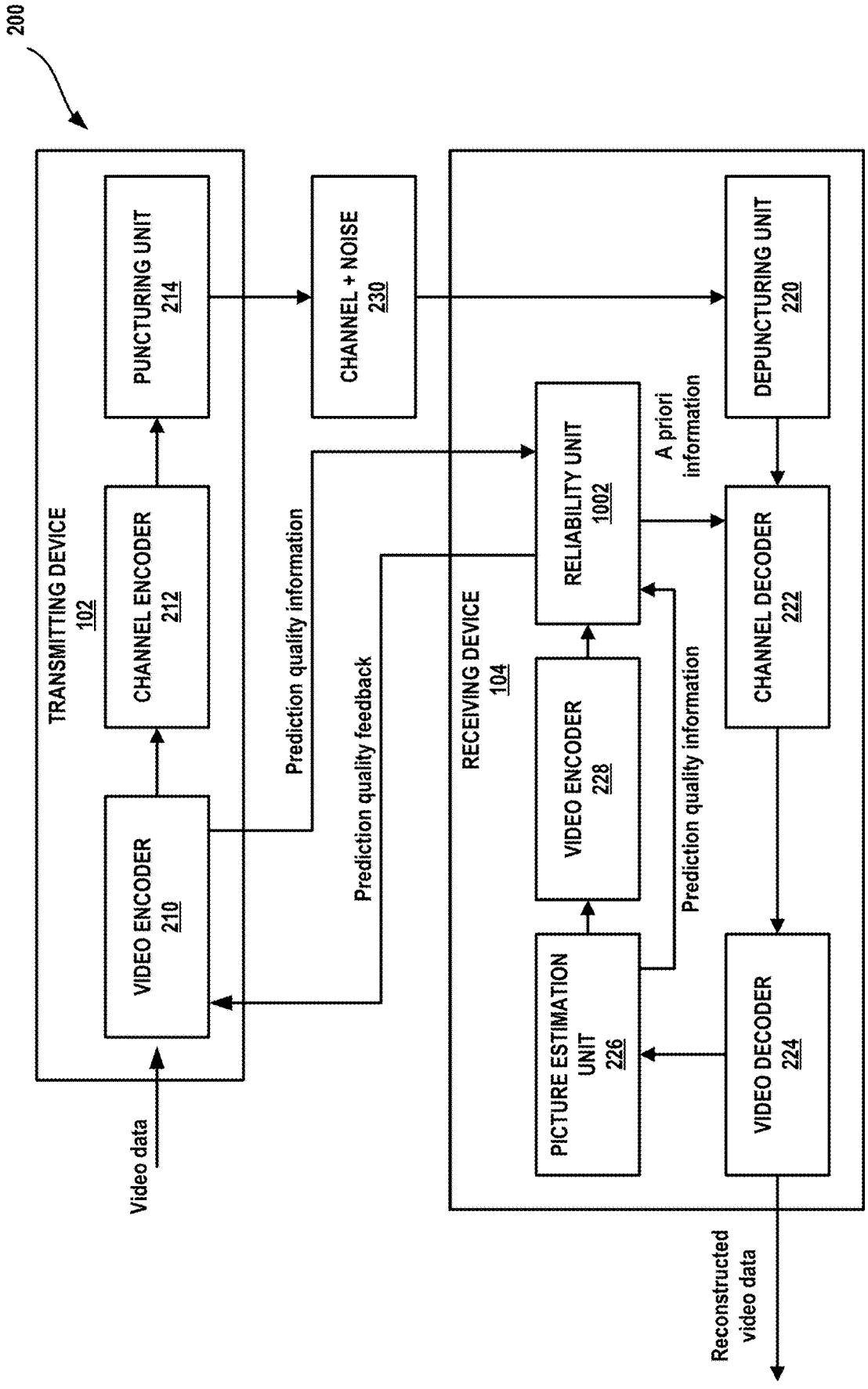

200
TRANSMITTING DEVICE
102
VIDEO ENCODER
210
CHANNEL ENCODER
212
PUNCTURING UNIT
214
Video data
Prediction quality information
Prediction quality feedback
CHANNEL + NOISE
230
RECEIVING DEVICE
104
RELIABILITY UNIT
1002
A priori information
DEPUNCTURING UNIT
220
CHANNEL DECODER
222
VIDEO ENCODER
228
PICTURE ESTIMATION UNIT
226
Prediction quality information
VIDEO DECODER
224
Reconstructed video data

FIG. 10

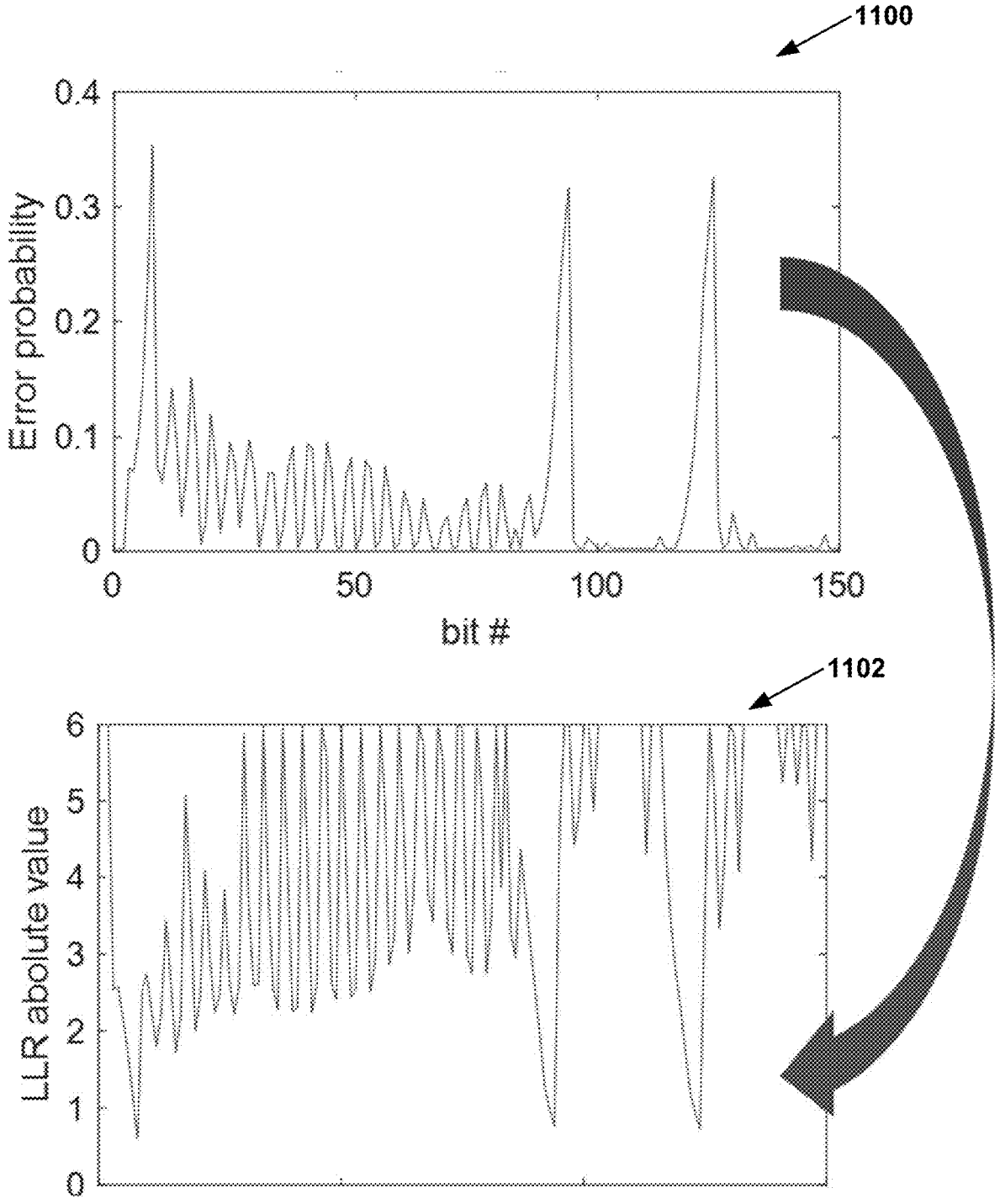

1100
0.4
0.3
0.2
0.1
0
Error probability
0
50
100
150
bit #
1102
6
5
4
3
2
1
0
LLR abolute value

FIG. 11

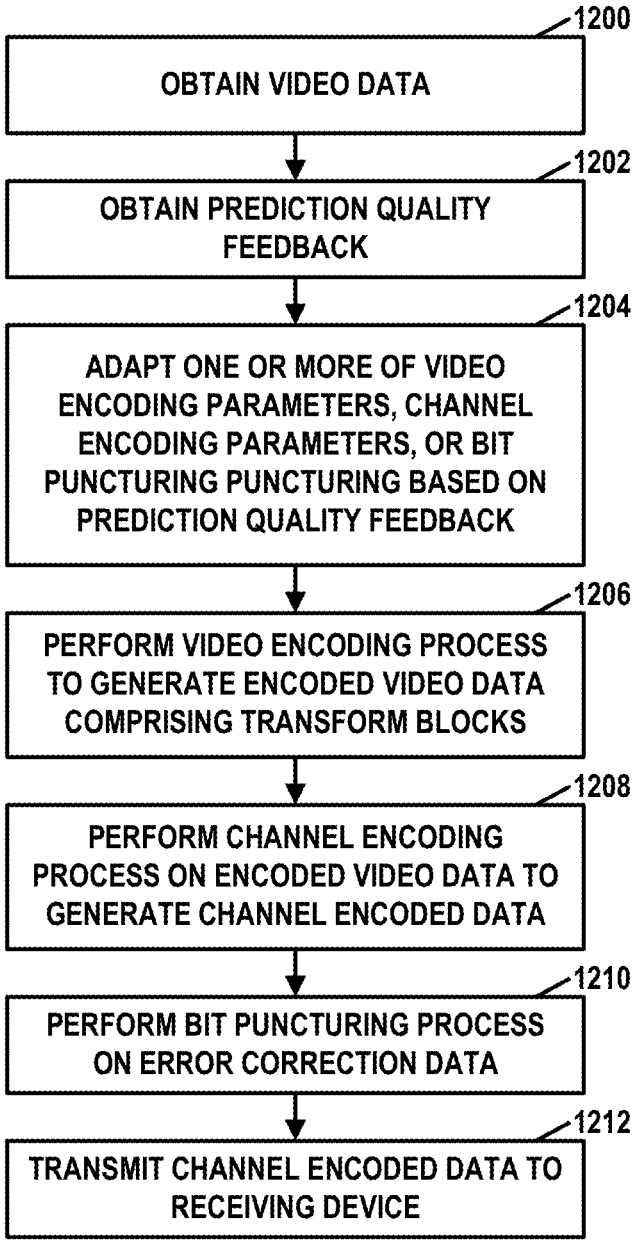

1200
OBTAIN VIDEO DATA
1202
OBTAIN PREDICTION QUALITY FEEDBACK
1204
ADAPT ONE OR MORE OF VIDEO ENCODING PARAMETERS, CHANNEL ENCODING PARAMETERS, OR BIT PUNCTURING PUNCTURING BASED ON PREDICTION QUALITY FEEDBACK
1206
PERFORM VIDEO ENCODING PROCESS TO GENERATE ENCODED VIDEO DATA COMPRISING TRANSFORM BLOCKS
1208
PERFORM CHANNEL ENCODING PROCESS ON ENCODED VIDEO DATA TO GENERATE CHANNEL ENCODED DATA
1210
PERFORM BIT PUNCTURING PROCESS ON ERROR CORRECTION DATA
1212
TRANSMIT CHANNEL ENCODED DATA TO RECEIVING DEVICE

FIG. 12

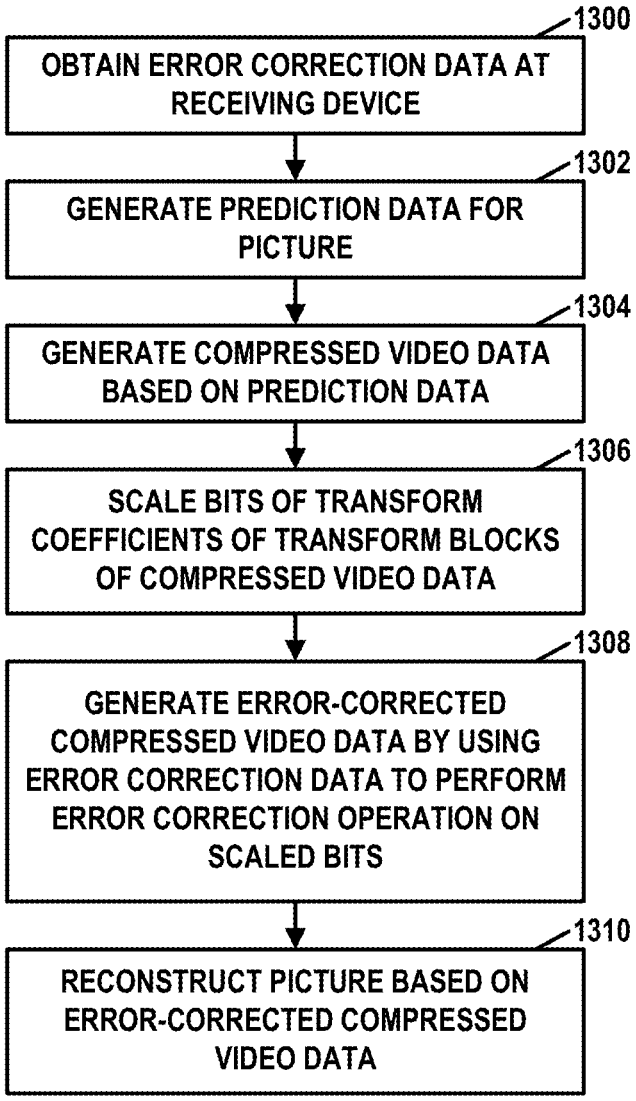

1300
OBTAIN ERROR CORRECTION DATA AT RECEIVING DEVICE
1302
GENERATE PREDICTION DATA FOR PICTURE
1304
GENERATE COMPRESSED VIDEO DATA BASED ON PREDICTION DATA
1306
SCALE BITS OF TRANSFORM COEFFICIENTS OF TRANSFORM BLOCKS OF COMPRESSED VIDEO DATA
1308
GENERATE ERROR-CORRECTED COMPRESSED VIDEO DATA BY USING ERROR CORRECTION DATA TO PERFORM ERROR CORRECTION OPERATION ON SCALED BITS
1310
RECONSTRUCT PICTURE BASED ON ERROR-CORRECTED COMPRESSED VIDEO DATA

FIG. 13

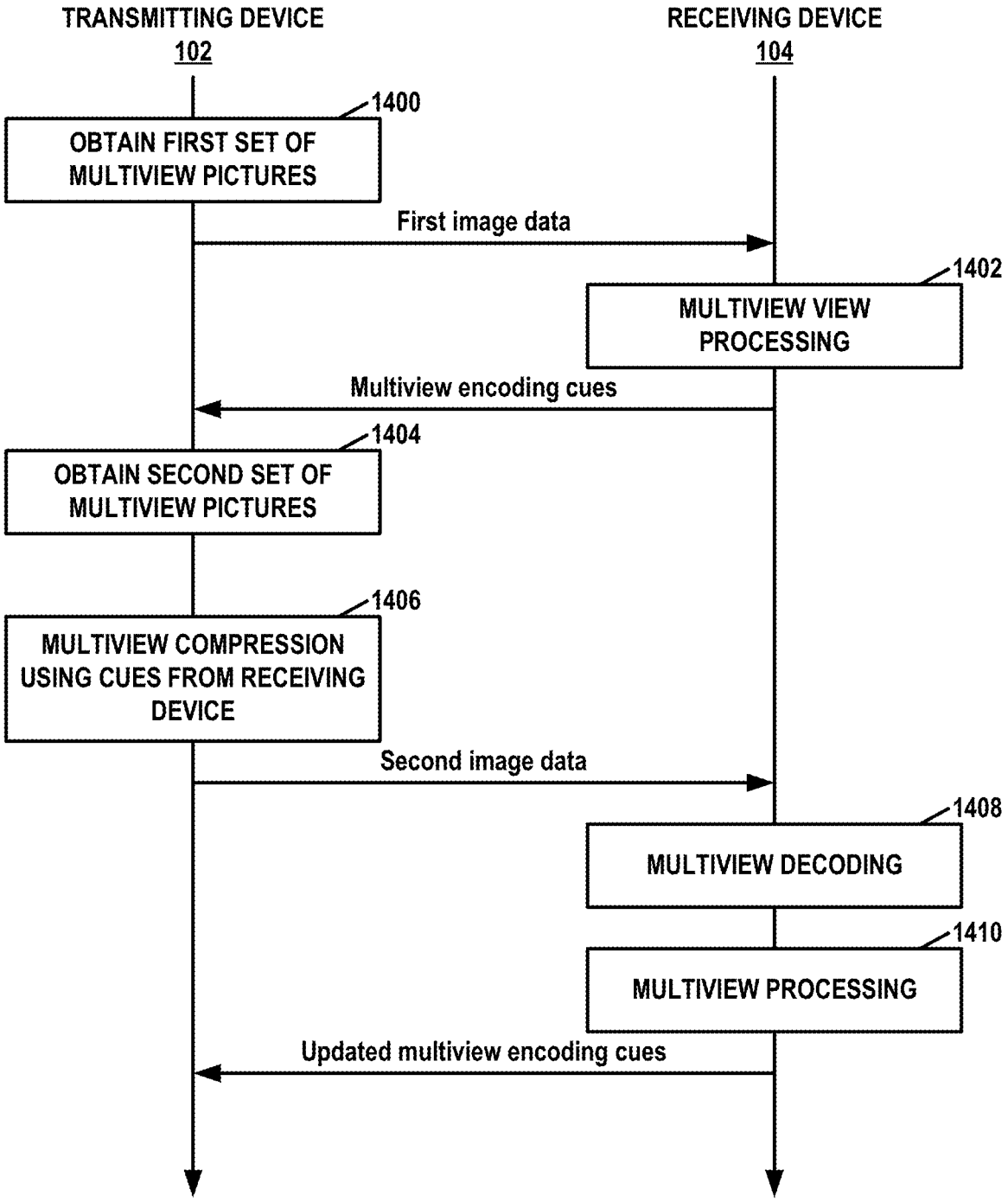

TRANSMITTING DEVICE
102
RECEIVING DEVICE
104
1400
OBTAIN FIRST SET OF MULTIVIEW PICTURES
First image data
1402
MULTIVIEW VIEW PROCESSING
Multiview encoding cues
1404
OBTAIN SECOND SET OF MULTIVIEW PICTURES
1406
MULTIVIEW COMPRESSION USING CUES FROM RECEIVING DEVICE
Second image data
1408
MULTIVIEW DECODING
1410
MULTIVIEW PROCESSING
Updated multiview encoding cues

FIG. 14

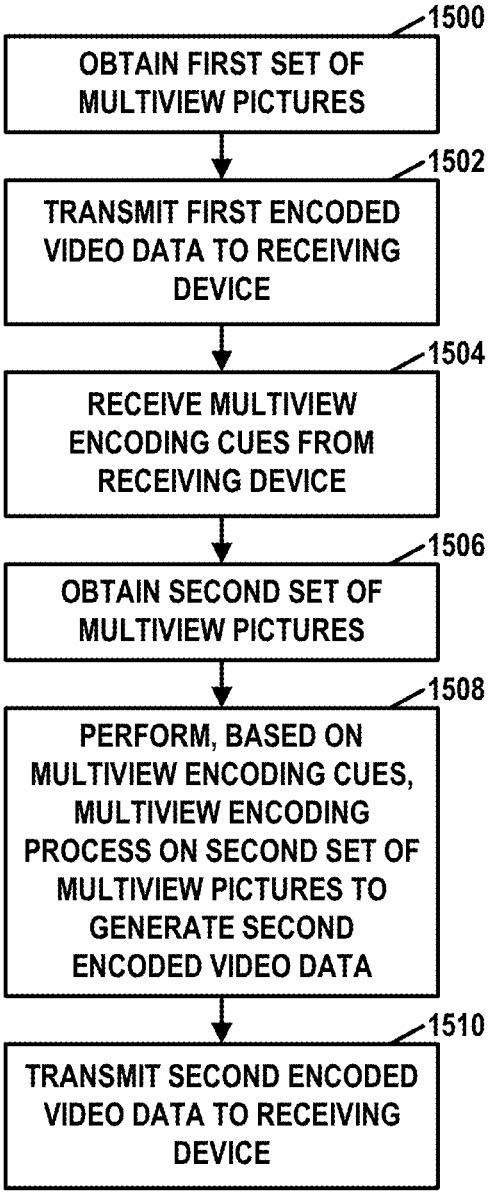

1500
OBTAIN FIRST SET OF MULTIVIEW PICTURES
1502
TRANSMIT FIRST ENCODED VIDEO DATA TO RECEIVING DEVICE
1504
RECEIVE MULTIVIEW ENCODING CUES FROM RECEIVING DEVICE
1506
OBTAIN SECOND SET OF MULTIVIEW PICTURES
1508
PERFORM, BASED ON MULTIVIEW ENCODING CUES, MULTIVIEW ENCODING PROCESS ON SECOND SET OF MULTIVIEW PICTURES TO GENERATE SECOND ENCODED VIDEO DATA
1510
TRANSMIT SECOND ENCODED VIDEO DATA TO RECEIVING DEVICE

FIG. 15

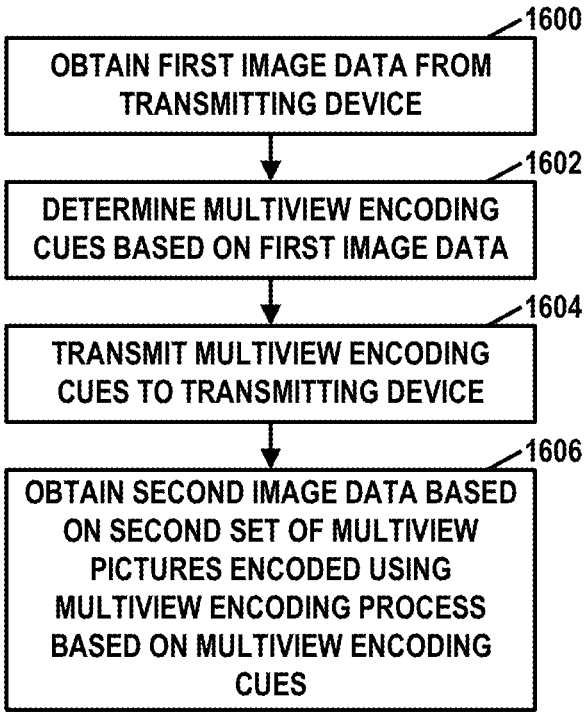

1600
OBTAIN FIRST IMAGE DATA FROM TRANSMITTING DEVICE
1602
DETERMINE MULTIVIEW ENCODING CUES BASED ON FIRST IMAGE DATA
1604
TRANSMIT MULTIVIEW ENCODING CUES TO TRANSMITTING DEVICE
1606
OBTAIN SECOND IMAGE DATA BASED ON SECOND SET OF MULTIVIEW PICTURES ENCODED USING MULTIVIEW ENCODING PROCESS BASED ON MULTIVIEW ENCODING CUES

FIG. 16

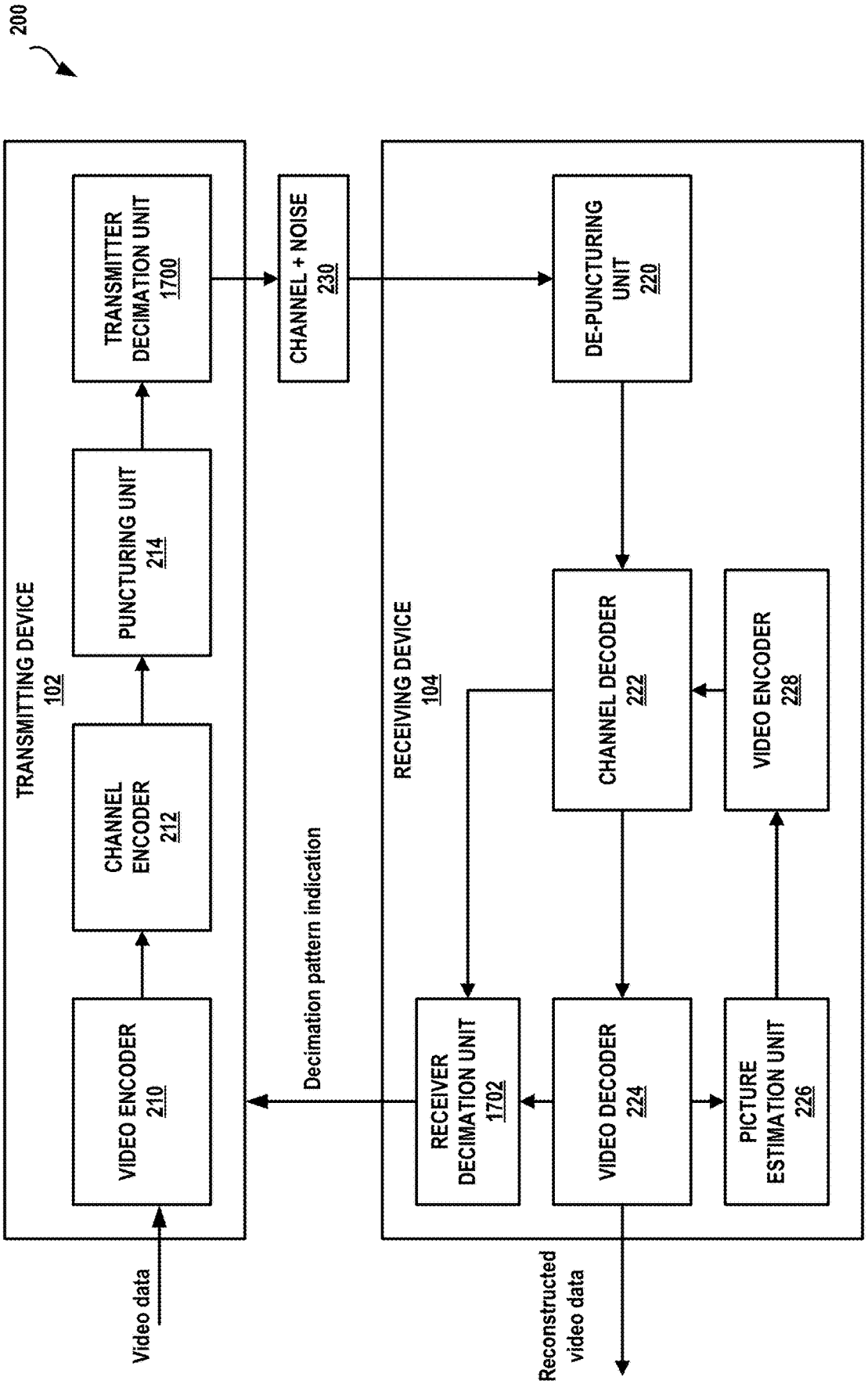

200
TRANSMITTING DEVICE
102
VIDEO ENCODER
210
CHANNEL ENCODER
212
PUNCTURING UNIT
214
TRANSMITTER DECIMATION UNIT
1700
CHANNEL + NOISE
230
RECEIVING DEVICE
104
DE-PUNCTURING UNIT
220
CHANNEL DECODER
222
VIDEO ENCODER
228
RECEIVER DECIMATION UNIT
1702
VIDEO DECODER
224
PICTURE ESTIMATION UNIT
226
Decimation pattern indication
Video data
Reconstructed video data

FIG. 17

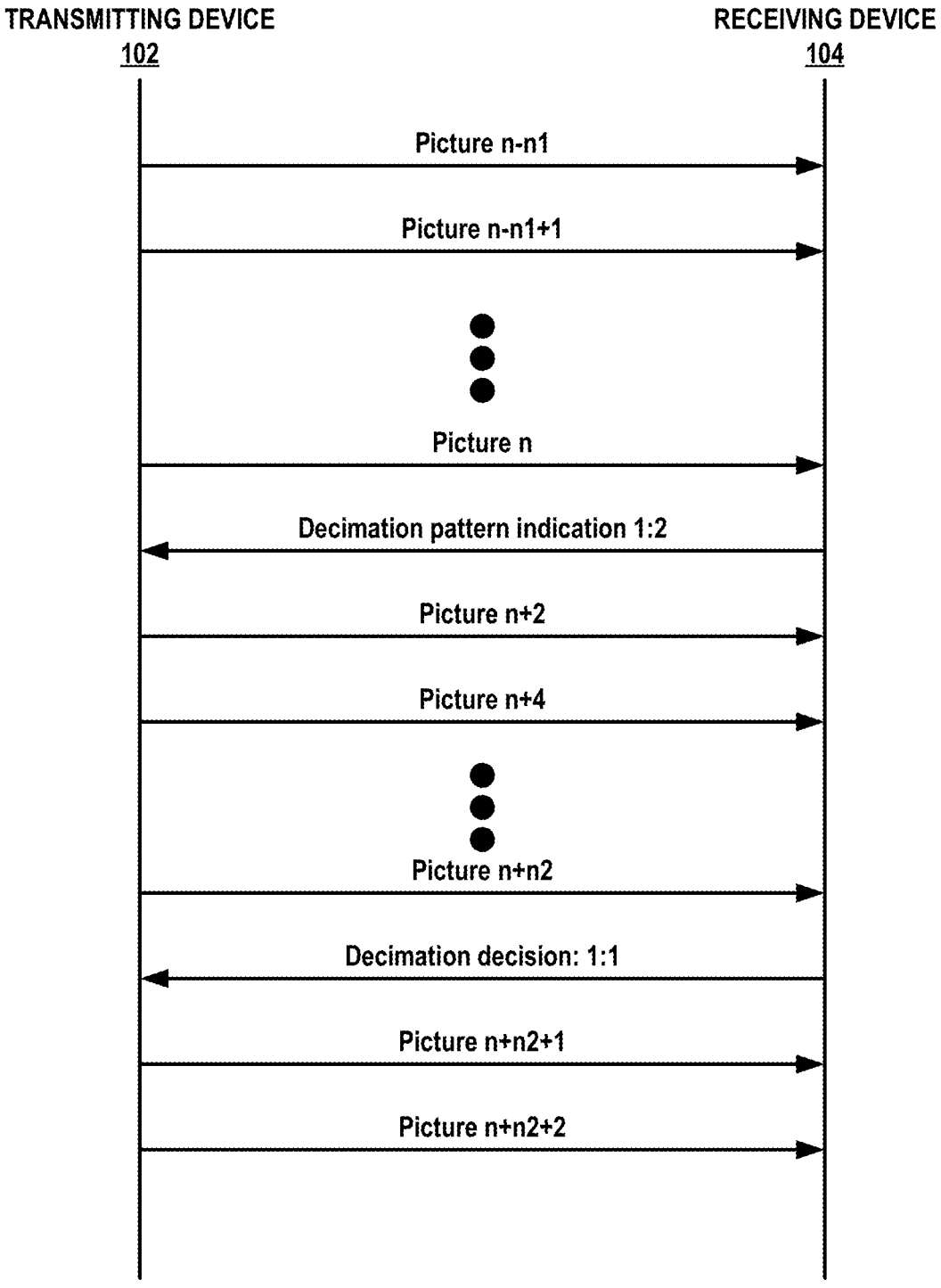

TRANSMITTING DEVICE
102
RECEIVING DEVICE
104
Picture n-n1
Picture n-n1+1
Picture n
Decimation pattern indication 1:2
Picture n+2
Picture n+4
Picture n+n2
Decimation decision: 1:1
Picture n+n2+1
Picture n+n2+2

FIG. 18

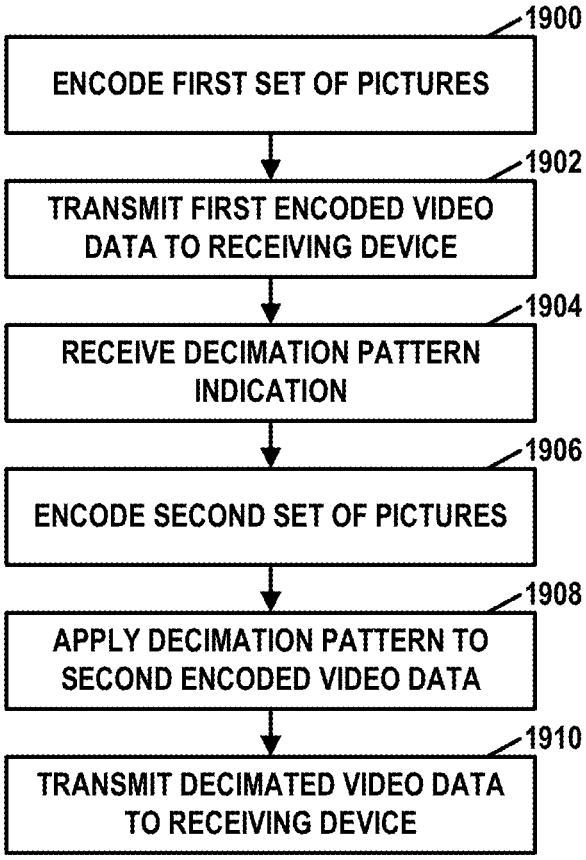

1900
ENCODE FIRST SET OF PICTURES
1902
TRANSMIT FIRST ENCODED VIDEO DATA TO RECEIVING DEVICE
1904
RECEIVE DECIMATION PATTERN INDICATION
1906
ENCODE SECOND SET OF PICTURES
1908
APPLY DECIMATION PATTERN TO SECOND ENCODED VIDEO DATA
1910
TRANSMIT DECIMATED VIDEO DATA TO RECEIVING DEVICE

FIG. 19

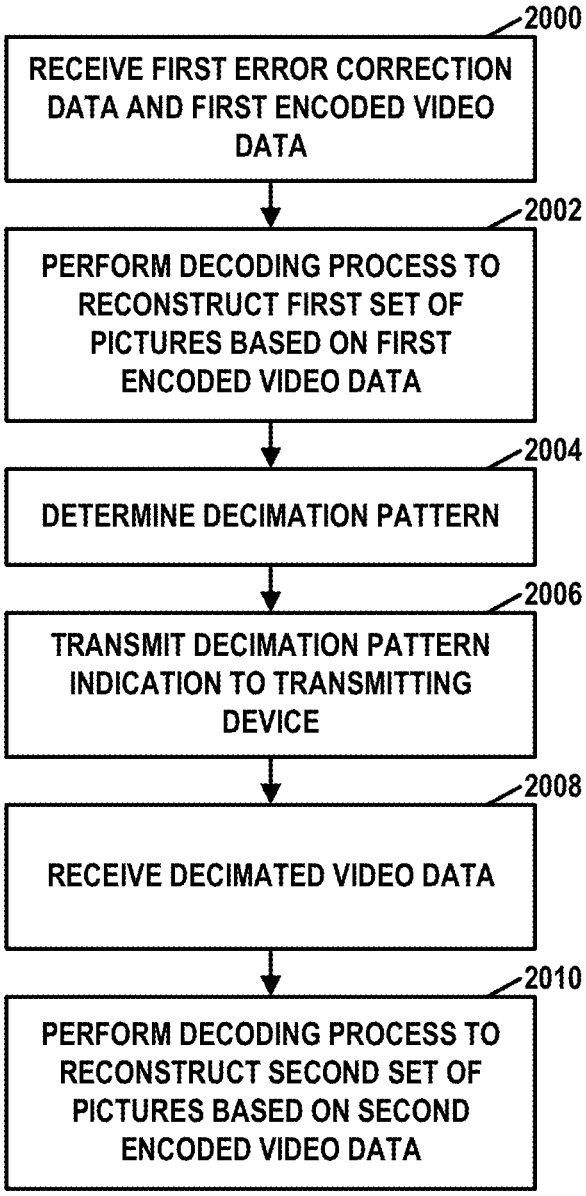

2000
RECEIVE FIRST ERROR CORRECTION DATA AND FIRST ENCODED VIDEO DATA
2002
PERFORM DECODING PROCESS TO RECONSTRUCT FIRST SET OF PICTURES BASED ON FIRST ENCODED VIDEO DATA
2004
DETERMINE DECIMATION PATTERN
2006
TRANSMIT DECIMATION PATTERN INDICATION TO TRANSMITTING DEVICE
2008
RECEIVE DECIMATED VIDEO DATA
2010
PERFORM DECODING PROCESS TO RECONSTRUCT SECOND SET OF PICTURES BASED ON SECOND ENCODED VIDEO DATA

FIG. 20

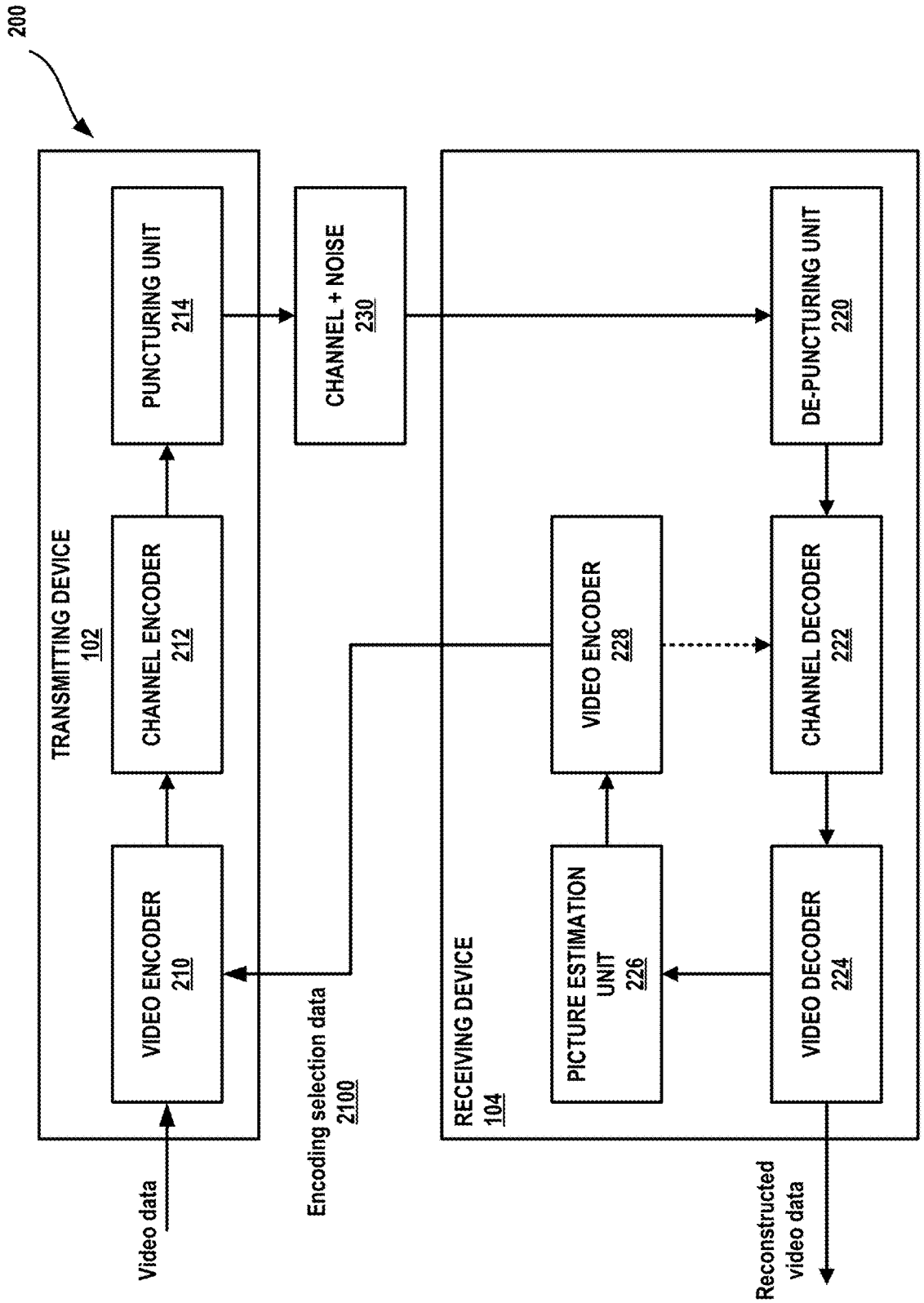

200
TRANSMITTING DEVICE
102
VIDEO ENCODER
210
CHANNEL ENCODER
212
PUNCTURING UNIT
214
CHANNEL + NOISE
230
RECEIVING DEVICE
104
VIDEO DECODER
224
CHANNEL DECODER
222
DE-PUNCTURING UNIT
220
PICTURE ESTIMATION UNIT
226
VIDEO ENCODER
228
Video data
Encoding selection data
2100
Reconstructed video data

FIG. 21

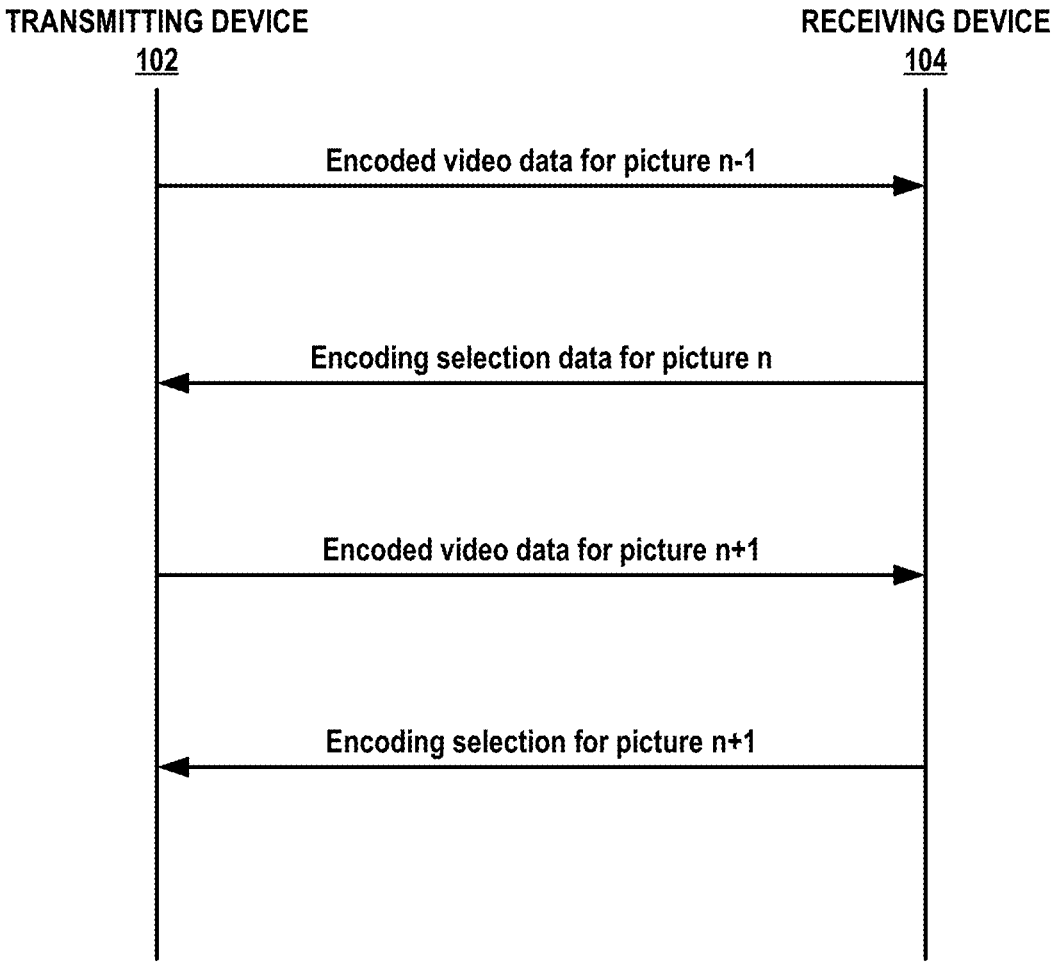

TRANSMITTING DEVICE
102
RECEIVING DEVICE
104
Encoded video data for picture n-1
Encoding selection data for picture n
Encoded video data for picture n+1
Encoding selection for picture n+1

FIG. 22

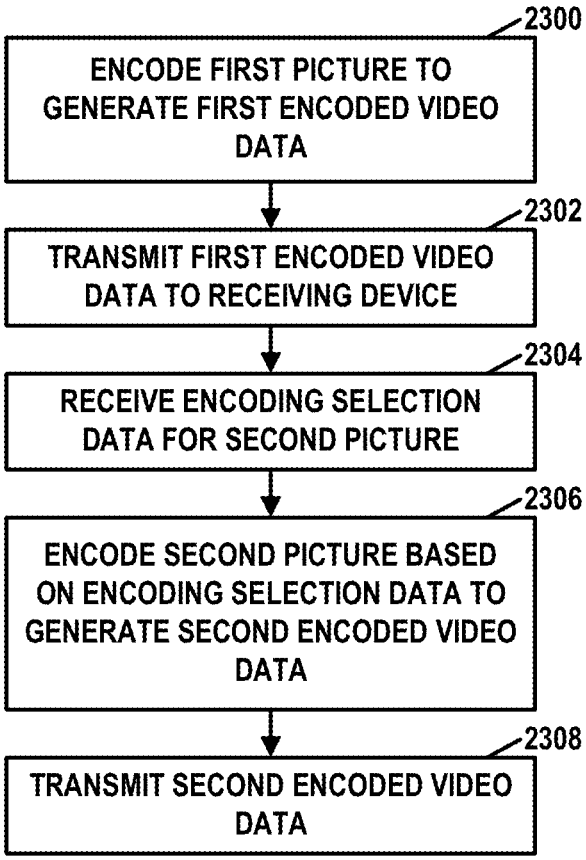

2300
ENCODE FIRST PICTURE TO GENERATE FIRST ENCODED VIDEO DATA
2302
TRANSMIT FIRST ENCODED VIDEO DATA TO RECEIVING DEVICE
2304
RECEIVE ENCODING SELECTION DATA FOR SECOND PICTURE
2306
ENCODE SECOND PICTURE BASED ON ENCODING SELECTION DATA TO GENERATE SECOND ENCODED VIDEO DATA
2308
TRANSMIT SECOND ENCODED VIDEO DATA

FIG. 23

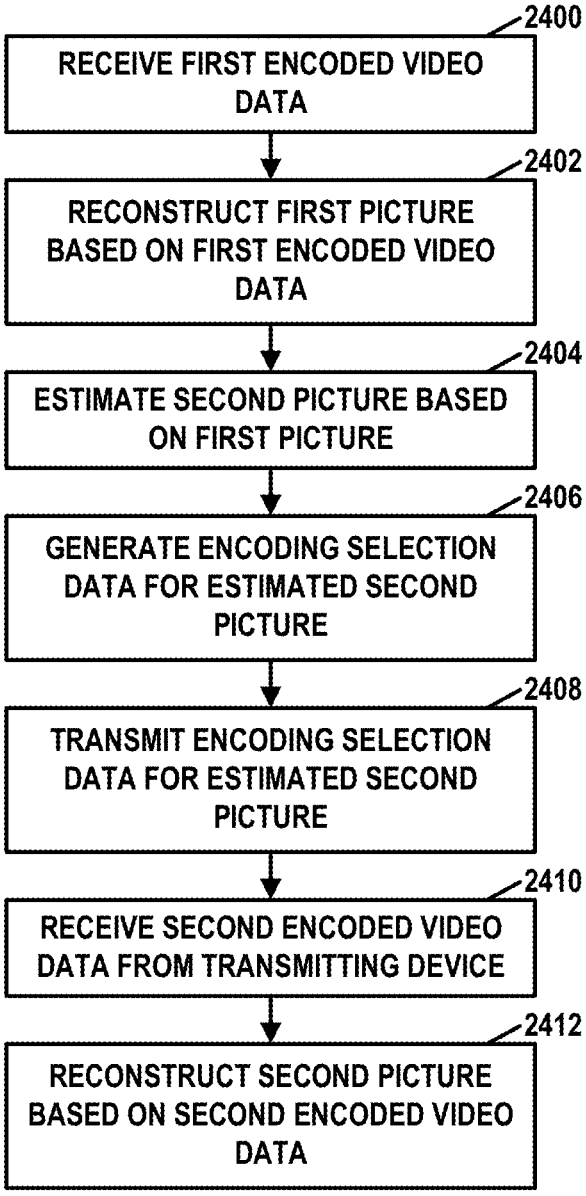

2400
RECEIVE FIRST ENCODED VIDEO DATA
2402
RECONSTRUCT FIRST PICTURE BASED ON FIRST ENCODED VIDEO DATA
2404
ESTIMATE SECOND PICTURE BASED ON FIRST PICTURE
2406
GENERATE ENCODING SELECTION DATA FOR ESTIMATED SECOND PICTURE
2408
TRANSMIT ENCODING SELECTION DATA FOR ESTIMATED SECOND PICTURE
2410
RECEIVE SECOND ENCODED VIDEO DATA FROM TRANSMITTING DEVICE
2412
RECONSTRUCT SECOND PICTURE BASED ON SECOND ENCODED VIDEO DATA

FIG. 24

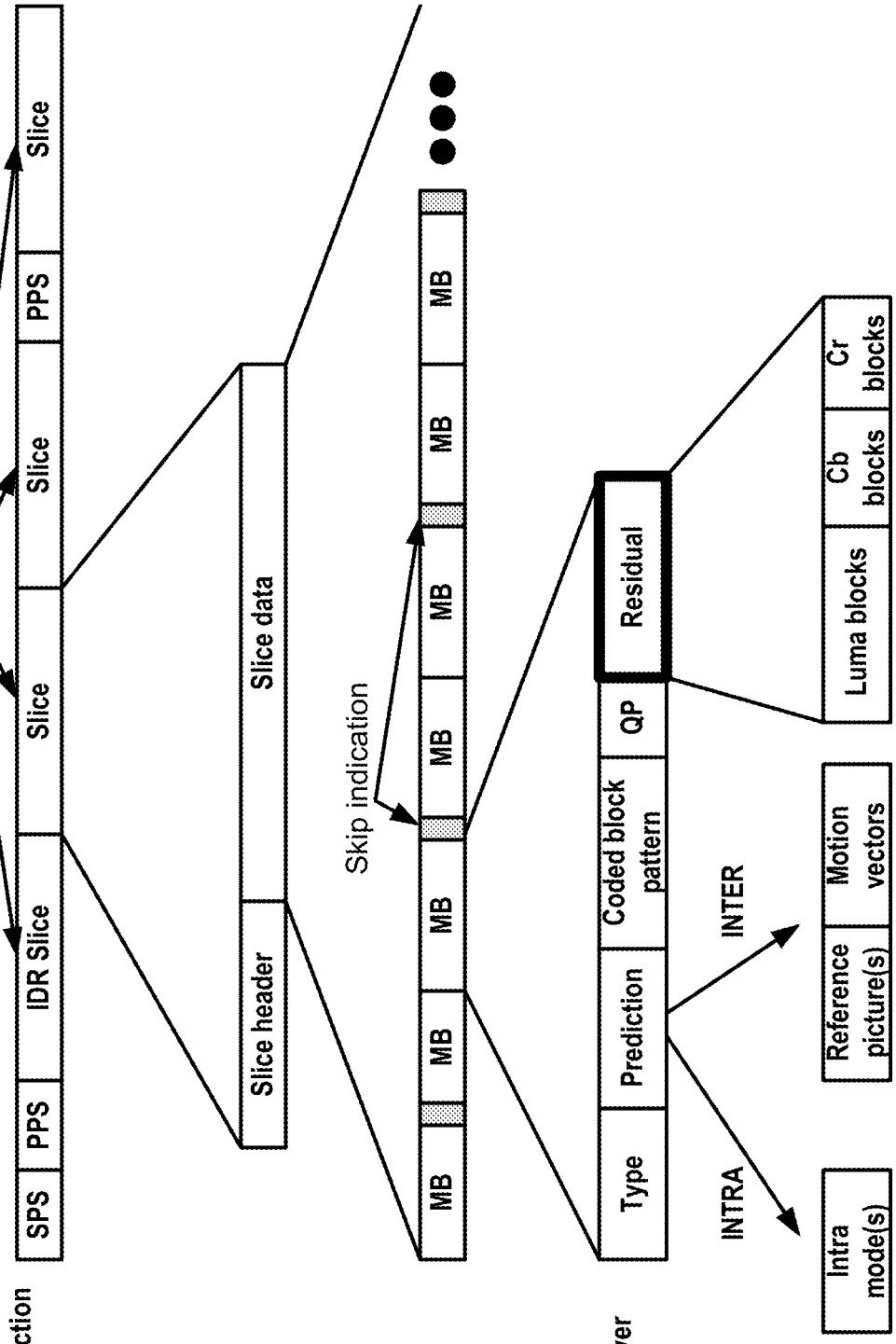

Network abstraction layer
VCL NAL units
SPS
PPS
IDR Slice
Slice
Slice
PPS
Slice
Slice layer
Slice header
Slice data
MB
MB
MB
MB
MB
MB
MB
Skip indication
Macroblock layer
Type
Prediction
Coded block pattern
QP
Residual
INTRA
INTER
Intra mode(s)
Reference picture(s)
Motion vectors
Luma blocks
Cb blocks
Cr blocks

FIG. 25

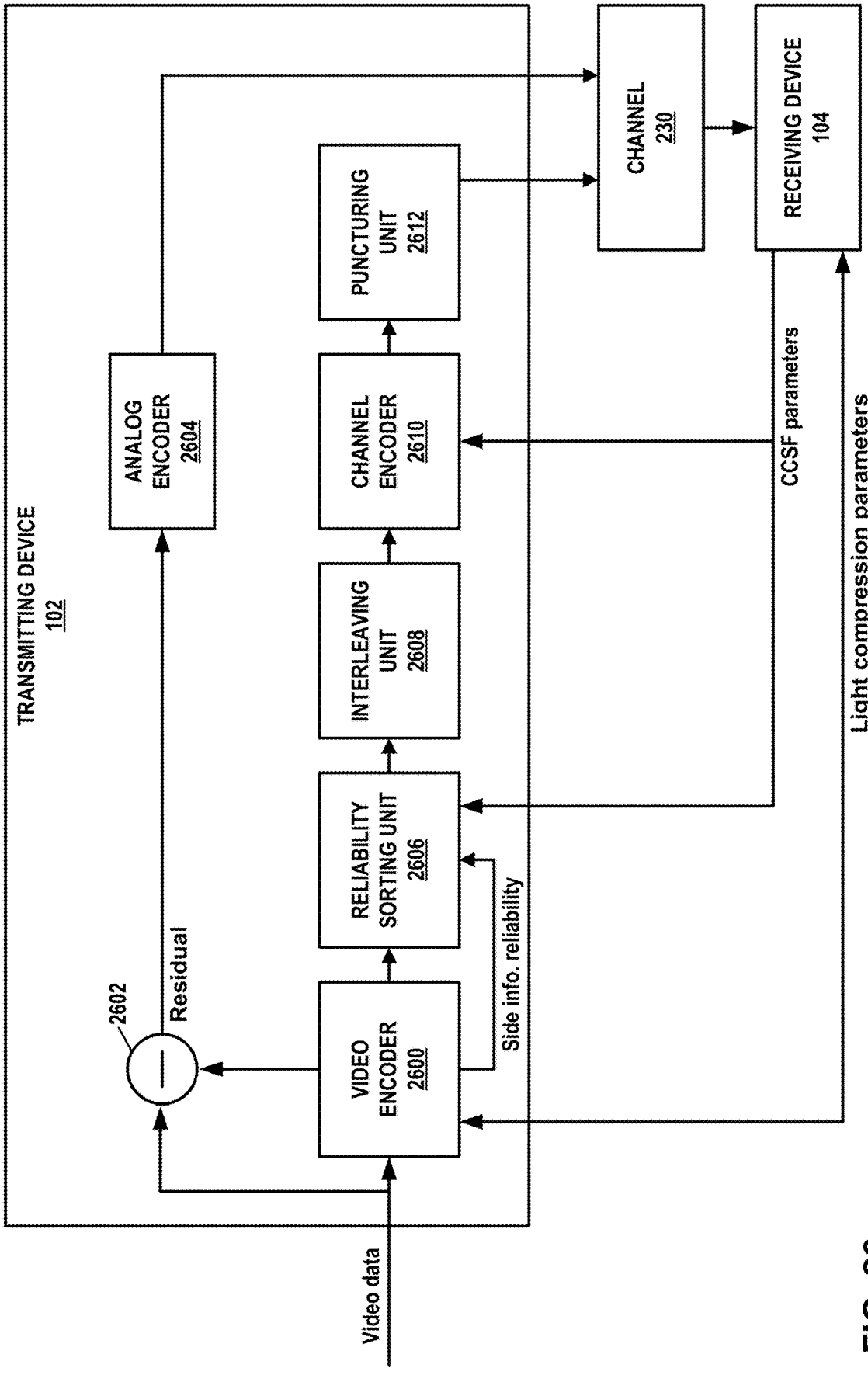

TRANSMITTING DEVICE
102
ANALOG ENCODER
2604
PUNCTURING UNIT
2612
CHANNEL
230
RECEIVING DEVICE
104
CHANNEL ENCODER
2610
INTERLEAVING UNIT
2608
RELIABILITY SORTING UNIT
2606
VIDEO ENCODER
2600
2602
Residual
Side info. reliability
CCSF parameters
Light compression parameters
Video data

FIG. 26

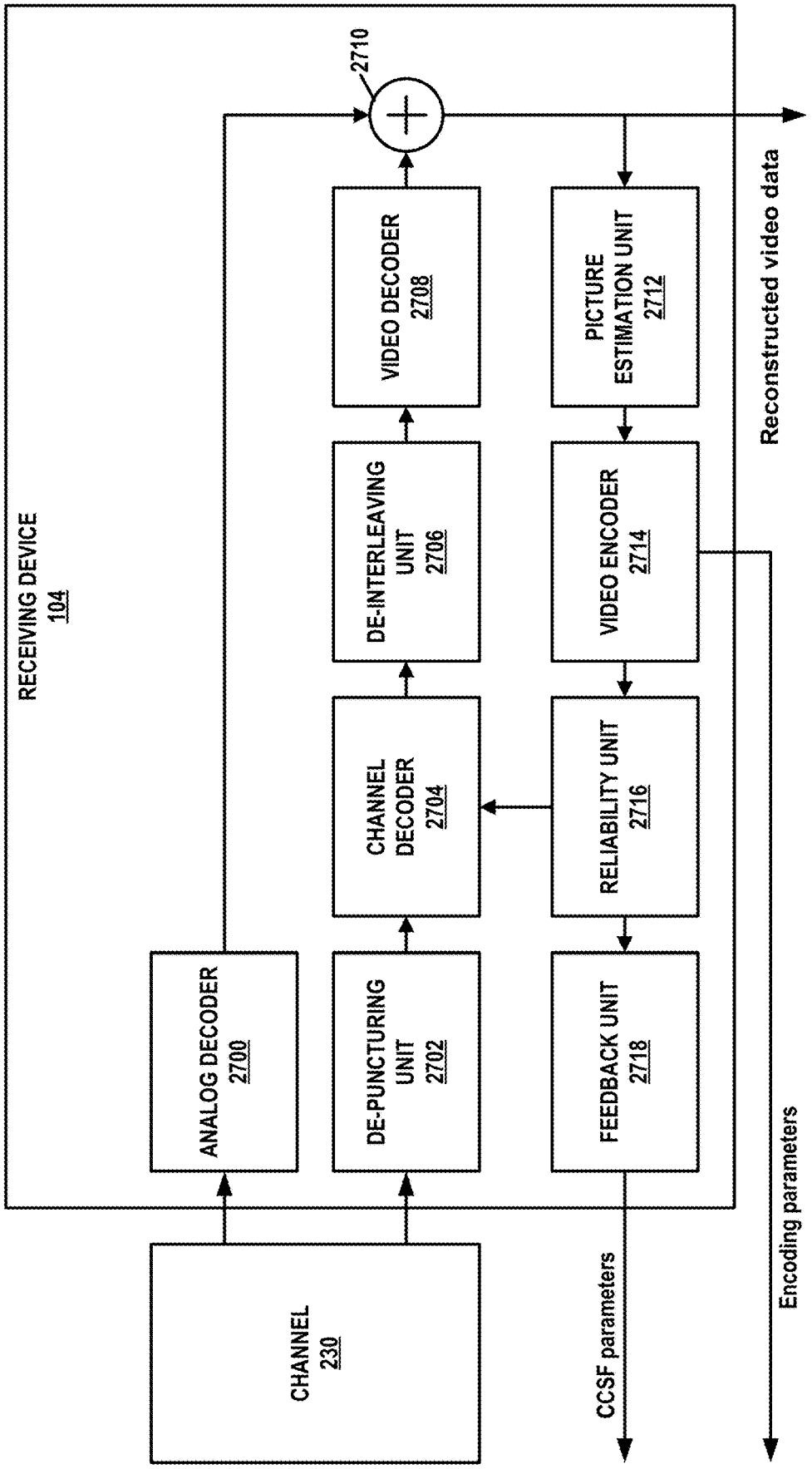

RECEIVING DEVICE
104
2710
VIDEO DECODER
2708
PICTURE
ESTIMATION UNIT
2712
Reconstructed video data
DE-INTERLEAVING
UNIT
2706
VIDEO ENCODER
2714
CHANNEL
DECODER
2704
RELIABILITY UNIT
2716
ANALOG DECODER
2700
DE-PUNCTURING
UNIT
2702
FEEDBACK UNIT
2718
CHANNEL
230
CCSF parameters
Encoding parameters

FIG. 27

COMPANION DEVICE ASSISTED MULTI-VIEW VIDEO CODING

TECHNICAL FIELD

[0001] This disclosure relates to video encoding and decoding.

BACKGROUND

[0002] The popularity of virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies is growing at a fast pace and is expected to be widely adopted for applications other than gaming, such as healthcare, education, social, retail and many more. VR, AR, and MR may be collectively referred to as extended reality (XR). Because of this growing popularity, there is an increase demand for XR devices, such as XR goggles, with high quality of 3D graphics, higher video resolution, and low latency responses.

SUMMARY

[0003] This disclosure describes techniques for processing video data in a transmitting device and a receiving device. The transmitting device may be an XR device or other type of device. The receiving device may be a user equipment (UE) device, such as a smartphone or tablet. The transmitting device may perform a limited video encoding process video data to generate encoded video data. The transmitting device may apply channel encoding to the encoded video data to generate error correction data. The transmitting device may transmit the error correction data and at least some of the encoded video data to the receiving device. The receiving device may estimate video data based on one or more previously reconstructed pictures. The receiving device may then encode the estimated video data. The receiving device may use one or more coding tools to encode the estimated video data that were not used by the transmitting device when performing the limited video encoding process on the video data. The receiving device may use the error correction data and the predicted video data to regenerate portions of the encoded video data that the transmitting device did not send. This process may avoid the need to send portions of the encoded video data.

[0004] In one example, this disclosure describes a method of decoding video data includes obtaining, at a receiving device and from a transmitting device, error correction data, wherein the error correction data provides error correction information and is generated based on encoded video data of one or more blocks of a picture of the video data; generating, at the receiving device, prediction data for the picture using one or more coding tools not used for generating the encoded video data of the one or more blocks, wherein the prediction data for the picture comprises predictions of the blocks of the picture based at least in part on blocks of one or more previously reconstructed pictures of the video data; generating, at the receiving device, encoded video data based on the prediction data for the picture; generating, at the receiving device, error-corrected encoded video data using the error correction data to perform an error correction operation on the encoded video data; and performing, at the receiving device, a reconstruction operation that reconstructs the blocks of the picture based on the error-corrected encoded video data, wherein the reconstruction operation is controlled by values of one or more parameters.

[0005] In another example, this disclosure describes a method of encoding video data includes obtaining, at a transmitting device, video data from a video source; generating, at the transmitting device, based on a set of parameters, encoded video data of a first picture of the video data and encoded video data of a second picture of the video data; performing, at the transmitting device, channel encoding on the encoded video data of the first picture and the encoded video data of the second picture to generate error correction data for the first picture and error correction data for the second picture; and transmitting, at the transmitting device, the encoded video data of the first picture, error correction data for the first picture, and error correction data for the second picture.

[0006] In another example, this disclosure describes a method of encoding video data includes obtaining, at a transmitting device, video data from a video source; generating, at the transmitting device, transform blocks based on the video data; determining, at the transmitting device, which of the transform blocks are anchor transform blocks; calculating, at the transmitting device, a correlation matrix for a transform block set; generating, at the transmitting device, bit-reduced non-anchor transform matrixes; and transmitting, at the transmitting device, the anchor transform blocks, the non-anchor transform blocks, and the correlation matrix to a receiving device.

[0007] In another example, this disclosure describes a device includes a memory configured to store video data; a communication interface; and one or more processing implemented in circuitry and coupled to the memory, the one or more processors configured to perform the methods of any of claims **1-22**.

[0008] In another example, this disclosure describes a device for processing video data includes a memory configured to store video data; and a communication interface configured to obtain error correction data from a transmitting device, wherein the error correction data provides error correction information regarding a picture of the video data; one or more processing implemented in circuitry and coupled to the memory, the one or more processors configured to: generate prediction data for the picture, wherein the prediction data for the picture comprises predictions of blocks of the picture based at least in part on one or more previously reconstructed pictures of the video data; generate encoded video data based on the prediction data for the picture, wherein the encoded video data includes transform blocks that comprises transform coefficients; scale bits of the transform coefficients of the transform blocks based on reliability values for bit positions; generate error-corrected encoded video data using the error correction data to perform an error correction operation on the scaled bits of the transform coefficients of the transform blocks; and reconstruct the picture based on the error-corrected encoded video data.

[0009] In another example, this disclosure describes a device for processing video data includes a memory configured to store video data; and one or more processing implemented in circuitry and coupled to the memory, the one or more processors configured to: obtain video data; obtain prediction quality feedback, wherein the prediction quality feedback is based on reliability of estimated pictures generated by a receiving device; adapt one or more of video encoding parameters or channel encoding parameters based on the prediction quality feedback; perform a video encod-

ing process to generate encoded video data based on one or more pictures of the obtained video data, wherein the video encoding process is controlled by the video encoding parameters; perform a channel encoding process on the encoded video data to generate channel encoded data, wherein the channel encoding process is controlled by the channel encoding parameters; and a communication interface configured to transmit the channel encoded data to the receiving device.

[0010] In another example, this disclosure describes a method of processing video data includes obtaining error correction data at a receiving device and from a transmitting device, wherein the error correction data provides error correction information regarding a picture of the video data; generating, at the receiving device, prediction data for the picture, wherein the prediction data for the picture comprises predictions of blocks of the picture based at least in part on one or more previously reconstructed pictures of the video data; generating, at the receiving device, encoded video data based on the prediction data for the picture, wherein the encoded video data includes transform blocks that comprises transform coefficients; scaling, at the receiving device, bits of the transform coefficients of the transform blocks based on reliability values for bit positions; generating, at the receiving device, error-corrected encoded video data using the error correction data to perform an error correction operation on the scaled bits of the transform coefficients of the transform blocks; and reconstructing, at the receiving device, the picture based on the error-corrected encoded video data.

[0011] In another example, this disclosure describes a method of processing video data includes obtaining video data; obtaining prediction quality feedback, wherein the prediction quality feedback is based on reliability of estimated pictures generated by a receiving device; adapting one or more of video encoding parameters or channel encoding parameters based on the prediction quality feedback; performing a video encoding process to generate encoded video data based on one or more pictures of the obtained video data, wherein the video encoding process is controlled by the video encoding parameters; performing a channel encoding process on the encoded video data to generate channel encoded data, wherein the channel encoding process is controlled by the channel encoding parameters; and transmitting the channel encoded data to the receiving device.

[0012] In another example, this disclosure describes a device includes a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: obtain a first set of multiview pictures of the video data, wherein the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; transmit first encoded video data to a receiving device, wherein the first encoded video data is based on the first set of multiview pictures; receive multiview encoding cues from the receiving device; obtain a second set of multiview pictures of the video data, wherein the second set of multiview pictures includes third pictures and fourth pictures, the third pictures being from the first viewpoint and the fourth pictures being from the second viewpoint; perform, based on the multiview encoding cues received from the receiving device, a multiview encoding process on the second set of multiview pictures to generate second encoded video data, wherein the multiview encoding process reduces inter-view redundancy between the third pictures and the fourth pictures; and transmit the second encoded video data to the receiving device.

[0013] In another example, this disclosure describes a device includes a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: obtain first encoded video data from a transmitting device, wherein the first encoded video data is based on a first set of multiview pictures of the video data, the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; determine multiview encoding cues based on the first encoded video data; transmit the multiview encoding cues to the transmitting device; obtain second encoded video data from the transmitting device, wherein the second encoded video data is based on a second set of multiview pictures that includes third pictures and fourth pictures, the second encoded video data being encoded using a multiview encoding process that reduces inter-view redundancy between the third pictures and the fourth pictures based on the multiview encoding cues.

[0014] In another example, this disclosure describes a method of processing video data includes obtaining a first set of multiview pictures of the video data, wherein the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; transmitting first encoded video data to a receiving device, wherein the first encoded video data is based on the first set of multiview pictures; receiving multiview encoding cues from the receiving device; obtaining a second set of multiview pictures of the video data, wherein the second set of multiview pictures includes third pictures and fourth pictures, the third pictures being from the first viewpoint and the fourth pictures being from the second viewpoint; performing, based on the multiview encoding cues received from the receiving device, a multiview encoding process on the second set of multiview pictures to generate second encoded video data, wherein the multiview encoding process reduces inter-view redundancy between the third pictures and the fourth pictures; and transmitting the second encoded video data to the receiving device.

[0015] In another example, this disclosure describes a method of processing video data includes obtaining first encoded video data from a transmitting device, wherein the first encoded video data is based on a first set of multiview pictures of the video data, the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; determining multiview encoding cues based on the first encoded video data; transmitting the multiview encoding cues to the transmitting device; obtaining second encoded video data from the transmitting device, wherein the second encoded video data is based on a second set of multiview pictures that includes third pictures and fourth pictures, the second encoded video data being encoded using a multiview encoding process that reduces inter-view redundancy between the third pictures and the fourth pictures based on the multiview encoding cues.

[0016] In another example, this disclosure describes a device includes means for obtaining a first set of multiview pictures of video data, wherein the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; means for transmitting first encoded video data to a receiving device, wherein the first encoded video data is based on the first set of multiview pictures; means for receiving multiview encoding cues from the receiving device; means for obtaining a second set of multiview pictures of the video data, wherein the second set of multiview pictures includes third pictures and fourth pictures, the third pictures being from the first viewpoint and the fourth pictures being from the second viewpoint; means for performing, based on the multiview encoding cues received from the receiving device, a multiview encoding process on the second set of multiview pictures to generate second encoded video data, wherein the multiview encoding process reduces inter-view redundancy between the third pictures and the fourth pictures; and means for transmitting the second encoded video data to the receiving device.

[0017] In another example, this disclosure describes a device includes means for obtaining first encoded video data from a transmitting device, wherein the first encoded video data is based on a first set of multiview pictures of the video data, the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; means for determining multiview encoding cues based on the first encoded video data; means for transmitting the multiview encoding cues to the transmitting device; means for obtaining second encoded video data from the transmitting device, wherein the second encoded video data is based on a second set of multiview pictures that includes third pictures and fourth pictures, the second encoded video data being encoded using a multiview encoding process that reduces inter-view redundancy between the third pictures and the fourth pictures based on the multiview encoding cues.

[0018] In another example, this disclosure describes a device includes a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: encode a first set of pictures of the video data to generate first encoded video data; transmit the first encoded video data to a receiving device; receive, from the receiving device, a decimation pattern indication that indicates a decimation pattern determined based on the first set of pictures, the decimation pattern being a pattern of encoded video data non-transmission; encode a second set of pictures of the video data to generate second encoded video data; apply the decimation pattern to the second encoded video data to generate decimated video data; and transmit the decimated video data to the receiving device.

[0019] In another example, this disclosure describes a device includes a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: receive, from a transmitting device, first encoded video data; perform a decoding process to reconstruct a first set of pictures based on the first encoded video data; determine, based on the first set of pictures, a decimation pattern that indicates a pattern of encoded video data non-transmission; transmit, to the transmitting device, a decimation pattern indication that indicates the determined decimation pattern; receive, from the transmitting device, decimated video data, wherein the decimated video data comprises second encoded video data to which the decimation pattern has been applied, wherein the second encoded video data is generated based on a second set of pictures of the video data; and perform the decoding process to reconstruct the second set of pictures based on the second encoded video data.

[0020] In another example, this disclosure describes a method includes encoding a first set of pictures of video data to generate first encoded video data; transmitting the first encoded video data to a receiving device; receiving, from the receiving device, a decimation pattern indication that indicates a decimation pattern determined based on the first set of pictures, the decimation pattern being a pattern of encoded video data non-transmission; encoding a second set of pictures of the video data to generate second encoded video data; applying the decimation pattern to the second encoded video data to generate decimated video data; and transmitting the decimated video data to the receiving device.

[0021] In another example, this disclosure describes a method includes receiving, from a transmitting device, first encoded video data; applying a decoding process to reconstruct a first set of pictures based on the first encoded video data; determining, based on the first set of pictures, a decimation pattern that indicates a pattern of encoded video data non-transmission; transmitting, to the transmitting device, a decimation pattern indication that indicates the determined decimation pattern; receiving, from the transmitting device, decimated video data, wherein the decimated video data comprises second encoded video data to which the decimation pattern has been applied, wherein the second encoded video data is generated based on a second set of pictures of the video data; and performing the decoding process to reconstruct the second set of pictures based on the second encoded video data.

[0022] In another example, this disclosure describes a device includes means for encoding a first set of pictures of video data to generate first encoded video data; means for transmitting the first encoded video data to a receiving device; means for receiving, from the receiving device, a decimation pattern indication that indicates a decimation pattern determined based on the first set of pictures, the decimation pattern being a pattern of encoded video data non-transmission; means for encoding a second set of pictures of the video data to generate second encoded video data; means for applying the decimation pattern to the second encoded video data to generate decimated video data; and means for transmitting the decimated video data to the receiving device.

[0023] In another example, this disclosure describes a device includes means for receiving, from a transmitting device, first encoded video data; means for performing a decoding process to reconstruct a first set of pictures based on the first encoded video data; means for determining, based on the first set of pictures, a decimation pattern that indicates a pattern of encoded video data non-transmission; means for transmitting, to the transmitting device, a decimation pattern indication that indicates the determined decimation pattern; means for receiving, from the transmitting device, decimated video data, wherein the decimated video data comprises second encoded video data to which the

decimation pattern has been applied, wherein the second encoded video data is generated based on a second set of pictures of the video data; and means for performing the decoding process to reconstruct the second set of pictures based on the second encoded video data.

[0024] In another example, this disclosure describes a device includes a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: encode a first picture of the video data to generate first encoded video data; transmit the first encoded video data to a receiving device; receive, from the receiving device, encoding selection data for a second picture of the video data, wherein: the encoding selection data for the second picture indicate encoding selections used to encode an estimate of the second picture, and the second picture follows the first picture in decoding order; encode the second picture based on the encoding selection data for the second picture to generate second encoded video data; and transmit the second encoded video data to the receiving device.

[0025] In another example, this disclosure describes a device includes a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: receive first encoded video data from a transmitting device; reconstruct a first picture of the video data based on the first encoded video data; estimate a second picture of the video data based on the first picture, the second picture being a picture occurring after the first picture in decoding order; generate encoding selection data for the second picture, wherein the encoding selection data for the second picture indicate encoding selections used to encode the second picture; transmit, to the transmitting device, the encoding selection data for the second picture; receive second encoded video data from the transmitting device; and reconstruct the second picture based on the second encoded video data.

[0026] In another example, this disclosure describes a method of processing video data includes encoding a first picture of the video data to generate first encoded video data; transmitting the first encoded video data to a receiving device; receiving, from the receiving device, encoding selection data for a second picture of the video data, wherein: the encoding selection data for the second picture indicate encoding selections used to encode an estimate of the second picture, and the second picture follows the first picture in decoding order; encoding the second picture based on the encoding selection data for the second picture to generate second encoded video data; and transmitting the second encoded video data to the receiving device.

[0027] In another example, this disclosure describes a method of processing video data includes receiving first encoded video data from a transmitting device; reconstructing a first picture of the video data based on the first encoded video data; estimating a second picture of the video data based on the first picture, the second picture being a picture occurring after the first picture in decoding order; generating encoding selection data for the second picture, wherein the encoding selection data for the second picture indicate encoding selections used to encode the second picture; transmitting, to the transmitting device, the encoding selection data for the second picture; receiving second encoded video data from the transmitting device; and reconstructing the second picture based on the second encoded video data.

[0028] In another example, this disclosure describes a device includes means for encoding a first picture of video data to generate first encoded video data; means for transmitting the first encoded video data to a receiving device; means for receiving, from the receiving device, encoding selection data for a second picture of the video data, wherein: the encoding selection data for the second picture indicate encoding selections used to encode an estimate of the second picture, and the second picture follows the first picture in decoding order; means for encoding the second picture based on the encoding selection data for the second picture to generate second encoded video data; and means for transmitting the second encoded video data to the receiving device.

[0029] In another example, this disclosure describes a device includes means for receiving first encoded video data from a transmitting device; means for reconstructing a first picture of the video data based on the first encoded video data; means for estimating a second picture of the video data based on the first picture, the second picture being a picture occurring after the first picture in decoding order; means for generating encoding selection data for the second picture, wherein the encoding selection data for the second picture indicate encoding selections used to encode the second picture; means for transmitting, to the transmitting device, the encoding selection data for the second picture; means for receiving second encoded video data from the transmitting device; and means for reconstructing the second picture based on the second encoded video data.

[0030] 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, drawings, and claims.

BRIEF DESCRIPTION OF DRAWINGS

[0031] FIG. **1** is a block diagram illustrating an example system according to techniques of this disclosure.

[0032] FIG. **2** is a block diagram illustrating example components of a transmitting device and a receiving device according to techniques of this disclosure.

[0033] FIG. **3**A is a conceptual diagram illustrating an example channel encoding process according to techniques of this disclosure.

[0034] FIG. **3**B is a block diagram illustrating an example channel decoding process according to techniques of this disclosure.

[0035] FIG. **4** is a flowchart illustrating an example operation of a transmitting device according to techniques of this disclosure.

[0036] FIG. **5** is a flowchart illustrating an example operation of a receiving device according to techniques of this disclosure.

[0037] FIG. **6** is a conceptual diagram illustrating an example decimation pattern according to techniques of this disclosure.

[0038] FIG. **7** is a flowchart illustrating an example operation of a transmitting device for hybrid decimation of transform blocks according to techniques of this disclosure.

[0039] FIG. **8** is a flowchart illustrating an example operation of a receiving device for hybrid decimation of transform blocks according to techniques of this disclosure.

[0040] FIG. **9** is a conceptual diagram illustrating an example decimation pattern adaptively selected by a receiving device according to one or more techniques of this disclosure.

[0041] FIG. **10** is a block diagram illustrating example components of a transmitting device and a receiving device according to techniques of this disclosure.

[0042] FIG. **11** illustrates charts of example error probabilities and corresponding log likelihood ratio (LLR) absolute values, according to one or more techniques of this disclosure.

[0043] FIG. **12** is a flowchart illustrating an example operation of a transmitting device using scaled bits according to techniques of this disclosure.

[0044] FIG. **13** is a flowchart illustrating an example operation of a receiving device using scaled bits according to techniques of this disclosure.

[0045] FIG. **14** is a flow diagram illustrating an example exchange of data between a transmitting device and a receiving device related to multiview processing according to one or more techniques of this disclosure.

[0046] FIG. **15** is a flowchart illustrating an example operation of a transmitting device for multiview processing according to techniques of this disclosure.

[0047] FIG. **16** is a flowchart illustrating an example operation of a receiving device for multiview processing according to techniques of this disclosure.

[0048] FIG. **17** is a block diagram illustrating example components of a transmitting device and a receiving device that perform decimation on encoded video data according to techniques of this disclosure.

[0049] FIG. **18** is a conceptual diagram illustrating an example exchange of information that includes decimation pattern indications according to techniques of this disclosure.

[0050] FIG. **19** is a flowchart illustrating an example operation of a transmitting device in which the transmitting device receives a decimation pattern indication according to techniques of this disclosure.

[0051] FIG. **20** is a flowchart illustrating an example operation of a receiving device in which the receiving device transmits a decimation pattern indication according to techniques of this disclosure.

[0052] FIG. **21** is a block diagram illustrating example components of a transmitting device and a receiving device that transmits encoding selection data to the transmitting device according to techniques of this disclosure.

[0053] FIG. **22** is a communication diagram illustrating an example exchange of data between a transmitting device and a receiving device that includes transmission and reception of encoding selection data according to techniques of this disclosure.

[0054] FIG. **23** is a flowchart illustrating an example operation of a transmitting device in which the transmitting device receives encoding selection data according to techniques of this disclosure.

[0055] FIG. **24** is a flowchart illustrating an example operation of a receiving device in which the receiving device transmits encoding selection data according to techniques of this disclosure.

[0056] FIG. **25** is a conceptual diagram illustrating an example hierarchy of encoded video data according to techniques of this disclosure.

[0057] FIG. **26** is a block diagram illustrating alternative example components of a transmitting device according to one or more techniques of this disclosure.

[0058] FIG. **27** is a block diagram illustrating example alternative components of a receiving device according to one or more techniques of this disclosure.

DETAILED DESCRIPTION

[0059] While modern video encoding processes can significantly reduce the amount of data needed to represent video data, such video encoding processes are typically resource intensive and may involve many memory operations. Modern video encoding processes may therefore require complex processors, fast memory, and consume considerable energy. However, with some contemporary and future planned wireless communication systems, such as 5G and 6G wireless communication systems, wireless transmission bandwidth may be less of a constraint, especially when communicating over short distances such as the distances between devices on a person's body.

[0060] This disclosure describes techniques that may reduce the complexity of video encoding at a transmitting device using error correction that is performed as part of channel decoding using error correction data. A transmitting device may perform a limited video encoding process that generates encoded video data. The limited video encoding process typically uses coding tools, such as intra prediction, that are relatively less resource intensive. Because the video encoding process uses less complex coding tools, the resulting encoded video data may be larger than video data encoded using more complex and resource intensive coding tools. The error correction data is based on the encoded video data. The transmitting device may transmit the error correction data to a receiving device. It may not be necessary for the transmitting device to transmit all of the encoded video data of one or more pictures to the receiving device.

[0061] The receiving device may estimate a picture of the video data based on one or more previously reconstructed pictures. In some examples, to estimate the picture, the receiving device may extrapolate the content of blocks from the previously reconstructed pictures. The receiving device may then perform a full video encoding process on the estimated picture to generate estimated encoded video data for the picture. When performing the full video encoding process, the receiving device may use more complex coding tools, such as inter prediction, than the limited video encoding process performed by the transmitting device. The receiving device may perform a channel decoding process that generates error-corrected encoded video data based on the estimated encoded video data for the picture and the error correction data for the picture. In some circumstances, the channel decoding process may generate the error-corrected encoded video data based on the error correction data for the picture and a combination of the estimated encoded video data for the picture and encoded video data for the picture sent by the transmitting device. The receiving device may reconstruct the picture based on the error-corrected encoded video data. In this way, the receiving device may be able to reconstruct each picture of the video data even though the transmitting device did not transmit all of the encoded video data of the picture.

[0062] As further described in this disclosure, various techniques, such as applications of decimation patterns, may be applied that specify which transform blocks of the lightly

encoded video data are not signaled or have reduced bit depths. Furthermore, in some examples of this disclosure, reliability values can be determined for bit positions, bits of transform coefficients of the transform blocks can be scaled using the reliability values, and the scaled values may be used in channel encoding and channel decoding.

[0063] As further described in this disclosure, the receiving device may determine a decimation pattern based on a first set of pictures. The decimation pattern is a pattern of encoded video data non-transmission. The receiving device may transmit, to the transmitting device, a decimation pattern indication that indicates the determined decimation pattern. The transmitting device may receive the decimation pattern indication from the receiving device and apply the indicated decimation pattern to encoded video data to generate decimated video data. The transmitting device may transmit the decimated video data to the receiving device. In this way, the techniques of this disclosure may further reduce resource consumption at the transmitting device while still avoiding transmitting excessive amounts of data. This may further increase coding efficiency.

[0064] FIG. **1** is a block diagram illustrating an example system **100** according to techniques of this disclosure. In the example of FIG. **1**, system **100** includes a transmitting device **102**, a receiving device **104**, and a base station **106**. Transmitting device **102** may be a device configured to perform include an extended reality (XR) device (e.g., an XR headset), a mobile device, a wearable device, a sensor device, an Internet of Things (IoT) device, intermediate networking device, or another type of device. In some examples, transmitting device **102** may be included in a robot or vehicle. Receiving device **104** may be a computing device, such as a mobile device (e.g., a mobile phone or tablet computer), personal computer, vehicle-based computing device, wireless base station, wearable computing device, intermediate network device, special-purpose device, Internet of Thing (IoT) device, or other type of device. In some examples, receiving device **104** is a device that a user of transmitting device **102** may have in addition to transmitting device **102**.

[0065] Transmitting device **102** and receiving device **104** may communicate with base station **106**. In some examples, transmitting device **102** and receiving device **104** may communicate with base station **106** using a 5th-generation (5G) wireless communication protocol, 6th-generation (6G) wireless communication protocol, WiFi protocol, Bluetooth protocol, or another type of wireless communication protocol. Base station **106** may transmit data from a network **115** to transmitting device **102** and receiving device **104** via wireless downlink channels **108**A, **108**B (collectively, "wireless downlink channels **108**"). Base station **106** may receive data from transmitting device **102** and receiving device **104** for transmission to other devices connected to network **115** via wireless uplink channels **110**A, **110**B (collectively, "wireless uplink channels **110**"). Transmitting device **102** and receiving device **104** may communicate directly with each other via a wireless sidelink channel **112**. In other examples, transmitting device **102** and receiving device **104** may communicate via other types of channels. In other examples, transmitting device **102** and receiving device **104** may communicate via other types of channels.

[0066] In the example of FIG. **1**, transmitting device **102** includes one or more processors **114**, a memory **116**, a communication interface **118**, a video source **120**, and a display system **122**. Receiving device **104** includes one or more processors **130**, a memory **132**, and a communication interface **134**. Processors **114** and processors **130** may include circuitry configured to perform various information processing tasks, including execution of computer-readable instructions. Processors **114** and processors **130** may include microprocessors, digital signal processors, and other types of circuitry. Memory **116** and memory **132** may be configured to store data, such as computer-readable instructions, video data, and other types of data. Communication interface **118** and communication interface **134** may be configured to send and receive data, e.g., via wireless downlink channels **108**, wireless uplink channels **110**, and wireless sidelink channel **112**.

[0067] In general, video source **120** represents a source of video data (e.g., raw, unencoded video data). Video source **120** may include one or more video capture devices, such as a video camera, a video archive containing previously captured raw video, and/or a video feed interface to receive video from a video content provider. As a further alternative, video source **120** may generate computer graphics-based data as the source video, or a combination of live video, archived video, and computer-generated video.

[0068] In examples where transmitting device **102** is an XR device that presents MR and AR imagery to a user, video data from video source **120** may need to be analyzed so that display system **122** of transmitting device **102** is able to display virtual elements at the correct locations. Processing video data in this way may require significant computational resources. In other words, powerful processors and significant amounts of energy may be used when processing the video data. Because transmitting device **102** may be designed for wear on a user's head, it may be important to minimize the weight and power consumption of transmitting device **102**, while supporting high-quality low-latency video.

[0069] Furthermore, in some examples, transmitting device **102** is an XR headset and transmitting device **102** may be configured to process pictures of the video data to generate virtual element data. Receiving device **104** may configured to transmit (and transmitting device **102** is configured to receive) the virtual element data. Transmitting device **102** may include a display system **122** configured to display one or more virtual elements in a XR scene based on the virtual element data.

[0070] Accordingly, it may be desirable to offload processing of the video data to a device other than transmitting device **102**, such as receiving device **104**. Receiving device **104** may, either permanently or on transitory basis, have greater resources than transmitting device **102**. For example, receiving device **104** may be equipped with a larger battery and comparatively powerful processors. However, for receiving device **104** to process the video data, transmitting device **102** may need to transmit the video data to receiving device **104** via wireless sidelink channel **112**. Because a very large number of bits may be required to represent unencoded high-quality video data, it would take a significant amount of time and energy for transmitting device **102** to transmit the unencoded high-quality video data to receiving device **104**. The required time for transmission may undermine the goal of providing low-latency video to the user. The required energy for transmission may undermine the goal of minimizing power consumption. Encoding the video data using a video coding specification, such as H.264/Advanced Video

Coding (AVC), H.265/High Efficiency Video Coding (HEVC), or H.266/Versatile Video Coding (VVC), may significantly reduce the amount of data required to represent the video data. However, the encoding process itself may introduce its own delays and power consumption demands.

[0071] This disclosure describes techniques that may address these problems. In accordance with a technique of this disclosure, transmitting device **102** and receiving device **104** may use a distributed video coding (DVC) process. The DVC process reduces the amount of encoding work performed by transmitting device **102** and shifts some of the encoding work to receiving device **104**. Receiving device **104** may have more resources (e.g., computation power, access to power, etc.) than transmitting device **102** and so may be better equipped to perform the encoding work. In some examples, the DVC process may be used for load balancing computational tasks among devices. For example, a system may determine that it may be more efficient overall for receiving device **104** to perform specific video-related computational tasks than transmitting device **102**.

[0072] In addition to the video encoding process, transmitting device **102** may perform channel encoding process to prepare the encoded video data for transmission to receiving device **104**. The channel encoding process may generate error correction data for sequences of data within the encoded video data. Typically, receiving device **104** uses error correction data to correct errors introduced into the encoded video data during transmission. However, in accordance with techniques of this disclosure, transmitting device **102** may send the error correction data for some encoded video data, but not the encoded video data to which the error correction data corresponds. Receiving device **104** may estimate one or more subsequent pictures. Receiving device **104** may perform a video encoding process on the subsequent pictures to generate estimated encoded video data. The receiving device may use the estimated encoded video data and the received error correction data to generate error-corrected encoded video data. Receiving device **104** may then decode the error-corrected encoded video data to reconstruct the video data that transmitting device **102** did not send.

[0073] Thus, in some examples, receiving device **104** may obtain, from transmitting device **102**, first encoded video data and first error correction data. The first encoded video data may represent one or more blocks of a first picture of the video data. The first error correction data may provide error correction information regarding the blocks of the first picture. Receiving device **104** may generate first error-corrected encoded video data using the first error correction data to perform an error correction operation on the first encoded video data. Additionally, receiving device **104** may perform a first reconstruction operation that reconstructs the blocks of the first picture based on the first encoded video data. The first reconstruction operation may be controlled by values of one or more parameters.

[0074] Furthermore, receiving device **104** may obtain second error correction data from transmitting device **102**. The second error correction data may provide error correction information regarding one or more blocks of a second picture of the video data. Receiving device **104** may generate prediction data for the second picture. The prediction data for the second picture may comprise predictions of the blocks of the second picture of the video data based at least in part on the blocks of one or more previously reconstructed pictures, such as the first picture. Receiving device **104** may use one or more coding tools to generate the prediction data that were not used for generating the encoded video data for the second picture. Receiving device **104** may generate second encoded video data based on the prediction of the blocks of the second picture. Receiving device **104** may generate second error-corrected encoded video data using the second error correction data to perform the error correction operation on the second encoded video data. Receiving device **104** may perform a second reconstruction operation that reconstructs the blocks of the second picture based on the second error-corrected encoded video data. The second reconstruction operation is controlled by the values of the parameters.

[0075] Furthermore, in accordance with one or more techniques of this disclosure, receiving device **104** may receive a decimation pattern indication from receiving device **104**. Receiving device **104** may determine a decimation pattern indication determined based on previously reconstructed pictures. The decimation pattern indication may indicate a pattern of encoded video data non-transmission. For example, the decimation pattern may indicate a pattern of skipping transmitting of encoded video data of full pictures. In some examples, the decimation pattern indicates a pattern of skipping transmission of encoded video data of specified regions within pictures. In some examples where the video data is multiview video data, the decimation pattern may indicate a pattern of skipping transmission of encoded video data of pictures from specified views.

[0076] Transmitting device **102** may perform a video encoding process on pictures of the video data. The video encoding process may compress the pictures less than a "heavy" or more complex compression operation, such as the compression operations described in H.264, H.265, and H.266 video coding standards. In addition to the video encoding process, transmitting device **102** may perform channel encoding process to prepare the encoded video data for transmission to receiving device **104**. The channel encoding process may generate error correction data for sequences of data within the encoded video data. Typically, receiving device **104** uses error correction data to correct errors introduced into the encoded video data during transmission. However, receiving device **104** may also use the error correction data to restore information that was intentionally not transmitted to receiving device. Thus, transmitting device **102** may apply the decimation pattern to the second encoded video data to generate decimated video data. Transmitting device **102** may transmit the error correction data (which was generated based on the undecimated encoded video data) and the decimated video data to receiving device **104**.

[0077] Receiving device **104** may obtain, from transmitting device **102**, first encoded video data and first error correction data. The first encoded data may represent one or more blocks of a first picture of the video data. The first error correction data may provide error correction information regarding the blocks of the first picture. Receiving device **104** may generate first error-corrected encoded video data using the first error correction data to perform an error correction operation on the first encoded video data. Additionally, receiving device **104** may perform a first reconstruction operation that reconstructs the blocks of the first

picture based on the first encoded video data. The first reconstruction operation may be controlled by values of one or more parameters.

[0078] Furthermore, receiving device **104** may obtain first error correction data and first encoded video data from transmitting device **102**. Receiving device **104** may apply an error correction process to modify the first encoded video data based on the first error correction data to generate first error-corrected encoded video data. Receiving device **104** may also apply a decoding process to reconstruct a first set of pictures based on the first error-corrected encoded video data. Receiving device **104** may determine, based on the first set of pictures, a decimation pattern that indicates a pattern of encoded video data non-transmission. Receiving device **104** may transmit, to transmitting device **102**, a decimation pattern indication that indicates the determined decimation pattern. Receiving device **104** may receive, from transmitting device **102**, second error correction data and decimated video data. The decimated video data may comprise second encoded video data to which the decimation pattern has been applied. The second encoded video data is generated based on a second set of pictures of the video data. Receiving device **104** may apply the error correction process to modify the second encoded video data based on the second error correction data to generate second error-corrected encoded video data. Receiving device **104** may apply the decoding process to reconstruct the second set of pictures based on the second error-corrected encoded video data.

[0079] FIG. **2** is a block diagram illustrating example components of a transmitting device and a receiving device according to techniques of this disclosure. System **200** includes transmitting device **102** and receiving device **104**. Transmitting device **102** is configured to transmit encoded video data to receiving device **104**. In the example of FIG. **2**, transmitting device **102** includes a video encoder **210**, a channel encoder **212**, and a puncturing unit **214**. Receiver device **104** includes a de-puncturing unit **220**, a channel decoder **222**, a video decoder **224**, a picture estimation unit **226**, and a video encoder **228**. In other examples, transmitting device **102** and receiver device **104** may include more, fewer, or different units. Processors **114** (FIG. **1**) of transmitting device **102** may implement video encoder **210**, channel encoder **212**, and puncturing unit **214**. Processors **130** of receiving device **104** may implement de-puncturing unit **220**, channel decoder **222**, video decoder **224**, picture estimation unit **226**, and video encoder **228**. Communication interface **118** (FIG. **1**) may transmit and receive data on behalf of transmitting device **102**. Communication interface **134** (FIG. **1**) may transmit and receive data on behalf of receiving device **104**.

[0080] Video encoder **210** of transmitting device **102** may receive video data from a video source (e.g., video source **120** (FIG. **1**). The video data may include raw, unencoded video pictures, e.g., from video source **120**. In some examples, a memory of transmitting device **102** (e.g., memory **116** (FIG. **1**)) may store the video data. Video encoder **210** may perform a video encoding process on the video data to generate encoded video data. The video encoding process may be "limited" in the sense that the video encoding process may be relatively quick and consumes fewer resources than a more robust video compression process, such as H.264/AVC, H.265/HEVC, or H.266/VVC. The video encoding process may not reduce the number of bits that represent the video data to the same extent as a more robust or full video encoding process.

[0081] Video encoder **210** may perform the limited video encoding process in one of a variety of ways. For instance, in some examples, video encoder **210** may perform a prediction process, such as an intra prediction process, on each picture of the video data to produce prediction data. Video encoder **210** may generate residual data based on the prediction data. For example, video encoder **210** may subtract samples of the prediction data from corresponding samples of the original pictures to determine samples of the residual data. A sample may be a value (such as a Y, Cb, or Cr value in a YCbCr color domain or a red, green, or blue value in an RGB color domain) indicating a color value.

[0082] Video encoder **210** may apply a transform, such as a discrete cosine transform (DCT), to the residual data to produce transform blocks that include transform coefficients. Additionally, video encoder **210** may quantize the transform coefficients. Video encoder **210** may apply entropy encoding, such as context adaptive binary arithmetic coding (CABAC) encoding or exponential Golomb-Rice coding to syntax elements representing the quantized transform coefficients. The encoded video data may include the entropy-encoded syntax elements. In some examples, video encoder **210** applies the transform and/or quantization directly to the video data without first using intra prediction. In some examples where video encoder **210** does not apply entropy encoding, the encoded video data includes the syntax elements representing quantized transform coefficients, non-quantized transform coefficients, or residual data.

[0083] In examples where video encoder **210** does not use inter picture prediction, fewer memory read requests may be needed as compared to a more robust video compression process that may need to read data regarding previously coded pictures from memory. Such memory read requests may be comparatively time and energy intensive.

[0084] In some examples where the video data is multiview video data, video encoder **210** may perform multiview video encoding to generate the prediction data. For example, video encoder **210** may use inter-view prediction to generate prediction data for blocks (e.g., macroblocks, coding units, etc.) of non-anchor pictures. In some instances, inter-view prediction may involve determining disparity vectors for the blocks that indicate lateral displacements between the blocks and corresponding blocks in pictures of one or more reference views.

[0085] Channel encoder **212** of transmitting device **102** may apply a channel encoding process to the encoded video data. The channel encoding process prepares the encoded video data for transmission on a wireless communication channel, such as channel **230**. Channel **230** may be wireless sidelink channel **112** (FIG. **1**) or another communication channel. The channel-encoded video data may include error correction data. Channel encoder **212** may generate the error correction data in various ways. For example, channel encoder **212** may generate the error correction data as convolutional codes or turbo codes. The error correction data may help receiving device **104** determine whether received encoded video data has been changed during transmission via channel **230** and may help receiving device **104** correct for such changes. A more detailed discussion of channel encoding and channel decoding is provided below with respect to FIG. **3**.

[0086] Furthermore, in the example of FIG. **2**, puncturing unit **214** of transmitted device **202** may apply a bit puncturing process to error correction data to generate bit-punctured error correction data. The bit puncturing process may reduce the number of bits in the error correction data. For example, puncturing unit **214** may perform an operation that removes bits from the error correction data according to a puncturing pattern.

[0087] Transmitting device **102** may transmit data, such as encoded video data and error correction data (e.g., bit-punctured error correction data), to receiving device **104** via channel **230**. Channel **230** may introduce noise into the transmitted data. In some examples, channel **230** is a multipath channel and data transmitted in channel **230** may be time varying. Receiving device **104** may receive the noise-modified data. Receiving device **104** may store the noise-modified data at least temporarily in a memory, such as memory **132** (FIG. **1**).

[0088] De-puncturing unit **220** may perform a de-puncturing operation on the received bit-punctured error correction data to reconstruct the error correction data. The de-puncturing operation may replace punctured symbols with neutral values as directed by the puncture pattern. The de-puncturing operation may generate erasure bits, which indicate the presence of neutral symbols in the error correction data.

[0089] Channel decoder **222** may apply a channel decoding process to generate error-corrected encoded video data based on the error correction data and encoded video data, such as encoded video data received from transmitting device and/or encoded video data generated by receiving device **104**. For example, channel decoder **222** may change the values of bits encoded video data in accordance with any of a variety of error correction schemes, such low-density parity-check (LDPC) coding or forward error correction (FEC).

[0090] Video decoder **224** may perform a video decoding process to reconstruct pictures based on the error-corrected encoded video data. For example, video decoder **224** may apply an entropy decoding process to bits of the error-corrected encoded video data to obtain quantized transform coefficients. Video decoder **224** may apply an inverse quantization operation on the quantized transform coefficients, apply an inverse transform to the inverse quantized transform coefficients to generate residual data, generate prediction data to generate prediction data, and use the prediction data and the residual data to reconstruct the pictures of the video data. Video decoder **224** may generate the prediction data in the same manner as video encoder **210**.

[0091] Picture estimation unit **226** may generate an estimate of a next picture of the video data. For example, picture estimation unit **226** may extrapolate the next picture from two or more previously reconstructed pictures. For instance, in this example, picture estimation unit **226** may partition a first previously reconstructed picture into blocks. For each block of the first previously reconstructed picture, picture estimation unit **226** may determine one or more corresponding blocks for the block in one or more additional previously reconstructed pictures. The corresponding blocks for the block may be the best available matches to the block. Picture estimation unit **226** may generate a prediction for the block based on the one or more corresponding blocks for the block. Picture estimation unit **226** may use uni-directional prediction or bi-directional prediction for generating the prediction. Thus, by generation a prediction for each block of the next picture, picture estimation unit **226** may generate an estimate of the next picture. In some examples, picture estimation unit **226** generate the next picture by applying global motion to a previously reconstructed picture.

[0092] In some examples, picture estimation unit **226** may re-encode a current picture that video decoder **224** has decoded. The next picture of the video data may be a picture that follows a picture in decoding order that video decoder **224** just decoded. In this example, picture estimation unit **226** may perform intra prediction or inter prediction on blocks of the current picture. When performing inter prediction on a block, picture estimation unit **226** may determine one or more motion vectors for the blocks. For instance, picture estimation unit **226** may determine that a specific block of the current picture has a motion vector having magnitude m relative to a reference block in a reference picture having a picture order count (POC) distance from the current picture of p_1. In this example, the current picture and the next picture may have a POC distance of p_2. Picture estimation unit **226** may determine a scale factor s as p_2/p_1. Picture estimation unit **226** may then scale the motion vector of the specific block by s(e.g., s*m). Picture estimation unit **226** may determine a location in the next picture indicated by the scaled motion vector and set the samples at the determined location to samples of the specific block of the current picture. Picture estimation unit **226** may repeat this process for each inter predicted block of the current picture.

[0093] In some examples, picture estimation unit **226** may apply one or more filters to the prediction data. For instance, picture estimation unit **226** may apply one or more deblocking filters, smoothing filters, adaptive loop filters, or other types of filters to the prediction data.

[0094] Video encoder **228** may perform the same limited video encoding process as video encoder **210** on the video data generated by picture estimation unit **226**. For example, video encoder **228** may perform intra prediction to generation prediction data. Video encoder **228** may use the prediction data and the corresponding blocks of the video data generated by picture estimation unit **226** to generate residual data. Video encoder **228** may apply a transform (e.g., a DCT transform, DST transform, etc.) to the residual data to generate transform coefficients. Video encoder **228** may apply quantization to the transformed coefficients. Additionally, video encoder **228** may apply entropy encoding to syntax elements representing the transform coefficients.

[0095] As mentioned briefly above, channel decoder **222** may apply a channel decoding process to channel-encoded video data. FIG. **3**A and FIG. **3**B provide more information about the channel encoding process performed by channel encoder **212** and the channel decoding process performed by channel decoder **222**.

[0096] Specifically, FIG. **3**A is a block diagram illustrating an example channel encoding process according to techniques of this disclosure. For each picture of the encoded video data, channel encoder **212** of transmitting device **102** may apply a systematic coding operation, such as low-density parity-check (LDPC) coding operation, to systematic bits for a picture to generate error correction data for the picture. The systematic bits of the picture may include the encoded video data of the picture generated by video encoder **210**.

[0097] In the example of FIG. **3**A, error correction data is labeled "error corr.bits." For a picture n, channel encoder **212** may generate error correction data **300**A based on systematic bits **302**A. Similarly, for a picture n+1, channel encoder **212** may generate error correction data **300**B based on systematic bits **302**B. Channel encoder **212** may classify pictures of the video data as anchor video pictures and non-anchor pictures. Channel encoder **212** may classify the pictures such that anchor pictures occur on a periodic basis among the pictures. In some examples, channel encoder **212** may classify a picture as an anchor picture if channel decoder **222** receives an indication (e.g., from receiving device **104**) that there is an error in the picture. For each of the anchor pictures, transmitting device **102** may transmit the encoded anchor picture and the error correction data for the anchor picture. However, for non-anchor pictures, transmitting device **102** may transmit only the error correction data for the non-anchor picture.

[0098] For instance, in the example of FIG. **3**A, picture n may be an anchor picture and picture n+1 is a non-anchor picture. Accordingly, transmitting device **102** may transmit systematic bits **302**A for picture n, error correction data **300**A for picture n, and error correction data **300**B for picture n+1, but not systematic bits **302**B for picture n+1.

[0099] FIG. **3**B is a block diagram illustrating an example channel decoding process according to techniques of this disclosure. As mentioned above, channel decoder **222** may perform a channel decoding process on encoded video data to reconstruct the encoded video data. When processing an anchor picture (e.g., picture n), channel decoder **222** may obtain systematic bits of the anchor picture (denoted SI, in FIG. **3**B) and error correction data of the anchor picture (denoted y, in FIG. **3**B) from de-puncturing unit **220**. The systematic bits of the anchor picture may represent the encoded video data of the anchor picture. Channel decoder **222** may use the error correction data for the anchor picture to detect and/or correct errors in the systematic bits of the anchor picture. Video decoder **224** may use the resulting error-corrected encoded video data for the anchor picture to reconstruct the anchor picture. Receiving device **104** may store reconstructed pictures, including reconstructed anchor pictures and reconstructed non-anchor pictures in a decoded pictures buffer **350**.

[0100] When processing a non-anchor picture, channel decoder **222** may obtain systematic bits (denoted SI_{n+1}) representing encoded video data of the non-anchor picture. Video encoder **228** of receiving device **104** may generate the encoded video data of the non-anchor picture based on video data generated by picture estimation unit **226**. Channel decoder **222** may obtain the error correction data (denoted y_{n+1} in FIG. **3**B) for the non-anchor picture from de-puncturing unit **220**. Channel decoder **222** may then perform the same channel decoding process that channel decoder **222** applied when processing an anchor picture. Thus, channel decoder **222** may use the error correction data of the non-anchor picture to detect and/or correct "errors" in the systematic bits for the non-anchor picture. However, the "errors" in the systematic bits for the non-anchor picture are not attributable to noise in channel **230** (as would be the case for errors in the systematic bits for anchor pictures. Rather, the "errors" in the systematic bits for the non-anchor picture may be due to differences between the predicted version of the non-anchor picture and the original version of the non-anchor picture. Thus, channel decoder **222** may use the transmitted error correction data for the non-anchor picture as a mechanism for "correcting" for prediction errors.

[0101] Video encoder **210** of transmitting device **102**, video decoder **224** of receiving device **104**, and video encoder **228** of receiving device **104** may perform video encoding processes and video decoding processes based on values of a set of one or more parameters. In other words, the values of the parameters may control various aspects of the video encoding process performed by video encoder **210** video encoder **228**, and video decoder **224**. In some examples, the parameters may include one or more of:

- **[0102]** parameter indicating a color space (e.g., Red-Green-Blue, Y—Cb—Cr, etc.),
- **[0103]** pixel decimation parameters
- **[0104]** a parameter indicating a DCT size
- **[0105]** transmitted DCT coefficients
- **[0106]** a parameter indicating a number of bits per DCT coefficient
- **[0107]** quantization parameters (e.g., parameters indicating a quantization scheme, such as linear, Max-Lloyd, etc.)

[0108] Each of video encoder **210**, video decoder **224**, and video encoder **228** may need to use the same values of the parameters. Hence, in accordance with one or more techniques of this disclosure, transmitting device **102** may transmit values of the parameters to receiving device **104**. Receiving device **104** may receive the transmitted values of the parameters. Video decoder **224** and video encoder **228** may use the values of the parameters in video decoding and video encoding processes.

[0109] In some examples, the transmitted values of the parameters are static or semi-static. For instance, in an example where the transmitted values of the parameters are static, transmitting device **102** may transmit the values of the parameters to receiving device **104** once and receiving device **104** may operate with the values of the parameters for an indefinite time period. In an example where the transmitted values of the parameters are semi-static, transmitting device **102** may occasionally update values of the parameters and retransmit the updated values of the parameters to receiving device **104**.

[0110] Transmitting device **102** may transmit the values of the parameters in one of a variety of ways. For instance, in some examples, transmitting device **102** may transmit the values of the parameters to receiving device **104** using an Uplink Control Information (UCI)/Media Access Control-Control Element (MAC-CE) message, a Radio Resource Control (RRC) message, or another type of message.

[0111] In an example where transmitting device **102** transmits the values of the parameters to receiving device **104**, video encoder **210** may segment each of the color components (e.g., R, G, and B components; Y, Cb, Cr components) of a picture of the video data into evenly sized (MxM) blocks. Examples of such blocks may include macroblocks (MBs) and largest coding units (LCUs). Video encoder **210** of transmitting device **102** may calculate a transform (e.g., a 2D-DCT) on each of the blocks, resulting in M^2 transform coefficients. Video encoder **210** may assign an ordering to the transform coefficients of the block. For instance, video encoder **210** may order the transform coefficients of the block according to a zigzag scanning order that starts from a most important transform coefficient (e.g., lowest frequency) and ends with a least important transform coefficient (e.g., highest frequency). Video encoder **210** may

select the first Ne transform coefficients, where Ne is a parameter value indicating a quantity of transmitted transform coefficients. Video encoder **210** may discard the non-selected transform coefficients.

[0112] Additionally, video encoder **210** may quantize the selected transform coefficients. For example, where the selected transform coefficients have indexes i ranging from 0 to N_c-1, the parameters may include bit-width parameters (e.g., B_i, i=0, 1, . . . , N_c-1) corresponding to the different index values. For each of the selected transform coefficients d_i, video encoder **210** may quantize the selected transform coefficient d_i using the following equation.

$$c_i = \text{round}(\alpha \quad d_i \quad B_i) \tag{1}$$

[0113] In the equation above, c_i is the quantized version of transform coefficient d_i, α is a scaling constant, B_i is the bit-width parameter for index i, and round is a function that rounds to the nearest integer. Thus, in an example where B_0 is 8, B_1 is 4, B_2 is 4, the quantized transform coefficients may be, for example, c_0=00100011, c_1=0110, c_2=1001, and so on.

[0114] Video encoder **228** of receiving device **104** may generate prediction data for the picture, generate residual data based on the prediction data, and apply one or more transforms to the residual data to generate transform blocks comprising transform coefficients. Video encoder **228** may need to use the same bit-width parameters as video encoder **210** so that the channel decoder **222** can correctly associate specific systematic bits with corresponding error correction data received from de-puncturing unit **220**.

[0115] In some examples of this disclosure, receiving device **104** may determine values of one or more of the parameters without transmitting device **102** transmitting the values of these parameters to receiving device **104**. Examples in which receiving device **104** determines values of one or more of the parameters without transmitting device **102** transmitting the values to receiving device **104** may enable a better compression-distortion tradeoff with lower control signaling overhead. For example, receiving device **104** may determine the number of DCT coefficients (N_c) without transmitting a value of N_c to receiving device **104**. For instance, in this example, receiving device **104** may determine the minimum value of N_c that achieves a desired peak signal-to-noise ratio (P-SNR). In other words, receiving device **104** may determine the minimum value of N_c that achieves the desired P-SNR as:

$$\hat{N_c} = \underset{N_c}{\text{argmin}} \frac{\sum_{i=0}^{N_c} |c_i|^2}{\sum_{j=N_c}^{M^2-1} |c_j|^2} > SNR_d \tag{2}$$

[0116] In the equation above, c_i is a transform coefficient (e.g., a DCT coefficient) with index i, SNR_d is the desired P-SNR, M^2-1 is largest the number of transform coefficients. In some examples, receiving device **104** may evaluate the number of transform coefficients (Ne) once per picture (or other segment) based on the robust prediction of the picture. Periodic reset of the values of the parameters may be applied to avoid error propagation.

[0117] In another example, receiving device **104** may determine numbers of quantization bits based on predicted pictures instead of receiving the numbers of quantization bits from transmitting device **102**. For instance, in this example, receiving device **104** may calculate a probability distribution for quantized and unquantized coefficients:

$$p_{Q_i}(x) = \frac{1}{\#MBs} \sum_{MBs} (c_i == x),\ p_i(x) = \frac{1}{\#MBs} \sum_{MBs} (d_i == x) \tag{3}$$

[0118] In the equation above, p_{Q_i} is the probability distribution for quantized coefficients, p_i is the probability distribution for unquantized coefficients, c_i is the quantized version of transform coefficient d_i.

[0119] Receiving device **104** may determine the number of quantization bits B_i based on the entropy ratio of the quantized and non-quantized coefficients as follows:

$$B_i = \text{argmin} \frac{\sum_x p_{Q_i}(x) \log\left(p_{Q_i}(x)\right)}{\sum_x p_i(x) \log(p_i(x))} > \text{threshold} \tag{4}$$

[0120] Receiving device **104** may therefore evaluate B_i once per each picture (or segment) based on the prediction of the picture generated by picture estimation unit **226**.

[0121] FIG. **4** is a flowchart illustrating an example operation of transmitting device **102** according to techniques of this disclosure. In the example of FIG. **4**, video encoder **210** of transmitting device **102** may obtain video data (**400**). For instance, video encoder **210** may obtain the video data from video source **120**. Additionally, video encoder **210** may perform video encoding on the video data to generate encoded video data (**402**). For example, video encoder **210** may apply intra prediction to generate prediction data, generate residual data based on the prediction data and the original video data, and apply transforms (e.g., DCT) to blocks of the residual data to generate transform blocks. Video encoder **210** may quantize transform coefficients of the transform blocks. Furthermore, in some examples, video encoder **210** may apply entropy encoding to syntax elements representing the quantized transform coefficients. In some examples, video encoder **210** may implement a reconstruction loop that may apply entropy decoding, inverse quantization, and one or more inverse transforms to reconstruct the residual data. Video encoder **210** may apply use the prediction data and the reconstructed residual data to reconstruct the video data. In some examples, video encoder **210** applies one or more filters to the reconstructed video data, such as deblocking filters, adaptive loop filters, sample adaptive offset filters, and so on. Video encoder **210** may use the reconstructed video data as reference data for intra prediction.

[0122] Video encoder **210** may perform the video encoding process based on the values of one or more parameters. For example, video encoder **210** quantize transform coefficients according to the specific quantization parameters, use a particular color space, and so on.

[0123] Channel encoder **212** of transmitting device **102** may perform channel encoding on the encoded video data to generate error correction data (**404**). Transmitting device **102** may transmit the encoded video data and error correc-

tion data to receiving device **104**, e.g., via channel **230** (**406**). In some examples, transmitting device **102** may selectively transmit parts of the encoded video data and transmit other parts of the encoded video data. For example, transmitting device **102** transmit encoded video data of some pictures and not transmit encoded video data of other pictures. In another example, transmitting device **102** may transmit encoded video data of some transform blocks of a picture and not encoded video data of other transform blocks of the picture. In some examples, transmitting device **102** may transmit a certain quantity of most significant bits of transform coefficients and not transmit less significant bits of the transform coefficients.

[0124] In some examples, transmitting device **102** may also transmit the values of one or more parameters to receiving device **104**. The values of the parameters may control how receiving device **104** reconstructs the video data. For example, the parameters may include a transform size parameter that indicates a size of transform blocks in the encoded video data generated by video encoder **210**. In this example, receiving device **104** may need to interpret the received encoded video data according to the same transform block size in order to properly reconstruct the video data. In other examples, the parameters may include a parameter indicating quantity of transform coefficients, bit-width parameters, and so on.

[0125] Thus, in the example of FIG. **4**, transmitting device **102** may obtain video data from a video source. Transmitting device **102** may generate, based on a set of parameters, encoded video data of a first picture of the video data and encoded video data of a second picture of the video data. Transmitting device **102** may perform channel encoding on the encoded video data of the first picture and the encoded video data of the second picture to generate error correction data for the first picture and error correction data for the second picture. Transmitting device **102** may transmit the encoded video data of the first picture, error correction data for the first picture, and error correction data for the second picture. In some examples, transmitting device **102** may transmit, to receiving device **104**, values of the parameters.

[0126] FIG. **5** is a flowchart illustrating an example operation of receiving device **104** according to techniques of this disclosure. In the example of FIG. **5**, receiving device **104** may obtain, from transmitting device **102**, first encoded video data and first error correction data (**500**). The first encoded data represents one or more blocks of a first picture of the video data. The first error correction data may provide error correction information regarding the blocks of the first picture.

[0127] Receiving device **104** may generate first error-corrected encoded video data using the first error correction data to perform an error correction operation on the first encoded video data (**502**). For example, channel decoder **222** of receiving device **104** may use the first error correction data to perform low-density parity-check (LDPC) coding on the first encoded video data. In other examples, channel decoder **222** may use the error correction data in other error correction algorithms, such as forward error correction (FEC) or turbo coding. Performing the error correction operation on the first encoded video data may remove errors introduced by noise in channel **230**.

[0128] Video decoder **224** of receiving device **104** may perform a first reconstruction operation that reconstructs the blocks of the first picture based on the first error-corrected encoded video data (**504**). The first reconstruction operation is controlled by values of one or more parameters. For example, video decoder **224** may perform an inverse transform on transform blocks of the first error-corrected encoded video data to obtain residual data. Additionally, in this example, video decoder **224** may generate prediction data, e.g., using intra prediction. In this example, video decoder **224** may use the prediction data and the residual data to reconstruct the blocks of the first picture.

[0129] In some examples, video encoder **210** and video encoder **228** may generate the encoded video data using quantization parameters to quantize transform coefficients generated based on the prediction data for the picture. When performing the reconstruction operation, video decoder **224** may use the quantization parameters to inverse quantize transform coefficients of the error-corrected encoded video data. In some examples, transmitting device **102** and/or receiving device **104** may calculate the quantization parameters based on an entropy ratio of quantized transform coefficients and unquantized transform coefficients, e.g., as described above.

[0130] In some examples, the parameters include a transform size parameter. As part of generating encoded video data, video encoder **210** and video encoder **228** may apply, to sample domain data (e.g., predicted sample data or residual data) of a picture, a forward transform having a transform size indicated by the transform size parameter. As part of performing the reconstruction operation, video decoder **224** may apply, to transform coefficients of the error-corrected encoded video data, an inverse transform having the transform size indicated by the transform size parameter.

[0131] In some examples, the parameters include a parameter that indicates a quantity of transform coefficients. As part of generating encoded video data, video encoder **210** and video encoder **228** may include in the encoded video data, a set of transform coefficients that includes the indicated quantity of transform coefficients. When performing the reconstruction operation, video decoder **224** may parse, from the error-corrected encoded video data, a set of transform coefficients that includes the indicated quantity of transform coefficients. Furthermore, in some examples, receiving device **104** may receive the encoded video data and the error correction data from the transmitting device via a communication channel, receiving device **104** may apply an optimization process that determines the number of transform coefficients based on a signal-to-noise ratio of data transmitted on the communication channel, e.g., as discussed above.

[0132] In some examples, the parameters include bit-width parameters for a plurality of index values. For each respective index value of the plurality of index values, performing the reconstruction operation may comprise parsing a first set of bits from the error-corrected encoded video data. The first set of bits may indicate a transform coefficient having the respective index value and a quantity of bits in the first set of bits is equal to a bit-width indicated by the bit-width parameter for the respective index value. As part of generating the encoded video data, video encoder **210** and video encoder **228** may include a second set of bits in the encoded video data. The second set of bits may indicate a transform coefficient having the respective index value and the quantity of bits in the second set of bits is equal to the bit-width indicated by the bit-width parameter for the

respective index value. Video decoder **224** may parse a third set of bits from the error-corrected encoded video data. The third set of bits may indicate a transform coefficient having the respective index value and a quantity of bits in the third set of bits is equal to the bit-width indicated by the bit-width parameter for the respective index value.

[0133] Other parameters may include one or more of: a color space, a transform size, quantization parameters, a number of transform coefficients in the first encoded video data, or a number of bits per transform coefficient in the first encoded video data.

[0134] Receiving device **104** may obtain second error correction data from transmitting device **102** (**506**). The second error correction data provides error correction information regarding one or more blocks of a second picture of the video data.

[0135] Additionally, picture estimation unit **226** of receiving device **104** may estimate the second picture based on one or more previously reconstructed pictures, such as the first picture (**508**). The estimated second picture includes predictions of the blocks of the second picture of the video data based at least in part on the blocks of the first picture. For example, picture estimation unit **226** may generate the prediction data using perform inter prediction, a combination of intra and inter prediction, or other video coding tools, e.g., as described elsewhere in this disclosure.

[0136] Video encoder **228** of receiving device **104** may generate second encoded video data based on the estimated second picture (**510**). For example, video encoder **228** of receiving device **104** may generate residual data based on the prediction data. For instance, video encoder **228** may perform intra prediction to generate second prediction data based on the estimated second picture. Video encoder **228** may then generate residual data by subtracting the second prediction data from the prediction data generated by picture estimation unit **226**. Video encoder **228** may then generate transform blocks by applying one or more forward transforms to the residual data. Video encoder **228** may perform the same process and video encoder **210** of transmitting device **102** and accordingly may need to use the same parameters as video encoder **210**.

[0137] Channel decoder **222** of receiving device **104** may perform the channel decoding process to generate second error-corrected encoded video data based on the second error correction data and the second encoded video data (**512**). Channel decoder **222** of receiving device **104** may perform the same process to generate the second error-corrected encoded video data as channel decoder **222** performed when generating the first error-corrected encoded video data.

[0138] Video decoder **224** of receiving device **104** may perform a second video decoding process to reconstruct the blocks of the second picture based on the second error-corrected encoded video data (**514**). The second reconstruction operation is controlled by the values of the parameters. Video decoder **224** may perform the second reconstruction operation in the same way as the first reconstruction operation. In this way, receiving device **104** may reconstruct video data of pictures (or blocks), without receiving all of the encoded video data of each of the pictures (or blocks).

[0139] As noted above, puncturing unit **214** of transmitting device **102** may perform a bit puncturing operation on the error correction data generated by channel encoder **212**. Bit puncturing involves selectively discarding some of the error correction data before transmitting device **102** transmits the error correction data. The discarded bits are typically the least important for performing error correction. De-puncturing unit **220** of receiving device **104** may perform an inverse bit puncturing operation (i.e., a bit de-puncturing operation) that reverses the bit puncturing operation performed by puncturing unit **214**. Puncturing unit **214** may perform the bit puncturing operation according to a set of one or more puncturing parameters. In different examples, the puncturing parameters may be predefined, static, or semi-static.

[0140] In accordance with one or more techniques of this disclosure, transmitting device **102** may perform a decimation procedure that may reduce memory bandwidth and may enhance compression. For example, video encoder **210** of transmitting device **102** may segment a picture of the video data into a grid of blocks (e.g., MBs, LCUs, etc.) and may generate transform blocks for each of the blocks. Transmitting device **102** may need to store to memory (e.g., memory **116**) each transform block destined for transmission to receiving device **104**. Transmitting device **102** may then retrieve the stored transform blocks from memory for channel encoding and ultimately for transmission. These writes to memory and reads from memory may increase time and energy requirements. These time and energy requirements may be directly related to the amount of data to be written and read. Accordingly, it may be advantageous to reduce the amount of data to be written to and read from memory.

[0141] Performing a decimation process may reduce the amount of data in transform blocks written to and read from memory. Performing the decimation process may also reduce the amount of data transmitted by transmitting device **102** to receiving device **104**. In some examples, when video encoder **210** is encoding a current block of a current picture, video encoder **210** may generate a transform block for the current block. Additionally, channel encoder **212** of transmitting device **102** may determine, based on a decimation pattern, whether the current block is targeted for decimation. If the current block is targeted for decimation (i.e., the transform block is a "non-anchor transform block"), channel encoder **212** may the reduce the number of bits in the non-anchor transform block prior to storing the transform block to memory. If the current block is not targeted for decimation (i.e., the transform block is an "anchor block"), channel encoder **212** does not reduce the number of bits in the anchor block. Channel encoder **212** may perform the decimation process after generating the error correction data. Thus, the error correction data generated by channel encoder **212** (and potentially transmitted to receiving device **104**) for non-anchor transform blocks may be based on the full set of bits of the transform blocks instead of the reduced number of bits.

[0142] FIG. **6** is a conceptual diagram illustrating an example decimation pattern **600** according to techniques of this disclosure. The example of FIG. **6** shows a grid of DCT blocks. A DCT block is a block of transform coefficients generated by applying a DCT transforms to video data, such as residual data or sample data. In other examples, the DCT blocks may be transform blocks generated using other types of transforms. In FIG. **6**, "X" marks in decimation pattern **600** indicate DCT blocks targeted for decimation (i.e., non-anchor transform blocks). Thus, in the example of FIG. **6**, decimation pattern **600** decimates the DCT blocks by 2 in the horizontal and vertical directions. In some examples,

which may be referred to herein as "full" decimation, video encoder **210** may reduce the number of bits in the non-anchor transform block to zero.

[0143] Thus, in some examples, a decimation pattern defines a pattern of anchor transform blocks and non-anchor transform blocks in the picture. Receiving device **104** may receive systemic bits of the anchor transform blocks and not systemic bits of the non-anchor transform blocks. The systemic bits of the anchor transform blocks may represent transform coefficients in the anchor transform blocks. The systemic bits of the non-anchor transform blocks may represent reduced bit depth versions of original transform coefficients in the non-anchor transform blocks. The error correction data may include error correction data for the anchor transform blocks and error correction data for the non-anchor transform blocks. The error correction data for the non-anchor transform blocks are based on the original transform coefficients in the non-anchor transform blocks. As part of generating the error-corrected encoded video data, channel decoder **222** may use the error correction data for the anchor transform blocks to perform error correction on the systemic bits of the anchor transform blocks. Channel decoder **222** may use the error correction data for the non-anchor transform blocks to perform error correction on portions of the encoded video data corresponding to the non-anchor transform blocks. In some examples, receiving device **104** may determine the decimation pattern and send the decimation pattern to transmitting device **102**.

[0144] In some examples, transmitting device **102** stores encoded bits (encoded video data and error correction data) in a cyclic buffer. Transmitting device **102** uses two parameters to select which bits in the cyclic buffer to transmit. The first parameter is a starting position and the second parameter indicates a number of consecutive bits to transmit. The starting position can only have a variety of values on order to support the selective transmission and non-transmission of system bits. The starting positions may be selected to skip transmission of specific systematic bits (i.e., bits of encoded video data) without skipping transmitting of error correction data. Thus, the decimation of non-anchor transform blocks may be accomplished simply by manipulating the first parameter and second parameter such that transmitting device **102** does not transmit bits of the non-anchor transform blocks.

[0145] In some examples, channel encoder **212** applies a hybrid decimation approach that does not reduce the number of bits in any of the targeted "non-anchor" transform blocks to zero but does reduce the number of bits in transform coefficients in the non-anchor transform blocks. For instance, in the example of FIG. **6**, channel encoder **212** may reduce the number of bits in each transform coefficients in the "X"-marked DCT blocks by a predetermined number (e.g., 2, 4, 5, etc.). Channel encoder **212** does not reduce the number of bits of transform coefficients not targeted by the decimation pattern.

[0146] Channel decoder **222** of receiving device **104** may receive the remaining, reduced bits of the non-anchor transform blocks and the error correction data for the non-anchor transform blocks. As part of the channel decoding process, channel decoder **222** may use the error correction data for the non-anchor transform blocks to perform an error correction process that restores the bits of the non-anchor transform blocks that were removed. This error correction process may be the same error correction process that channel decoder **222** uses to correct errors introduced by noise in channel **230**. To summarize, channel encoder **212** generates the error correction data because the error correction data are going to be needed to correct for the inevitable noise in channel **230**, but these same error correction data are used for restoring bits as if the noise in channel **230** just so happened to corrupt the least significant bits of particular transform coefficients in particular transform blocks in particular pictures. Thus, the number of bits sent in channel **230** may effectively be reduced.

[0147] In some examples, channel encoder **212** may generate a correlation matrix based on a set of transform blocks of a picture prior to performing any decimation process on any non-anchor transform blocks in the set of transform blocks. The correlation matrix includes values that indicate a level of correlation between transform coefficients at corresponding positions within the transform blocks. For example, the correlation matrix may include a correlation value for the DC transform coefficients (i.e., top-left transform coefficients) of the set of transform blocks. If differences between the DC transform coefficients are relatively small, the correlation value for the DC transform coefficients may be relatively high. Conversely, if differences between the DC transform coefficients are relatively great, the correlation value for the DC transform coefficients may be relatively small. Each of the correlation values may be a value between 0 and 1.

[0148] In some examples, channel encoder **212** may calculate a correlation value for the DC transform coefficients using the following formula:

$$R_{yy}(l) = \lim_{N\to\infty} \frac{1}{N} y(n)\overline{y(n-l)} \tag{5}$$

[0149] In equation (5) above, I represents the spacing between the transform blocks containing the DC coefficients and N represents the number of transform block the calculation is performed on. The function y is the transform coefficient. The line above the y represents conjugate. If each consecutive transform block is used, the spacing may be 1, if alternating transform blocks are used, the spacing may be 2, and so on. Channel encoder **212** may calculate correlation values for corresponding AC transform coefficients (i.e., non-DC transform coefficients) in the same way. In this disclosure, corresponding transform coefficients occupy the same locations within transform blocks. Thus, by calculating an autocorrelation value for each transform coefficient in a transform block, channel encoder **212** may generate a correlation matrix for the transform block. Channel encoder **212** may repeat the process of generating correlation matrixes for each transform block because channel encoder **212** will use transform coefficients from different transform blocks when calculating the correlation values.

[0150] Transmitting device **102** may transmit the correlation matrixes to receiving device **104** along with encoded video data and error correction data. Channel decoder **222** of receiving device **104** may use the correlation matrixes as part of the process to restore non-anchor transform blocks their original bit-widths. For instance, continuing the example of the DC transform coefficients, after applying the error correction process, channel decoder **222** may obtain a

value of a non-anchor DC transform coefficient (i.e., a DC transform coefficient in a non-anchor transform block).

[0151] The error correction process may use the correlation value to estimate a non-anchor transform coefficient. For example, if we have all the even transform blocks as anchor transform blocks and non-even transform blocks as non-anchor transform blocks, channel decoder **222** may estimate the value of a non-anchor transform coefficient in transform block n by:

$$y[n] = (R_{yy}[1] * y[n+1] + R_{yy}[3] * y[n+3] + R_{yy}[3] * y[n+5] \ \ldots \ )/ \quad (6)$$
$$(R_{yy}[1] + R_{yy}[3] + R_{yy}[3] \ \ldots \ )$$

[0152] In equation (6) above, $R_{yy}[1]$ indicates the correlation value in the correlation matrix for a transform block with index 1 (i.e., a non-even, non-anchor transform block), y[n+1] indicates a corresponding transform coefficient in an anchor transform block with index n+1. $R_{yy}[2]$ indicates a correlation value in the correlation matrix for a transform block with index 3, y[n+3] indicates a corresponding transform coefficient in an anchor transform block is index n+3, and so on. The number of transform blocks used in equation (6) may be configurable. In this way, the estimated values of a non-anchor transform coefficient may be considered to be a weighted average of corresponding transform coefficients in the anchor blocks weighted based on the correlation values in corresponding locations in the correlation matrices. In other words, channel decoder **222** may interpolate the value of the non-anchor transform coefficient according to the correlation matrices. Channel decoder **222** may output the calculated values of transform coefficients to video decoder **224**. Channel decoder **222** may perform this process for other transform coefficients. Using correlation matrices in this way may improve the quality of the reconstructed video data.

[0153] In some examples, video encoder **210** may reduce the bit-widths of each transform coefficient in a targeted transform block by the same amount. In other examples, video encoder **210** may reduce the bit-widths of different transform coefficients in a target transform block by different amounts. In some examples, the amount by which video encoder **210** reduces the bit-width of a transform coefficient is related to a distance of the transform coefficient from an anchor transform block. An anchor transform block is a transform block not targeted by the decimation pattern.

[0154] FIG. **7** is a flowchart illustrating an example operation of transmitting device **102** for hybrid decimation of transform blocks according to techniques of this disclosure. In the example of FIG. **7**, transmitting device **102** may obtain video data from video source **120** (FIG. **7**) (**700**). Video encoder **210** of transmitting device **102** may generate transform blocks based on the video data (**702**). For example, video encoder **210** may generate prediction blocks by performing intra prediction on blocks of a picture of the video data. Video encoder **210** may use the prediction blocks to generate residual data. Video encoder **210** may generate transform blocks by applying a transform, such as a DCT, DST, or other transform, to the residual data. In other examples, video encoder **210** may generate the transform blocks by apply the transform directly to blocks of the video data.

[0155] Channel encoder **212** may then determine, based on a decimation pattern, which of the transform blocks are anchor transform blocks (**704**). For instance, in an example where channel encoder **212** uses the decimation pattern **600** of FIG. **6**, video encoder **210** may determine that every other transform block in both the horizontal and vertical directions are anchor transform blocks. In other examples, channel encoder **212** may use other decimation patterns to determine which of the transform blocks are anchor transform blocks. Channel encoder **212** may store the anchor transform blocks to a memory of transmitting device **102** (e.g., memory **116** (FIG. **1**)) (**706**).

[0156] Channel encoder **212** may calculate correlation matrixes for transform block sets (**708**). Each transform block set includes one or more anchor transform blocks and one or more non-anchor transform blocks. For example, each transform block set may correspond to a different row of transform blocks in FIG. **6**. In another example, each transform block set may correspond to a group of 2 transform blocks by 2 transform blocks. The number of values in the correlation matrix for a transform block set is the same as the number of transform coefficients in each of the transform blocks individually. Each value in the correlation matrix corresponds to a different position within a transform coefficient block. For example, a value in position (0,0) of the correlation matrix corresponds to the transform coefficients at position (0,0) of each transform coefficient block in the transform block set, a value in position (0,1) of the correlation matrix corresponds to the transform coefficients at position (0,1) of each transform coefficient block in the transform block set, and so on. The transform coefficients at position (0,0) of the transform coefficient blocks may be referred to as DC coefficients and all other transform coefficients may be referred to as AC coefficients.

[0157] Additionally, channel encoder **212** may generate bit-reduced non-anchor transform matrixes (**710**). The non-anchor transform matrixes are transform matrixes other than the anchor transform matrixes. For instance, with reference to FIG. **6**, the transform matrices marked with X may be non-anchor transform matrices. Transform coefficients in the bit-reduced non-anchor transform matrices may include fewer bits than in original versions of the non-anchor transform matrices. Transmitting device **102** may then transmit the anchor transform blocks, non-anchor transform blocks, bit reduction value, correlation matrices, and error correction data (**712**).

[0158] Channel encoder **212** may reduce the bits in the non-anchor transform coefficients in one of a variety of ways. For example, channel encoder **212** may determine a bit reduction value for each transform coefficient in the non-anchor transform coefficient block. In this example, to calculate the bit reduction value, channel encoder **212** may calculate an interpolated value of a transform coefficient according to the correlation matrices. Channel encoder **212** may calculate the interpolated value using equation (6), above. Channel encoder **212** may then subtract the interpolated value of the transform coefficient from the original value of the transform coefficient to calculate a first distortion value. Channel encoder **212** may then reduce the number of bits of the original value of the transform coefficient by one. Channel encoder **212** may subtract the interpolated value from the reduced-bit original value of the transform coefficient to calculate a second distortion value. Channel encoder **212** may determine, based on the first

distortion value and the second distortion value, whether the second distortion value is acceptable. For example, channel encoder **212** may calculate a mean or max squared error from the interpolated value. Channel encoder **212** may determine that the second distortion value is acceptable by comparing the second distortion value to a predefined threshold.

[0159] If the second distortion value is acceptable, channel encoder **212** may reduce the number of bits of the original value of the transform coefficient value and repeat the process. If the second distortion value is not acceptable, channel encoder **212** may increase the number of bits of original value of the transform coefficient. The resulting number of bits by which the original value of the transform coefficient is reduced is the bit reduction value.

[0160] In some examples, channel encoder **212** may determine a bit reduction value for the non-anchor transform coefficient block as a whole. In this example, to calculate the bit reduction value for a transform coefficient blocks, channel encoder **212** may calculate an interpolated value of each transform coefficient according to the correlation matrices, e.g., as described above. Video encoder **210** may then subtract the interpolated values of the transform coefficients from the original values of the transform coefficient and use the resulting differences to calculate a first distortion value. For instance, video encoder **210** may calculate the first distortion value as a mean square error. Video encoder **210** may then reduce the number of bits of the original values of each of the transform coefficients by one. Video encoder **210** may subtract the interpolated values from the reduced-bit original values of the transform coefficient and use the resulting values to calculate a second distortion value (e.g., using mean square error). Channel encoder **212** may determine, based on the first distortion value and the second distortion value, whether the second distortion value is acceptable. If the second distortion value is acceptable, video encoder **210** may reduce the number of bits of the original values of the transform coefficient value again and repeat the process. If the second distortion value is not acceptable, video encoder **210** may increase the number of bits of original value of the transform coefficient. The resulting number of bits by which the original value of the transform coefficient is reduced is the bit reduction value.

[0161] Thus, in some examples, transmitting device **102** may obtain video data from a video source. Transmitting device **102** may generate transform blocks based on the video data. Transmitting device **102** may determine which of the transform blocks are anchor transform blocks. Transmitting device **102** may calculate a correlation matrix for a transform block set. Additionally, transmitting device **102** may generate bit-reduced non-anchor transform matrixes. Transmitting device **102** may transmit the anchor transform blocks, the non-anchor transform blocks, and the correlation matrix to a receiving device. In some examples, transmitting device **102** may receive an indication of the decimation pattern from receiving device **104**.

[0162] FIG. **8** is a flowchart illustrating an example operation of receiving device **104** for hybrid decimation of transform blocks according to techniques of this disclosure. In the example of FIG. **8**, receiving device **104** may receive anchor transform blocks, non-anchor transform blocks, one or more bit reduction values, and correlation matrices for the non-anchor blocks (**800**).

[0163] Furthermore, in the example of FIG. **8**, channel decoder **222** of receiving device **104** may calculate an interpolated value of a current non-anchor transform coefficient (**802**). The current non-anchor transform coefficient is a transform coefficient of one of the non-anchor transform blocks. Channel decoder **222** may calculate the interpolated value of the current non-anchor transform coefficient based on the correlation matrix for the non-anchor blocks. Channel decoder **222** may calculate the interpolated value of the current non-anchor transform coefficient in one of a variety of ways. For instance, in some examples, channel decoder **222** may apply a machine-learned model that takes one or more non-anchor transform coefficients (including the current non-anchor transform coefficient), one or more anchor transform coefficients, and the correlation matrix for the non-anchor transform coefficient block as input. In this example, the machine-learned model may output the interpolated value of the current non-anchor transform coefficient. In this example, the machine learned model may be implemented as a neural network model, a support vector machine, a regression model, or another type of machine learned model.

[0164] In another example, the correlation matrices may include values indicating correlation between the current non-anchor transform coefficient and each corresponding anchor transform coefficient in one or more anchor transform coefficient blocks. Video decoder **224** may calculate the interpolated value of the current non-anchor transform coefficient as:

$$t_{int} = \frac{1}{n}\sum_{i}^{n} c_i a_i \tag{7}$$

[0165] In the equation above, t_{int} is the current non-anchor transform coefficient, a_i is an anchor transform coefficient, c_i is a correlation value indicating a correlation between the current non-anchor transform coefficient and a_i, n indicates a number of anchor transform coefficients from which the current non-anchor transform coefficient is derived. In this example, the values of c_0 to c_n may add up to 1.

[0166] Additionally, video decoder **224** may calculate a reconstructed value of the non-anchor transform coefficient (**804**). Video decoder **224** may calculate the reconstructed value of the non-anchor transform coefficient based on the interpolated value of the current non-anchor transform coefficient and a transmitted value of the non-anchor transform coefficient. The transmitted value of the non-anchor transform coefficient is included in the received non-anchor transform blocks. In some examples, video decoder **224** calculates the reconstructed value of the non-anchor transform coefficient as an average of the interpolated value of the current non-anchor transform coefficient and the transmitted value of the non-anchor transform coefficient.

[0167] Video decoder **224** may determine whether there are any remaining non-anchor transform coefficients in the non-anchor transform blocks (**806**). If there are one or more remaining non-anchor transform coefficients in the non-anchor transform blocks ("YES" branch of **806**), video decoder **224** may repeat steps **802**-**806** with another of the non-anchor transform coefficients. Video decoder **224** may continue to do so until there are no remaining non-anchor transform coefficients ("NO" branch of **806**). In this way,

video decoder **224** may calculate reconstructed values for each of the non-anchor transform coefficients.

[0168] In this way, receiving device **104** may receive systemic bits of the anchor transform blocks, systemic bits of the non-anchor transform blocks, and a correlation matrix. The systemic bits of the anchor transform blocks may represent transform coefficients in the anchor transform blocks. The systemic bits of the non-anchor transform blocks may represent reduced bit depth versions of original transform coefficients in the non-anchor transform blocks. As part of performing the reconstruction operation, receiving device **104** may, for each non-anchor transform coefficient in the non-anchor transform blocks, calculate an interpolated value of the non-anchor transform coefficient based on the correlation matrix and a corresponding anchor transform coefficient. Receiving device **104** may calculate, at the receiving device, a reconstructed value of the non-anchor transform coefficient based on the interpolated value of the non-anchor transform coefficient and a value of the non-anchor transform coefficient in the error-corrected encoded video data.

[0169] In some examples, receiving device **104** may adaptively select the decimation pattern used for reducing or eliminating bits of particular transform blocks. In such examples, receiving device **104** may communicate the selected decimation pattern back to transmitting device **102**. Transmitting device **102** may then use the selected decimation pattern in one or more pictures of the video data.

[0170] FIG. **9** is a conceptual diagram illustrating an example decimation pattern **900** adaptively selected by receiving device **104** according to one or more techniques of this disclosure. In contrast to the decimation pattern **600** of FIG. **6**, non-anchor blocks in decimation pattern **900** do not necessarily occur at regular spacings or intervals.

[0171] Receiving device **104** may determine a decimation pattern based on information about previous pictures of the video data. The previous pictures may or may not have been decimated. In some examples, receiving device **104** may send a request to transmitting device **102** for an undecimated version of a picture. Transmitting device **102** may send the undecimated version of the picture to receiving device **104** in response to the request. After receiving the undecimated version of the picture, receiving device **104** may determine a decimation pattern based on the undecimated version of the picture. For example, receiving device **104** may perform a rate-distortion optimization process that evaluates multiple potential decimation patterns in order to identify which of the decimation patterns results in a best combination of bit rate and distortion.

[0172] In some examples, transmitting device **102** and receiving device **104** may continue using a selected decimation pattern for a predetermined number of pictures, after which transmitting device **102** and/or receiving device **104** may adaptively select another decimation pattern. In some examples, transmitting device **102** may send a message to receiving device **104** requesting transmitting device **102** select another decimation pattern. In some examples, receiving device **104** may determine that an event or condition has occurred that would make selecting another decimation pattern advantageous. For instance, receiving device **104** may determine that it may be advantageous to select another decimation pattern when receiving device **104** determines that a scene change has occurred, that motion in the video data has crossed one or more thresholds, or other characteristics of the video data have changed.

[0173] Receiving device **104** may signal a selected decimation pattern to transmitting device **102** in one of a variety of ways. For example, receiving device **104** may signal the selected decimation scheme to transmitting device **102** by indicating differences from an existing decimation scheme, such as the decimation scheme currently in use. For instance, in this example, receiving device **104** may indicate the selected decimation scheme to transmitting device **102** by specifying a change in down-sampling or up-sampling along specific axes, specifying changes in specific regions of pictures, eliminating specific transform blocks, enabling specific transform blocks, and so on.

[0174] In some examples, there may be a predefined mapping of index values to predefined decimation patterns. In such examples, receiving device **104** may select a decimation pattern from among the predefined decimation patterns and signal an index value of the selected decimation pattern to transmitting device **102**.

[0175] FIG. **10** is a block diagram illustrating example components of a transmitting device and a receiving device according to techniques of this disclosure. In the example of FIG. **10**, transmitting device **102** may include the same components as shown in FIG. **2**. However, in the example of FIG. **10**, receiving device **104** may additionally include a reliability unit **1002**. Unless otherwise noted, similarly named components of transmitting device **102** and receiving device **104** in FIG. **2** and FIG. **10** perform the same function.

[0176] In general, it may be easier to accurately predict more-significant bits (MSBs) of transform coefficients than less-significant bits (LSBs) of transform coefficients. This is because MSBs translate to higher Euclidean distance in the video picture domain. Additionally, blocks of video pictures that experience high motion may be harder to accurately predict than blocks that are in low-motion regions.

[0177] According to one or more techniques of this disclosure, transmitting device **102** and receiving device **104** may implement a system in which bit-level reliability values are used. Use of the bit-level reliability values may enable transmitting device **102** and receiving device **104** to correctly weigh a priori information. This may result in an increase in system performance (e.g., a decrease in the amount of transmitted data and/or increased video quality). For example, decoding performance may be improved if "soft" information is used. In other words, when receiving device **104** is "informed" with the reliability of each bit (what is the a-priori probability the bit value is '0' or '1'), receiving device **104** can make use of this information and the performance may be improved.

[0178] In the example of FIG. **10**, reliability unit **1002** of receiving device **104** receives encoded video data from video encoder **228** of receiving device **104**. The encoded video data may include transform coefficients of transform blocks of the video data. Additionally, in some examples, reliability unit **1002** receives prediction quality information from picture estimation unit **226** of receiving device **104**.

[0179] In a constant scaling process, for each bit position of the transform coefficients of a transform block, the prediction quality information includes a reliability value for the bit position. For example, the most significant bits of the transform coefficients have a first reliability value, the second most-significant bits of the transform coefficients have a second reliability value, the third most-significant

bits of the transform coefficients have a third reliability value, and so on. The reliability value for a bit position is a measure of how likely a bit at the bit position is to have an erroneous value. For example, the bit at a bit position may have an erroneous value when the bit value is predicted '0' but the actual value is '1' or the bit is predicted '1' but the actual value is '0'.

[0180] Picture estimation unit **226** may determine the reliability value of a bit position by collecting statistics regarding rates of errors that occur in bits at the bit position. For example, picture estimation unit **226** may determine a probability that the most significant bits of the transform coefficients contain an error, determine a probability that the second most-significant bits of the transform coefficients contain an error, determine a probability that the third most-significant bits of the transform coefficients contain an error, and so on. Picture estimation unit **226** may collect these statistics by counting the number of times a predicted bit (i.e., a bit in an estimated picture) was incorrect out of the number of tested events. For instance, picture estimation unit **226** may estimate a picture and video encoder **228** may encode the video data of the estimated picture. Subsequently, video decoder **224** may decode error-corrected encoded video data of the picture. Picture estimation unit **226** may compare bits in transform coefficients of the encoded video data of the estimated picture and the error corrected video data of the picture to determine whether the bits of the encoded video data of the estimated picture are erroneous.

[0181] Reliability unit **1002** may convert the probability values into LLR values. In some examples, reliability unit **1002** may convert the probability values into LLR values using the following formula:

$$M = \ln \frac{1 - P_{error}}{P_{error}} \tag{8}$$

[0182] In the formula above, M indicates an LLR value, P_{error} indicates an error probability value, and In indicates the natural log function. In some examples, the LLR values are reliability values.

[0183] FIG. **11** illustrates charts of example error probabilities and corresponding log likelihood ratio (LLR) absolute values, according to one or more techniques of this disclosure. In the example of FIG. **11**, each transform block is represented using 150 bits. Graph **1100** plots error probability for individual bit positions within a transform block. As one can see in graph **1100**, bits at specific positions have greater probability of error. Graph **1102** shows error probabilities converted to LLR absolute values. The LLR absolute values may be scaled.

[0184] In some examples, receiving device **104** uses a dynamic scaling process. In the dynamic scaling process, picture estimation unit **226** determines the prediction quality information dynamically based on the video data. For example, some regions of pictures are harder to predict (e.g., regions in which prediction accuracy is diminished) than regions which are easier to predict. Examples of regions of pictures that are harder to predict may include regions with higher motion. For instance, if a total magnitude of motion vectors in a region crosses a threshold, picture estimation unit **226** may determine that the region is a hard-to-predict region. Accordingly, picture estimation unit **226** may identify such regions and generate reliability values for bits of transform coefficients of transform blocks based at least in part on whether the transform blocks are inside or outside of such regions. In some examples, picture estimation unit **226** determines a reliability value for a bit of a transform coefficient based on general statistics regarding errors for a position of the bit modified based on whether or not the transform block containing the transform coefficient is in a hard-to-predict region.

[0185] Reliability unit **1002** may use the reliability values to scale bits of the transform coefficients in the encoded video data generated by video encoder **228**. For example, the bits of encoded video data generated by video encoder **228** may be considered "hard" bits and may have values of exactly 0 or exactly 1. Reliability unit **1002** may the prediction quality information generated by picture estimation unit **226** and the encoded video data generated by video encoder **228** to determine "soft" bits that are between 0 and 1. For example, if the value of a bit of the encoded video data is 1, reliability unit **1002** may generate a "soft" value of the bit by multiplying the LLR absolute value for the bit by negative 1 (i.e., −1). If the value of the bit of the encoded video data is 0, reliability unit **1002** may generate a "soft" value of the bit by multiplying the LLR absolute value for the bit by positive 1 (i.e., +1). Thus, the "soft" or scaled values of the bits of a transform coefficient may be M or −M.

[0186] Thus, in some examples, each bit may be transformed into a scaled value that has a more positive value if there is greater confidence that the bit has a value of 0 and a more negative value if there is greater confidence that the bit has a value of 1. Reliability unit **1002** provides the scaled values to channel decoder **222** as a priori information.

[0187] Channel decoder **222** performs a channel decoding process using the scaled values. For example, reliability unit **1002** and channel encoder **212** may encode encoded video data into codewords (e.g., low-density parity check codes). Bits of the codewords generated by reliability unit **1002** may scale the bits of the codewords as described above. Bits of the codewords generated by channel encoder **212** may be altered during transit through channel **230** such that the bits of the codewords may be received as values between −1 and 1. Channel decoder **222** may apply an LPDC decoding process to the codewords to correct errors in the codewords. The bit values in the corrected codewords are 0 or 1. The LPDC decoding process may then convert the codeword back into the original data from the encoded video data. In other examples, other coding schemes may be used. In this example, the error correction data received by channel decoder **222** may include cyclic redundancy check (CRC) data that is not used in the LPDC decoding process. In this way, channel decoder **222** may determine values for each bit of the transform coefficients.

[0188] In some examples, channel encoder **212** may use the prediction quality feedback to sort bits of transform coefficients before applying unequal protection channel coding, such as polar or spinal codes. Unequal protection channel coding involves allocating coding redundancy depending on the importance of the information bits. For instance, channel encoder **212** can use the reliability data to protect different bits according to their predictability by receiving device **104**.

[0189] In some examples, reliability unit **1002** sends prediction quality feedback to transmitting device **102**. Video encoder **210** may adjust one or more encoding parameters of

the video encoding process that video encoder **210** applies to video data. For example, transmitting device **102** may determine a compression rate of the limited video encoding process based on the predictability (reliability) of receiving device **104**. For instance, if the predictability is low, transmitting device **102** may reduce the quality of the encoded video by reducing the number of transform coefficients or the bit width per transform coefficient such that less information is communicated.

[0190] In some examples, transmitting device **102** may adjust one or more channel coding parameters used by channel encoder **212** based on the prediction quality feedback. For example, channel encoder **212** may use unequal protection codes, where the protection is dependent on the prediction quality feedback. In some examples, channel encoder **212** may select different LDPC graphs depending on the reliability. In some examples, channel encoder **212** may change the encoding scheme for generating error correction data to increase error correction capabilities for bit positions or regions of pictures having lower reliability, or decrease error correction capabilities for bit positions or regions of pictures having greater reliability.

[0191] In some examples, transmitting device **102** may update one or more bit puncturing parameters used by puncturing unit **214** based on the prediction quality feedback. For example, puncturing unit **214** may change a puncturing pattern to allow transmission of more error correction data for bit positions and/or picture regions that have lower reliability. Thus, transmitting device **102** may avoid puncturing of bits with lower reliability. In some examples, puncturing unit **214** may change a puncturing pattern to allow transmission of fewer error correction data for bit positions and/or picture regions that have higher reliability.

[0192] In some examples, the prediction quality feedback that reliability unit **1002** sends to transmitting device **102** is applicable to a complete picture. In some examples, reliability unit **1002** may send the prediction quality feedback to transmitting device **102** on a per region basis. Each region may be a defined area within a picture. Reliability unit **1002** may send the prediction quality feedback for some regions of a picture but not others.

[0193] In some examples, reliability unit **1002** may send the prediction quality feedback to transmitting device **102** on a periodic basis. For example, reliability unit **1002** may send the prediction quality feedback to transmitting device **102** every N pictures, where N is an integer value. In some examples, reliability unit **1002** sends the prediction quality feedback to transmitting device **102** after completion of a specific number of groups of pictures (GOPs). In other examples, reliability unit **1002** may send the prediction quality feedback on an aperiodic basis, such as in response to specific conditions or events.

[0194] In some examples, the prediction quality feedback may include prediction quality data based on one or more noise models, such as a Gaussian noise model or a Laplacian noise model. Noise model parameters may control the one or more noise models. Reliability unit **1002** may transmit the noise model parameters to transmitting device **102**. The use of a noise model is an alternative for gathering error statistics. In this mode the prediction error (the statistics of the error between the estimated picture as estimated by picture estimation unit **226** and the actual picture reconstructed by video decoder **224**) may be modeled using a few parameters that describe the error distribution function.

[0195] The parameters of the noise model may be easier for receiving device **104** to communicate to transmitting device **102** because the parameters of the noise model may include less data as compared to per-bit statistics. Transmitting device **102** may use the noise model in the same way as transmitting device **102** may use other types of prediction quality feedback.

[0196] In some examples, instead of reliability unit **1002** receiving prediction quality information from picture estimation unit **226** of receiving device **104**, video encoder **210** may generate the prediction quality information and send the prediction quality information to reliability unit **1002**. Video encoder **210** may determine the prediction quality information based on a priori information about the video encoding process. For example, video encoder **210** may evaluate, based on the compression parameters, the reliability per bit (e.g., that MSBs is more reliable than LSBs, low frequency transform coefficients are more reliable than higher frequency transform coefficients, etc.). Video encoder **210** may perform the prediction process to evaluate the statistics by itself, have predefined statistics for different light compression set of parameters. In addition, transmitting device **102** may evaluate the instantaneous motion using other sensors, and adjust the reliability accordingly.

[0197] FIG. **12** is a flowchart illustrating an example operation of transmitting device **102** using scaled bits according to techniques of this disclosure. In the example of FIG. **12**, transmitting device **102** may obtain video data, e.g., from video source **120** (**1200**). Furthermore, transmitting device **102** may obtain prediction quality feedback (**1202**). In some examples, transmitting device **102** may obtain the prediction quality feedback from receiving device **104**. The prediction quality feedback includes bit reliability information. In some examples, the prediction quality feedback is represented in terms of noise model parameters, such as parameters of a Gaussian noise model or a Laplacian noise model.

[0198] Transmitting device **102** may adapt one or more of video encoding parameters, channel encoding parameters, or bit puncturing parameters based on the prediction quality feedback (**1204**). Video encoder **210** of transmitting device **102** may perform the video encoding process to generate encoded video data (**1206**). The video encoding process may be controlled by the video encoding parameters. For example, the video encoding parameters may control the number of transform coefficients included in transform blocks, the number of bits included in transform coefficients, and so on. In some examples, the video encoding parameters include a quantization parameter, and video encoder **210** may adapt the quantization parameter based on the prediction quality feedback. For instance, if the prediction quality feedback indicates low reliability, the quantization parameter may be reduced to reduce the level of quantization. As part of performing the video encoding process, video encoder **210** may use the quantization parameters to quantize transform coefficients of transform blocks of the one or more pictures.

[0199] Channel encoder **212** of transmitting device **102** may perform a channel encoding process on the scaled bits to generate channel encoded data (**1208**). The channel encoding process may be controlled by the channel encoding parameters. For example, the channel encoding parameters

may include control which LDPC graph the channel encoding process uses to generate codewords, the channel encoding parameter may control error correction capabilities, and so on. For example, the channel encoding parameters include a LDPC graph, channel encoder **212** may adapt the LPDC graph, and use the LDPC graph to generate codewords for transmission to the receiving device.

[0200] Furthermore, puncturing unit **214** of transmitting device **102** may perform a bit puncturing process on error correction data generated by channel encoder **212** (**1210**). The bit puncturing process may be controlled by the bit puncturing parameters. For example, the prediction quality feedback may indicate that certain parts of encoded video data are less reliable. Accordingly, transmitting device **102** may adjust the bit puncturing parameters to reduce bit puncturing on error correction data for the less reliable parts of the encoded video data. Transmitting device **102** may transmit the channel encoded data and bit-punctured error correction data to receiving device **104** (**1212**).

[0201] FIG. **13** is a flowchart illustrating an example operation of receiving device **104** using scaled bits according to techniques of this disclosure. In the example of FIG. **13**, receiving device **104** may obtain error correction data from a transmitting device (**1300**). The error correction data provides error correction information regarding a picture of the video data.

[0202] Picture estimation unit **226** may generate prediction data for the picture (**1302**). The prediction data for the picture may comprise predictions of blocks of the picture based at least in part on one or more previously reconstructed pictures of the video data. For example, picture estimation unit **226** may use inter prediction and/or intra prediction to generate the predictions of the blocks.

[0203] Furthermore, receiving device **104** may generate encoded video data based on the prediction data for the picture (**1304**). For example, video encoder **228** of receiving device **104** may perform a video encoding process that generates the encoded video data. The encoded video data includes transform blocks that comprises transform coefficients.

[0204] Receiving device **104** may scale bits of the transform coefficients of the transform blocks based on reliability values for bit positions (**1306**). In some examples, receiving device **104** generates the reliability values. For instance, receiving device **104** may generate the reliability values based on statistics regarding occurrence of errors in the bit positions. In some examples, receiving device **104** may generate the reliability values based on reliability characteristics for individual regions of pictures of the video data. In some examples, receiving device **104** may generate the reliability values based on a noise model. Furthermore, in some examples, receiving device **104** may send the reliability value to transmitting device **102**. In other examples, receiving device **104** may receive the reliability values from transmitting device **102**.

[0205] Additionally, channel decoder **222** of receiving device **104** may generate error-corrected encoded video data using the error correction data to perform an error correction operation on the scaled bits of the transform coefficients of the transform blocks (**1308**).

[0206] Video decoder **224** of channel decoder **222** may reconstruct the picture based on the error-corrected encoded video data (**1310**).

[0207] This disclosure describes techniques that may reduce the complexity of video encoding at a transmitting device, such as an extended reality (XR) headset. The transmitting device may obtain multiview video data. The multiview video data may include pictures from two or more viewpoints. For example, an XR headset may include two cameras for a stereoscopic view of a scene that a user is viewing. In this example, the multiview video data may include pictures from each of the cameras.

[0208] Processing the content of multiview video data may consume considerable processing resources. For instance, the context of augmented reality (AR) or mixed reality (MR), considerable processing resources may be required in order to determine where to position a virtual element and how the virtual element should appear. The multiview video data may help in processing virtual elements. As an example, the same virtual element may need to be darker when the virtual element is to be positioned in a shaded area of a scene and brighter when the virtual element is positioned in a sunny area of a scene. As another example, the system may need to analyze the content of a scene to determine whether a virtual element is to be occluded by physical elements in the scene, such as rocks or trees. Multiview video data may be useful in determining the depths of objects in a scene. To keep the XR headset light and to preserve battery power at the XR headset, it may be desirable to minimize the processing of video data performed at the XR headset. Processing the video data at another device, such as the user's smartphone or other nearby device may therefore help to reduce the demands for processing resources at the XR headset.

[0209] While multiview video data may be very useful in particular circumstances, simply transmitting unencoded multiview video data may be impractical since the amount of data needed to transmit multiple parallel streams of video data concurrently may be very large. However, there is often considerable redundancy between pictures of different views of multiview video data. As an example, what a person's left eye sees is often not that different from what a person's right eye sees. Accordingly, video compression techniques have been developed to reduce this redundancy in order to reduce the amount of data needed to transmit multiview video data.

[0210] However, some of the techniques for multiview video coding themselves require considerable computational resources. For example, a video encoder may determine differences between a set of two or more concurrent pictures to determine a depth map of a scene. The depth map is an array of values indicating the depths/distances from the cameras of objects shown in the pictures. In this example, one of the concurrent pictures may be an anchor picture and one or more of the concurrent pictures may be non-anchor pictures. The video encoder may use the depth map to calculate disparity vectors for blocks in the non-anchor pictures. A disparity vector for a block indicates a lateral displacement between the block and a corresponding block in another concurrent picture, such as the anchor picture. In general, blocks representing deeper objects have lower magnitude disparity vectors than blocks representing closer objects. The video encoder may use a disparity vector of a block to determine a prediction block, generate residual data based on the prediction block, apply a transform to the residual data, quantize transform coefficients of the resulting transform block, and signal the quantized transform coeffi-

cients. In this example, considerable computational resources may be involved in generating the depth map.

[0211] In another example, the illumination level may differ between concurrent pictures from different viewpoints. These differences in illumination may undermine the coding efficiency of multiview video coding. Illumination compensation may therefore be applied to non-anchor pictures to temporarily modify illumination levels of the non-anchor pictures in accordance with illumination compensation factors to make the non-anchor pictures more consistent with an illumination level of an anchor picture during video encoding. The original illumination levels of the non-anchor pictures may be restored during video decoding. Determining illumination compensation factors may consume computational resources.

[0212] The techniques of this disclosure may shift some of the processing associated with multiview video encoding from the transmitting device (e.g., the XR headset) to a receiving device (e.g., a mobile device). For example, the transmitting device may obtain a first set of multiview pictures of the video data. The first set of multiview pictures includes first pictures and second pictures. The first pictures are from a first viewpoint and the second pictures are from a second viewpoint. The transmitting device may transmit first encoded video data to a receiving device. The first encoded video data is based on the first set of multiview pictures. The transmitting device may receive multiview encoding cues from the receiving device. Furthermore, the transmitting device may obtain a second set of multiview pictures of the video data. The second set of multiview pictures includes third pictures and fourth pictures. The third pictures are from the first viewpoint and the fourth pictures are from the second viewpoint. The transmitting device may perform, based on the multiview encoding cues received from the receiving device, a multiview encoding process on the second set of multiview pictures to generate second encoded video data. The multiview encoding process reduces inter-view redundancy between the third pictures and the fourth pictures. The transmitting device may then transmit the second encoded video data to the receiving device.

[0213] Similarly, the receiving device may obtain first encoded video data from a transmitting device. The first encoded video data is based on a first set of multiview pictures of the video data. The first set of multiview pictures may include first pictures and second pictures. The first pictures are from a first viewpoint and the second pictures are from a second viewpoint. The receiving device may determine multiview encoding cues based on the first encoded video data. The receiving device may transmit the multiview encoding cues to the transmitting device. Additionally, the receiving device may obtain second encoded video data from the transmitting device. The second encoded video data is based on a second set of multiview pictures that includes third pictures and fourth pictures. The second encoded video data is encoded using a multiview encoding process that reduces inter-view redundancy between the third pictures and the fourth pictures based on the multiview encoding cues.

[0214] Because the receiving device determines the multiview encoding cues and sends the multiview encoding cues to the transmitting device, the burden of determining the multiview encoding cues may be shifted from the transmitting device to the receiving device. This may reduce the demand for resources at the transmitting device.

[0215] With reference to FIG. **2**, video encoder **210** may perform a multiview encoding process based on multiview encoding cues obtained from receiving device **104**. For example, the multiview encoding cues may include a depth map. In this example, video encoder **210** may use the depth map to estimate disparity vectors for blocks of pictures in a non-anchor view of the multiview video data. Video encoder **210** may use the disparity vector of a current block of a current picture to determine a prediction block for the current block based on samples of a concurrent reference picture. The concurrent reference picture has the same picture order count (POC) value as the current picture. Video encoder **210** may determine residual data for the current block based on original samples of the current block and the prediction block for the current block. Video encoder **210** may apply one or more transforms to the residual data to generate one or more transform blocks. Video encoder **210** may quantize transform coefficients in the transform blocks. The encoded video data generated by video encoder **210** may be based on the quantized transform coefficients.

[0216] In some examples, the multiview encoding cues may include one or more illumination compensation factors. When encoding a current picture of the multiview video data, video encoder **210** may modify each sample of the current picture based on the one or more illumination compensation factors. In some examples, different illumination compensation factors may apply to different regions of the current picture. Modifying the samples of the current picture in this way may make the illumination level of the current picture more consistent with an illumination level of a concurrent reference picture. After modifying the samples of the current picture, video encoder **210** may perform a multiview encoding process, such as that described in the previous paragraph, to encode blocks of the current picture.

[0217] Furthermore, in accordance with some examples of this disclosure, video decoder **224** may perform a multiview decoding process. For example, video decoder **224** may use disparity vectors of blocks of a current picture to generate prediction blocks. Video decoder **224** may use the prediction blocks and residual data received from channel decoder **222** to reconstruct samples of the blocks of the current picture. In some examples where video encoder **210** applied illumination compensation to a picture, video decoder **224** may use illumination parameters to reverse the illumination compensation applied to the picture. In other examples, video decoder **224** may apply other multiview decoding operations.

[0218] Furthermore, in accordance with one or more techniques of this disclosure, video decoder **224** may determine multiview encoding cues based on encoded video data received from transmitting device **102**. For example, video decoder **224** may determine depth maps, determine illumination compensation parameters, and other information that may be used in a multiview encoding operation. Receiving device **104** may transmit the multiview encoding cues back to transmitting device **102** so that transmitting device **102** may use the multiview encoding cues to perform a multiview encoding process on subsequent pictures.

[0219] Picture estimation unit **226** may generate an estimate of a next picture of the video data. In some examples, picture estimation unit **226** may estimate a picture based on one or more previously reconstructed reference pictures

associated with different views. For instance, picture estimation unit **226** may use information, such as disparity vectors or depth maps, from pictures for a previous time instant to extrapolate the content of the picture from a picture in the same time instant. In another example, picture estimation unit **226** may extrapolate the picture based on one or more pictures associated with the same view regardless of pictures associated with other views, in much the same way as discussed elsewhere in this disclosure with regard to picture estimation unit **226** estimating pictures of single view video data.

[0220] Video encoder **228** may perform the same operation as video encoder **210** on the estimated next picture. For instance, video encoder **228** may perform intra prediction to predict blocks, use the prediction blocks and the corresponding predicted blocks of the picture generated by picture estimation unit **226** to generate residual data. In some examples, video encoder **228** may perform the same multiview encoding processes as video encoder **210** using the multiview encoding cues. Video encoder **228** may apply a transform (e.g., a DCT transform) to the residual data to generate transform coefficients. Video encoder **228** may apply quantization to the transformed coefficients.

[0221] FIG. **14** is a flow diagram illustrating an example exchange of data between transmitting device **102** and receiving device **104** related to multiview processing according to one or more techniques of this disclosure. In the example of FIG. **14**, transmitting device **102** may obtain a first set of multiview pictures (**1400**). Transmitting device **102** may transmit first encoded video data based on the first set of multiview pictures to receiving device **104**. In some examples, transmitting device **102** performs light compression on first set of multiview pictures to generate the first encoded video data. In other examples, the first encoded video data may include unencoded versions of the first set of multiview pictures.

[0222] Receiving device **104** may perform multiview view processing on the first set of multiview pictures (**1402**). For example, receiving device **104** may decode the first set of multiview pictures, if necessary. Additionally, receiving device **104** may determine multiview encoding cues, e.g., as described elsewhere in this disclosure. Receiving device **104** may transmit the multiview encoding cues to transmitting device **102**.

[0223] Furthermore, in the example of FIG. **14**, transmitting device **102** may obtain a second set of multiview pictures (**1404**). Transmitting device **102** may perform a multiview encoding process on the second set of multiview pictures to generate second encoded video data (**1406**). The second encoded video data may include encoded anchor and secondary (non-anchor) pictures. Receiving device **104** may perform multiview decoding on the second encoded video data to reconstruct the second set of multiview pictures (**1408**). Receiving device **104** may also perform multiview processing on the second set of multiview pictures to determine updated multiview encoding cues (**1410**). Receiving device **104** may send the updated multiview encoding cues to transmitting device **102**. Transmitting device **102** may use the updated multiview encoding cues for multiview encoding of subsequent sets of multiview pictures.

[0224] FIG. **15** is a flowchart illustrating an example operation of transmitting device **102** for multiview processing according to techniques of this disclosure. In the example of FIG. **5**, transmitting device **102** may obtain a first set of multiview pictures of the video data (**1500**). The first set of multiview pictures includes first pictures and second pictures. The first pictures are from a first viewpoint and the second pictures are from a second viewpoint. Communication interface **118** (FIG. **1**) of transmitting device **102** may transmit first encoded video data to receiving device **104** (**1502**). The first encoded video data is based on the first set of multiview pictures. Transmitting device **102** may receive multiview encoding cues from receiving device **104** (**1504**). In some examples, the multiview encoding cues include one or more of: a relative shift between blocks of the first pictures (i.e., pictures of the first viewpoint) and the second pictures (i.e., pictures of the second viewpoint), a brightness correction between the first pictures and the second pictures, an inter block shift between an anchor block and a reconstructed block, or motion data for reference shift. Transmitting device **102** may receive the multiview encoding cues in one of a variety of ways. For example, transmitting device **102** may receive the multiview encoding cues via an Uplink Control Information (UCI)/Media Access Control-Control Element (MAC-CE) message, a Radio Resource Control (RRC) message, or another type of message.

[0225] Furthermore, transmitting device **102** may obtain a second set of multiview pictures of the video data (**1506**). The second set of multiview pictures includes third pictures and fourth pictures. The third pictures are from the first viewpoint and the fourth pictures are from the second viewpoint. Video encoder **210** may perform, based on the multiview encoding cues received from the receiving device, a multiview encoding process on the second set of multiview pictures to generate second encoded video data (**1508**). The multiview encoding process reduces inter-view redundancy between the third pictures and the fourth pictures. Transmitting device **102** may then transmit the second encoded video data to receiving device **104** (**1510**).

[0226] The operation of FIG. **15** may be performed multiple times for subsequent sets of multiview pictures. For example, after transmitting the second encoded video data to the receiving device, transmitting device **102** may receive updated multiview encoding cues from receiving device **104**. Transmitting device **102** may obtain a third set of multiview pictures of the video data. The third set of multiview pictures may include fifth pictures and sixth pictures, the fifth pictures being from the first viewpoint and the sixth pictures being from the second viewpoint. Video encoder **210** of transmitting device **102** may encode the third set of multiview pictures based on the updated multiview encoding cues received from the receiving device to generate third encoded video data. Transmitting device **102** may transmit the third encoded video data to receiving device **104**.

[0227] FIG. **16** is a flowchart illustrating an example operation of receiving device **104** for multiview processing according to techniques of this disclosure. In the example of FIG. **16**, receiving device **104** may obtain first encoded video data from transmitting device **102** (**1600**). For instance, receiving device **104** may obtain the first encoded video data via communication interface **134** (FIG. **1**). The first encoded video data is based on a first set of multiview pictures of the video data. The first set of multiview pictures may include first pictures and second pictures. The first pictures are from a first viewpoint and the second pictures

are from a second viewpoint. Receiving device **104** may determine multiview encoding cues based on the first encoded video data (**1602**).

[0228] Receiving device **104** may transmit the multiview encoding cues to transmitting device **102** (**1604**). Receiving device **104** may transmit the multiview encoding cues in one of a variety of ways. For example, receiving device **104** may transmit the decimation pattern indication via an Uplink Control Information (UCI)/Media Access Control-Control Element (MAC-CE) message, a Radio Resource Control (RRC) message, or another type of message.

[0229] Additionally, receiving device **104** may obtain second encoded video data from transmitting device **102** (**1606**). The second encoded video data is based on a second set of multiview pictures that includes third pictures and fourth pictures. The second encoded video data is encoded using a multiview encoding process that reduces inter-view redundancy between the third pictures and the fourth pictures based on the multiview encoding cues. Video decoder **224** of receiving device **104** may decode the second encoded video data.

[0230] In some examples, the multiview encoding cues include a depth map indicating depths of objects represented in the first and second pictures. Receiving device **104** may, as part of determining the multiview encoding cues, determine the depth map based on the first and second pictures. In some examples, the multiview encoding cues includes one or more illumination compensation factors and receiving device **104** may, as part of determining the multiview encoding cues, determine the illumination compensation factors based on the first and second pictures.

[0231] The process of FIG. **16** may be repeated multiple times. For example, receiving device **104** may determine second multiview encoding cues based on the second encoded video data. Receiving device **104** may transmit the second multiview encoding cues to transmitting device **102**. Subsequently, receiving device **104** may obtain third encoded video data from transmitting device **102**. The third encoded video data is based on a third set of multiview pictures that includes fifth pictures and sixth pictures, the third encoded video data being encoded using the multiview encoding process that reduces inter-view redundancy between the fifth pictures and the sixth pictures based on the second multiview encoding cues.

[0232] In accordance with one or more techniques of this disclosure, transmitting device **102** may receive a decimation pattern indication from receiving device **104**. The decimation pattern indication may indicate a decimation pattern. As described in greater detail elsewhere in this disclosure, receiving device **104** may determine the decimation pattern. The decimation pattern may be a pattern of encoded video data non-transmission.

[0233] Transmitting device **102** may receive the decimation pattern indication in one of a variety of ways. For example, transmitting device **102** may receive the decimation pattern indication via an Uplink Control Information (UCI)/Media Access Control-Control Element (MAC-CE) message, a Radio Resource Control (RRC) message, Sidelink Control Information (SCI), or another type of message.

[0234] Transmitting device **102** may apply the decimation pattern to the encoded video data generated by video encoder **210**, thereby generating decimated video data. For example, the decimation pattern may indicate a pattern of skipping transmission of encoded video data of full pictures. Accordingly, in this example, transmitting device **102** (e.g., channel encoder **212** of transmitting device **102**) may transmit encoded video data of some pictures and not transmit encoded video data of other picture in accordance with the indicated pattern. For example, transmitting device **102** may skip transmission of encoded video data of every other picture. In another example, transmitting device **102** may transmit encoded video data of one picture and then not transmit encoded video data of the next two or more pictures.

[0235] In another example, the decimation pattern may indicate a pattern of skipping transmission of encoded video data of specified regions within pictures. Specific regions of a series of pictures may not change much, if at all, from picture-to-picture. For instance, the background of a scene from a static viewpoint may not change significantly while changes occur in a more confined region of interest. Because regions outside the regions of interest do not change much, such regions may be easier to predict accurately. Hence, in accordance with a technique of this disclosure, receiving device **104** may identify the regions outside the regions of interest. Accordingly, transmitting device **102** may transmit encoded video data for the regions of interest and not transmit encoded video data of other regions.

[0236] In another example, the video data is multiview video data and the decimation pattern may indicate a pattern of skipping transmission of encoded video data of pictures from specified views. For instance, two views may have very similar content, such as views primarily showing distant objects. Accordingly, in this example, transmitting device **102** may transmit encoded video data of one of the views and not transmit encoded video data of one or more other views, as indicated by the decimation pattern.

[0237] In another example, the decimation pattern may indicate a pattern of bits to omit from syntax elements indicating transform coefficients. For instance, the decimation pattern may indicate that a specific number of least significant bits are to be omitted from transform coefficients. In some examples, the decimation pattern may indicate that specific transform coefficients (e.g., high frequency transform coefficients) are to be omitted.

[0238] FIG. **17** is a block diagram illustrating example components of a transmitting device and a receiving device that perform decimation on encoded video data according to techniques of this disclosure. In the example of FIG. **17**, transmitting device **102** includes video encoder **210**, channel encoder **212**, puncturing unit **214**, and also a transmitter decimation unit **1700**. Receiving device **104** includes de-puncturing unit **220**, channel decoder **222**, video decoder **224**, picture estimation unit **226**, video encoder **228**, and also a receiver decimation unit **1702**. Video encoder **210**, channel encoder **212**, puncturing unit **214**, de-puncturing unit **220**, channel decoder **222**, video decoder **224**, picture estimation unit **226**, and video encoder **228** may operate in the same way as described elsewhere in this disclosure.

[0239] However, in the example of FIG. **17**, transmitter decimation unit **1700** may apply a decimation pattern to encoded video data after channel encoder **212** generates error correction data for the encoded video data. The decimation pattern indicates a pattern of non-transmission of encoded video data. For example, transmitter decimation unit **1700** may cause transmitting device **102** not to transmit encoded video data for specific pictures, regions of pictures, a pattern of blocks within pictures, specific views, and so on.

Receiver decimation unit **1702** may determine a decimation pattern indication based on pictures reconstructed by video decoder **224**. Receiver decimation unit **1702** may transmit a decimation pattern indication indicating a decimation pattern to transmitting device **102**. Transmitter decimation unit **1700** may apply the decimation pattern indicated by the decimation pattern indication.

[0240] Although FIG. **17** is described with respect to a DVC-based scheme, the techniques of this disclosure related to sending a decimation pattern indication from receiving device **104** to transmitting device **102** are not necessarily so limited. For instance, in some examples, picture estimation unit **226** and video encoder **228** may be omitted.

[0241] FIG. **18** is a conceptual diagram illustrating an example exchange of information that includes decimation pattern indications according to techniques of this disclosure. In the example of FIG. **18**, transmitting device **102** may transmit encoded video data for a first set of pictures (e.g., picture $n-n_1$, picture $n-n_{n1+1}$, and picture n) to receiving device **104**. Transmitting device **102** may also transmit error correction data for the first set of pictures.

[0242] Receiving device **104** may transmit, and transmitting device **102** may receive, a decimation pattern indication that indicates a decimation pattern determined based on the first set of encoded pictures. In the example of FIG. **18**, the decimation pattern decimates pictures according to a 1:2 ratio. In other words, the encoded video data for one picture out of every two pictures is to be transmitted.

[0243] Accordingly, transmitting device **102** may transmit encoded video data for a second set of pictures to receiving device **104**. In accordance with the decimation pattern indicated by the received decimation pattern indication, transmitting device **102** skips transmission of encoded video data of every other picture in the second set of pictures. As shown in the example of FIG. **18**, the index values (e.g., n+2, n+4, n+n2) of pictures in the second set of pictures increase by 2 instead of 1, as was the case for the first set of pictures.

[0244] Subsequently, receiving device **104** may determine, based on the second set of pictures, that a more appropriate decimation pattern would be a 1:1 decimation pattern (i.e., a decimation pattern in which transmitting device **102** transmits encoded video data for each picture). Accordingly, in the example of FIG. **18**, receiving device **104** may transmit, and transmitting device **102** may receive, a second decimation pattern indication that indicates a second decimation pattern. Subsequently, transmitting device **102** may transmit encoded video data for a third set of pictures. In accordance with the second decimation pattern, transmitting device **102** does not skip transmission of encoded video data of any picture of the third set of pictures. Thus, as shown in the example of FIG. **18**, the index values (e.g., n+n2+1, n+n2+2, etc.) increase by 1 instead of 2.

[0245] FIG. **19** is a flowchart illustrating an example operation of transmitting device **102** in which transmitting device **102** receives a decimation pattern indication according to techniques of this disclosure. In the example of FIG. **19**, video encoder **210** of transmitting device **102** may encode a first set of pictures of the video data to generate first encoded video data (**1900**). Transmitting device **102** may transmit the first encoded video data to receiving device **104** (**1902**).

[0246] Furthermore, transmitting device **102** may receive, from receiving device **104**, a decimation pattern indication that indicates a decimation pattern determined based on the first set of pictures (**1904**). The decimation pattern may be a pattern of encoded video data non-transmission. For instance, in some examples, the decimation pattern indicates a pattern of skipping transmission of encoded video data for full pictures. In other words, transmitting device **102** may not transmit any encoded video data for specific pictures and may transmit some or all of the encoded video data for other pictures. In some examples, the decimation pattern indicates a pattern of skipping transmission of encoded video data of specific regions within pictures. For instance, the decimation pattern may indicate that transmitting device **102** is to skip transmission of encoded video data associated with specific blocks of pictures, e.g., as shown in FIGS. **6** and **9**. In some examples where the video data is multiview video data, the decimation pattern may indicate a pattern of skipping transmission of encoded video data of pictures from specific views. In such examples, the views may be associated with sensors on the same piece of user equipment (e.g., same XR headset) or views associated with sensors on different pieces of user equipment (e.g., different XR headsets worn by different users) or cameras. In some examples, there may be different decimation patterns for different regions without pictures. For instance, no decimation may be applied to a region of interest and a decimation pattern that limits transmission of blocks or less significant bits or higher frequency transform coefficients may be applied with respect to areas of pictures outside the region of interest.

[0247] Video encoder **210** may encode a second set of pictures of the video data to generate second encoded video data (**1906**). Additionally, transmitter decimation unit **1700** may apply the decimation pattern to the second encoded video data to generate decimated video data (**1908**). Transmitting device **102** may transmit the decimated video data to the receiving device (**1910**).

[0248] In some examples, transmitter decimation unit **1700** may determine a decimation pattern. Thus, in the context of FIG. **19**, transmitting device **102** may encode a third set of pictures of the video data to generate third encoded video data, determine a second decimation pattern indicating a second pattern of encoded video data non-transmission, and apply the second decimation pattern to the third encoded video data to generate second decimated video data. Transmitting device **102** may transmit the second decimated video data to receiving device **104**. Transmitting device **102** may transmit a second decimation pattern indication to the receiving device. The second decimation pattern indication indicating that the second decimation pattern was applied to the third encoded video data.

[0249] Transmitter decimation unit **1700** may determine the decimation pattern in various ways. For example, transmitter decimation unit **1700** may test various decimation patterns. When testing a decimation pattern, transmitter decimation unit **1700** may apply the decimation pattern to a picture and reconstruct the picture from error correction data for the picture and one or more previous original pictures of the video data. Transmitter decimation unit **1700** may compare the reconstructed picture to the picture to determine a level of distortion. Transmitter decimation unit **1700** may compare the levels of distortion associated with the different decimation patterns to determine a decimation pattern.

[0250] In some examples, the operation of FIG. **19** is performed in the context of DVC. Thus, channel encoder **212** of transmitting device **102** may generate first error correction data based on the first encoded video data.

Transmitting device **102** may transmit the first error correction data to receiving device **104**. Channel encoder **212** may generate second error correction data based on the second encoded video data. Transmitting device **102** may transmit the second error correction data to the receiving device.

[0251] FIG. **20** is a flowchart illustrating an example operation of receiving device **104** in which receiving device **104** transmits a decimation pattern indication according to techniques of this disclosure. In the example of FIG. **20**, receiving device **104** may receive, from transmitting device **102**, first encoded video data (**2000**). Video decoder **224** may perform a decoding process to reconstruct a first set of pictures based on the first error-corrected encoded video data (**2002**).

[0252] Additionally, receiver decimation unit **1702** may determine, based on the first set of pictures, a decimation pattern that indicates a pattern of encoded video data non-transmission (**2004**). In some examples, the decimation pattern indicates a pattern of skipping transmission of encoded video data of full pictures. In some examples, the decimation pattern indicates a pattern of skipping transmission of encoded video data of specified regions or blocks within pictures, such as in the examples of FIG. **6** and FIG. **9**. In some examples where the video data is multiview video data and the decimation pattern indicates a pattern of skipping transmission of encoded video data of pictures from specified views.

[0253] Receiver decimation unit **1702** may determine the decimation pattern in one of a variety of ways. For example, receiver decimation unit **1702** may, for one or more trial decimation patterns, apply the trial decimation pattern to the error-corrected encoded video data generated by channel decoder **222** for the first set of pictures to generate decimated encoded video data. Receiver decimation unit **1702** may then cause channel decoder **222** to apply the error correction process to modify the decimated encoded video data based on the first error correction data to generate trial error-corrected video data. Receiver decimation unit **1702** may then cause video decoder **224** to apply the decoding process to reconstruct the first set of pictures based on the trial error-corrected video data. Receiver decimation unit **1702** may determine whether the decimation pattern satisfies one or more criteria based on a comparison of the first set of pictures as reconstructed based on the trial error-corrected video data and the first set of pictures as reconstructed based on the first error-corrected video data. For case of explanation, this disclosure may refer to pictures reconstructed based on the trial error-corrected video data as "trial pictures" and may refer to pictures reconstructed based on the first error-corrected video data as "baseline pictures." Receiver decimation unit **1702** may repeat this procedure with multiple trial decimation patterns until receiver decimation unit **1702** identifies a decimation pattern that satisfies the criteria.

[0254] For example, receiver decimation unit **1702** may compare each trial picture to a corresponding baseline picture to determine whether the trial picture satisfies a criterion. For instance, receiver decimation unit **1702** may determine that a trial picture satisfies the criterion if a sum of differences between the trial picture and the corresponding baseline picture is less than a specific amount. If at least a given quantity of the trial pictures exceed a threshold, receiver decimation unit **1702** may select the decimation pattern associated with the trial pictures.

[0255] In a more general example, receiver decimation unit **1702** may apply a function to the trial pictures and corresponding baseline pictures to generate a value. If the value is less than a threshold, receiver decimation unit **1702** may select the decimation pattern associated with the trial pictures.

[0256] Furthermore, in some examples, receiver decimation unit **1702** may cancel use of a decimation pattern (e.g., revert to a pattern in which all encoded video data is transmitted) or change to a less aggressive decimation pattern if particular conditions occur. For example, receiver decimation unit **1702** may cancel use of a decimation pattern in response to determining that a given number of baseline pictures fail to satisfy a criterion. For instance, receiver decimation unit **1702** may determine that a trial picture fails the criterion if a sum of differences between the trial picture and the corresponding baseline picture is greater than a specific amount. If at least a given quantity of the trial pictures failing the criteria exceed a threshold, receiver decimation unit **1702** may cancel use of the decimation pattern or revert to a less aggressive decimation pattern. In a more general example, receiver decimation unit **1702** may apply a function to the trial pictures and corresponding baseline pictures to generate a value. If the value is greater than a second threshold, receiver decimation unit **1702** may cancel use of the decimation pattern or revert to a less aggressive decimation pattern.

[0257] Receiver decimation unit **1702** may transmit, to transmitting device **102**, a decimation pattern indication that indicates the determined decimation pattern (**2006**). Receiver decimation unit **1702** may transmit the decimation pattern indication using an Uplink Control Information (UCI)/Media Access Control-Control Element (MAC-CE) message, a Radio Resource Control (RRC) message, a Sidelink Control Information (SCI) message, or another type of message.

[0258] Receiving device **104** may receive, from transmitting device **102**, decimated video data (**2008**). The decimated video data may comprise second encoded video data to which the decimation pattern has been applied. The second encoded video data is generated based on a second set of pictures of the video data.

[0259] Video decoder **224** may perform the decoding process to reconstruct the second set of pictures based on the second error-corrected encoded video data (**2010**). Video decoder **224** may perform the same decoding process as described elsewhere in this disclosure.

[0260] In some examples, receiving device **104** may receive and use a decimation pattern indication from transmitting device **102**. Thus, in the example of FIG. **20**, receiving device **104** may receive a second decimation pattern indication indicating a second pattern of encoded video data non-transmission. Receiving device **104** may receive, from transmitting device **102**, third error correction data and second decimated video data. The second decimated video data may comprise third encoded video data to which the second decimation pattern has been applied. The third encoded video data may be generated based on a third set of pictures of the video data. Channel decoder **222** may apply the error correction process to generate third error-corrected encoded video data based on the third encoded video data and the third error correction data. Video decoder

224 may apply the decoding process to reconstruct the third set of pictures based on the third error-corrected encoded video data.

[0261] In some examples, the process of FIG. 20 may be performed in a DVC-based implementation. Thus, receiving device 104 may receive, from transmitting device 102, first error correction data. Receiving device 104 apply an error correction process to modify the first encoded video data based on the first error correction data to generate first error-corrected encoded video data. Receiving device 104 may perform the decoding process to reconstruct the first set of pictures based on the first error-corrected encoded video data. Additionally, receiving device 104 may receive, from transmitting device 102, second error correction data. Receiving device 104 may apply the error correction process to generate second error-corrected encoded video data based on the second encoded video data, predicted encoded video data generated by video encoder 228, and the second error correction data. Receiving device 104 may perform the decoding process to reconstruct the second set of pictures based on the second error-corrected encoded video data.

[0262] During the video encoding process, a video encoder typically analyzes multiple encoding options and selects the best option. For example, the video encoder may analyze multiple ways of partitioning a largest coding unit (LCU) or macroblock into coding units (CUs) and/or prediction units (PUS). In another example, the video encoder may analyze multiple intra prediction modes when performing intra prediction to generate a prediction block for a PU. In another example, the video encoder may analyze multiple reference pictures and motion vectors when performing inter prediction to generate a prediction block for a PU. Such analysis and selection may be resource intensive. For instance, to be effective, the video encoder may need to process multiple options in parallel, which increases the hardware complexity of the video encoder and increases power requirements. The analysis and selection may also involve multiple requests to read and write data to memory, which further increases power requirements.

[0263] In accordance with one or more techniques of this disclosure, much of the process of analyzing and selecting encoding operations is shifted from the transmitting device (e.g., transmitting device 102) to the receiving device (e.g., receiving device 104). For example, the transmitting device may encode a first picture of the video data to generate first encoded video data. The transmitting device may transmit the first encoded video data to a receiving device. The receiving device may receive first encoded video data from the transmitting device and reconstruct the first picture based on the first encoded video data. Additionally, the receiving device may estimate a second picture of the video data based on the first picture. The second picture may be a picture occurring after the first picture in decoding order. The receiving device may generate encoding selection data for the estimated second picture. The encoding selection data indicate encoding selections used to encode the estimated second picture. The receiving device may transmit the encoding selection data for the second picture. The transmitting device may receive the encoding selection data for the second picture of the video data. The transmitting device may encode the second picture based on the encoding selection data to generate second encoded video data. The transmitting device may transmit the second encoded video data to the receiving device. The receiving device may receive second encoded video data from the transmitting device. The receiving device may reconstruct the second pictured based on the second encoded video data. In this way, because the transmitting device receives the encoding selection data from the receiving device, the transmitting device does not need to perform the resource intensive analysis and selection process while encoding the second picture because the analysis and selection process already occurred for the second picture at the receiving device. This may reduce the resource requirements of the transmitting device.

[0264] The transmitting device and the receiving device may communicate using a low range, low power links over an ultra-wideband (e.g., large bandwidth) communication link. In some examples, the transmitting device and the receiving device may communicate using a time division duplexing (TDD) scheme, a sub-band non-overlapping full duplex (SBFD) scheme, or a SFFD scheme. The low latency associated with this type of communication may allow the transmitting device to receive the encoding selection data quick enough for the transmitting device to continue transmitting encoded video data to satisfy a predetermined picture rate.

[0265] FIG. 21 is a block diagram illustrating example components of transmitting device 102 and receiving device 104 that transmits encoding selection data to the transmitting device according to techniques of this disclosure. In the example of FIG. 21, transmitting device 102 may include video encoder 210, channel encoder 212, and puncturing unit 214. Receiving device 104 may include de-puncturing unit 220, channel decoder 222, video decoder 224, picture estimation unit 226, and video encoder 228.

[0266] In the example of FIG. 21, video encoder 210 may encode pictures of video data. Unlike some of the examples provided above, video encoder 210 may perform a full video encoding process that may include intra and inter prediction. In some examples, video encoder 210 may encode the video data using a video codec, such as H.264/AVC, H.265/HEVC, H.266/VVC, Essential Video Coding (EVC), AV1, and so on. Channel encoder 212, puncturing unit 214, de-puncturing unit 220, and channel decoder 222 may operate in the same manner as described elsewhere in this disclosure.

[0267] Furthermore, in the example of FIG. 21, video decoder 224 of receiving device 104 may perform a video decoding process on error-corrected encoded video data generated by channel decoder 222. Video decoder 224 may perform a full video decoding process that includes intra and inter prediction. Video decoder 224 may use the same video codec as video encoder 210.

[0268] After video decoder 224 reconstructs at least part of a picture of the video data, picture estimation unit 226 may estimate corresponding parts of a subsequent picture that that follows the reconstructed picture. Picture estimation unit 226 may estimate the subsequent picture in the same manner as described elsewhere in this disclosure. Moreover, video encoder 228 may apply a video encoding process to the subsequent picture. In examples where video encoder 210 and video decoder 224 use a video codec, video encoder 228 may use the same codec.

[0269] However, in accordance with one or more techniques of this disclosure, receiving device 104 may transmit encoding selection data 2100 to transmitting device 102. Encoding selection data 2100 indicate encoding selections

used to encode the estimated subsequent picture. For example, the encoding selection data may include motion parameters for blocks in the estimated subsequent picture. The motion parameters for a block may include motion vectors, reference picture indicators, merge candidate indices, affine motion parameters, and other data used to determine a prediction block for the block in one or more reference pictures. Thus, in this example, video encoder **228** may encode the block using inter prediction and encoding selection data **2100** may include motion parameters that indicate how video encoder **228** encoded the block using inter prediction.

[0270] In some examples, the encoding selection data may include intra prediction parameters for blocks in the estimated subsequent picture. The intra prediction parameters may include data indicating intra prediction modes (e.g., planar mode, DC mode, directional prediction modes, etc.) that video encoder **228** used for intra prediction of the blocks. In some examples, the encoding selection data may include other information, such as information that describes how video encoder **228** partitioned the estimated subsequent picture into blocks, whether residual prediction is used, whether and how intra block copy (IBC) is used, whether specific filters are used, and so on.

[0271] Video encoder **210** may use encoding selection data **2100** when encoding the actual (non-estimated) subsequent picture. That is, instead of searching through different possibilities during the video encoding process, video encoder **210** may use the video encoding selections indicated by the encoding selection data **2100**. For example, the encoding selection data **2100** may indicate that a specific block of the subsequent picture is encoded with a specific intra prediction mode. Accordingly, in this example, when encoding the subsequent picture, video encoder **210** may encode the specific block with the specific intra prediction mode without analyzing different potential intra prediction modes to select the specific intra prediction mode. In another example, encoding selection data **2100** may indicate a motion vector and reference picture for a specific block of the subsequent picture. Accordingly, in this example, when encoding the subsequent picture, video encoder **210** may use the motion vector to determine a prediction block in the reference picture without analyzing potential reference pictures and motion vectors. Video encoder **210** may use the prediction block to encode the specific block.

[0272] Transmitting device **102** may handle encoded video data for the subsequent picture in the same manner as other pictures. Additionally, receiving device **104** may handle the encoded video data for the subsequent picture in the same manner as other encoded video data. Thus, after video decoder **224** reconstructs at least part of the subsequent picture, picture estimation unit **226** may predict corresponding parts of a picture that follows the subsequent picture, video encoder **228** may encode video data of that estimated following picture and transmit encoding selection data for the estimated following picture, and the cycle can repeat. In this way, some of the burden of encoding video data may be shifted from video encoder **210** of transmitting device **102** to video encoder **228** of receiving device **104**. This may reduce the resource requirements of transmitting device **102**.

[0273] The process described with respect to FIG. **21** may be adapted for use with DVC techniques. For example, transmitting device **102** may apply a decimation pattern to encoded video data (e.g., according to any of the examples provided elsewhere in this disclosure) such that transmitting device **102** only transmits some encoded video data but still transmits error correction data for the decimated video data. Channel decoder **222** of receiving device **104** may receive error correction data for a specific picture from transmitting device (e.g., by way of de-puncturing unit **220**). In this example, channel decoder **222** may apply the error correction process to generate error-corrected encoded video data based on the error correction data for the specific picture and the encoded video data for the specific picture generated by video encoder **228** of receiving device **104**. Video decoder **224** may decode the error-corrected encoded video data to reconstruct the specific feature.

[0274] In some instances, transmitting device **102** needs to transmit encoded video data according to a schedule. For instance, transmitting device **102** may need to transmit encoded video data to receiving device **104** according to predetermined picture per minute rate in order to support a specific application. Thus, circumstances may occur in which transmitting device **102** does not receive encoding selection data for a picture in time for transmitting device **102** to encode and transmit encoded video data for the picture. Accordingly, in some examples, based on determining that encoding selection data for a picture is not received from receiving device **104** prior to expiration of a time limit, video encoder **210** may encode the picture without use the encoding selection data for the picture. Video encoder **210** may use a limited video encoding process to encode the picture. Furthermore, in some examples, the encoded video data for the picture may include encoding selection data generated by video encoder **210**. In some examples, the encoded video data for the picture may include data indicating that the encoded video data for the picture was not generated based on encoding selection data generated by receiving device **104**. The time limit may be subject to or defined based on the capabilities of transmitting device **102**.

[0275] The encoding selection data and time limit can be defined in per image segment (e.g., slice, region, etc.) basis. Thus, in this disclosure, discussion of encoding selection data, encoded video data, or other types of data for a picture may apply only with respect to an individual segment of the picture.

[0276] FIG. **22** is a communication diagram illustrating an example exchange of data between transmitting device **102** and receiving device **104** that includes transmission and reception of encoding selection data according to techniques of this disclosure. In the example of FIG. **22**, transmitting device **102** transmits encoded video data for a picture n−1 to receiving device **104**. Receiving device **104** may reconstruct picture n−1 based on the encoded video data for picture n−1. Additionally, receiving device **104** may estimate and encode a picture n based on picture n−1. Receiving device **104** may transmit encoding selection data for picture n to transmitting device **102**. Transmitting device **102** may encode picture n based on the encoding selection data for picture n and transmit the resulting encoded video data for picture n to receiving device **104**. The process may repeat multiple times. Thus, in the example of FIG. **22**, receiving device **104** may reconstruct picture n based on the encoded video data for picture n, estimate a picture n+1 based on picture n and/or one or more other previously reconstructed pictures, encode picture n+1, and transmit encoding selection data for picture n+1 to transmitting device **102**.

[0277] FIG. **23** is a flowchart illustrating an example operation of transmitting device **102** in which transmitting device **102** receives encoding selection data according to techniques of this disclosure. In the example of FIG. **23**, video encoder **210** encodes a first picture of video data to generate first encoded video data (**2300**). In some examples, if transmitting device **102** has not received encoding selection data for the first picture, transmitting device **102** may perform a limited video encoding process on the first picture. The limited video encoding process may use relatively less computationally intensive coding tools than a full video encoding process. For example, the limited video encoding process may use intra prediction but not inter prediction.

[0278] Transmitting device **102** may transmit the first encoded video data to receiving device **104** (**2302**). In some examples, transmitting device **102** may apply channeling encoding process to the first encoded video data to generate error correction data for the first encoded video data. Transmitting device **102** may transmit the first encoded video data and the error correction data to receiving device **104**.

[0279] Subsequently, transmitting device **102** may receive from receiving device **104**, encoding selection data for a second picture of the video data (**2304**). The encoding selection data may indicate encoding selections used to encode an estimate of the second picture. The second picture follows the first picture in decoding order. In some examples, the second picture may occur before or after the first picture in output coder. In some examples, the encoding selection data is entropy encoded. Accordingly, in such examples, transmitting device **102** may entropy decode the encoding selection data. For example, transmitting device **102** may apply CABAC decoding, Golomb-Rice decoding, or another type of entropy decoding to the encoding selection data. In some examples, the encoding selection data is channel encoded. Accordingly, transmitting device **102** may apply an error correction operation to the encoding selection data based on error correction data for the encoding selection data.

[0280] Video encoder **210** of transmitting device **102** may encode the second picture based on the encoding selection data to generate second encoded video data (**2306**). For example, the encoding selection data may include data indicating how to partition specific macroblocks into CUs. In this example, video encoder **210** may partition the macroblocks into CUs in the manner indicated by the encoding selection data. In another example, the encoding selection data may indicate an intra prediction mode for a block (e.g., a CU or PU) and video encoder **210** may use the indicated intra prediction mode for encoding the block. Thus, in this example, the encoding selection data received from receiving device **104** may include intra prediction parameters for blocks of the second picture and video encoder **210** may, as part of encoding the second picture, perform intra prediction based on the intra prediction parameters for the blocks of the second picture to generate predictive blocks. The second encoded video data may include encoded video data based on the predictive blocks.

[0281] In another example, the encoding selection data received from receiving device **104** includes motion parameters for blocks of the second picture and transmitting device **102** may, as part of encoding the second picture, perform motion compensation based on the motion parameters for the blocks of the second picture to generate predictive blocks. The second encoded video data includes encoded video data based on the predictive blocks.

[0282] Transmitting device **102** may transmit the second encoded video data to the receiving device (**2308**). In some examples the second encoded video data does not include encoding selection data indicating encoding selections that transmitting device **102** used in encoding the second picture or that receiving device **104** used in encoding the estimate of the second picture. It may be unnecessary for the second encoded video data to include the encoding selection data because receiving device **104** generated the encoding selection data and therefore already has the encoding selection data.

[0283] In some examples, the operation of FIG. **23** may be used with DVC techniques. For example, transmitting device **102** may receive encoding selection data for a third picture of the video data. The encoding selection data for the third picture may indicate encoding selections used to encode an estimate of the third picture. Video encoder **210** may encode the third picture based on the encoding selection data for the third picture to generate third encoded video data. Channel encoder **212** may apply a channel encoding process that generates error correction data for the third encoded video data. Transmitting device **102** may transmit the error correction data for the third encoded video data to the receiving device without transmitting at least a portion of the third encoded video data.

[0284] FIG. **24** is a flowchart illustrating an example operation of receiving device **104** in which receiving device **104** transmits encoding selection data according to techniques of this disclosure. In the example of FIG. **24**, receiving device **104** may receive first encoded video data from transmitting device (**2400**).

[0285] Video decoder **224** of receiving device **104** may reconstruct a first picture of the video data based on the first encoded video data (**2402**). Picture estimation unit **226** may receiving device **104** may estimate a second picture of the video data based on the first picture (**2404**). The second picture may be a picture occurring after the first picture in decoding order.

[0286] Video encoder **228** of receiving device **104** may generate encoding selection data for the estimated second picture (**2406**). The encoding selection data indicates encoding selections used to encode the estimated second picture. For example, as part of encoding the estimated second picture, video encoder **228** may perform motion compensation based on motion parameters for the blocks of the second picture to generate predictive blocks. In this example, the encoding selection data may include the motion parameters for blocks of the second picture the one or more processors. In some examples, as part of encoding the second picture, video encoder **228** may perform intra prediction based on the intra prediction parameters for the blocks of the second picture to generate predictive blocks. In this example, the encoding selection data may include intra prediction parameters for blocks of the second picture.

[0287] Receiving device **104** may transmit, to transmitting device **102**, the encoding selection data for the second picture (**2408**). In some examples, receiving device **104** may apply entropy encoding (e.g., CABAC encoding, Golomb-Rice coding, etc.) to the encoding selection data for the second picture prior to transmitting the encoding selection data for the second picture. In some examples, receiving device **104** may perform a channel encoding process on

encoding selection data to generate error correction data for the encoding selection data. Receiving device **104** may transmit the encoding selection data and error correction data for the encoding selection data to transmitting device **102**. In some examples, communication interface **134** (FIG. **1**) of receiving device **104** may modulate the encoding selection data at a lower modulation order as compared to other data transmissions in a data link (e.g., wireless sidelink channel **112**, wireless uplink/downlink channels, etc.) between receiving device **104** and transmitting device **102**. This may increase the likelihood of transmitting device **102** receiving the encoding selection data correctly.

[0288] Subsequently, receiving device **104** may receive second encoded video data from the transmitting device (**2410**). Video decoder **224** may reconstruct the second picture based on the second encoded video data (**2412**). In some examples, the second encoded video data does not include the encoding selection data. Video decoder **224** may apply the decoding process comprises using the encoding selection data to reconstruct the second picture based on the second encoded video data.

[0289] The process of FIG. **24** may be used with DVC techniques. For example, picture estimation unit **226** may estimate a third picture of the video data based on one or more of the first or second pictures. Video encoder **228** may encode the estimated third picture to generate third encoded video data. Receiving device **104** may transmit third encoding selection data to transmitting device **102**. The third encoding selection data may indicate encoding selections used to encode the estimated third picture. Subsequently, receiving device **104** may receive error correction data for the third picture. Channel decoder **222** may apply an error correction process to generate error-corrected encoded video data for the third picture based on the error correction data for the third picture and the third encoded video data. Video decoder **224** may apply a decoding process that reconstructs the third picture based on the error-corrected encoded video data for the third picture. In some examples in which transmitting device **102** and receiving device **104** use DVC techniques, the error-corrected video data for the third picture does not include the third encoding selection data. However, video decoder **224** may apply the decoding process using the third encoding selection data generated by video encoder **228** of receiving device **104** to reconstruct the third picture based on the error-corrected encoded video data for the third picture.

[0290] FIG. **25** is a conceptual diagram illustrating an example hierarchy of encoded video data according to techniques of this disclosure. More specifically, FIG. **25** illustrates a hierarchy of encoded video data generated using the H.264/AVC video coding standard. As shown in the example of FIG. **25**, a network abstraction layer (NAL) is the highest level of the hierarchy. At the network abstraction layer, data is organized into NAL units. In some examples, NAL units are assigned to different packets or coding blocks for transmission. The NAL units of the network abstraction layer may include sequence parameter sets (SPSs) and picture parameter sets (PPSs) that contain high-level syntax. The NAL units of the network abstraction layer may also include video coding layer (VCL) NAL units. The VCL NAL units may include slice NAL units that contain slice level data. A slice may be a series of macroblocks within a picture. The slices may include instantaneous decoder refresh (IDR) slices and regular slices. Decoding of a IDR slice does not depend on any other slice. Regular slices may have dependencies to other slices.

[0291] Each slice NAL unit may include a slice header and slice data. The slice header of a slice NAL unit includes information for decoding the slice data of the slice NAL unit. The slice data of a slice NAL unit includes a series of macroblocks (MBs). Skip indications may be interspersed among the MBs. Each of the MBs contains encoded video data for a specific block of a slice. Furthermore, as shown FIG. **25**, a MB may include a type indicator, a prediction information, a coded block pattern, a quantization parameter (QP) and encoded residual data. If the MB is encoded using intra prediction, the prediction data may indicate one or more intra modes used to encode the MB. If the MB is encoded using inter prediction, the prediction data may indicate one or more reference pictures and one or more motion vectors. The encoded residual data for a MB may include encoded residual data for luma blocks within the MB, encoded residual data for Cb blocks within the MB, and encoded residual data for Cr blocks within the MB. In general, the encoded residual data is the most voluminous part of the encoded video data.

[0292] In accordance with the techniques of this disclosure, everything in the hierarchy at the macroblock layer except the encoded residual data may be encoding selection data. Thus, in some examples, receiving device **104** may the type data, the prediction data, the coded block pattern, and the QP to transmitting device **102** for each MB of an estimated picture. Furthermore, in some examples, transmitting device **102** may transmit only encoded residual data of a MB to receiving device **104** and does not transmit the type data, the prediction data, the coded block pattern, or the QP of the MB. In some examples, the encoding selection data transmitted by receiving device **104** may include slice header data, SPS data, and PPS data. Transmitting device **102** and receiving device **104** may exchange information or may be preconfigured with information indicating encoder and decoder capabilities.

[0293] In some examples, transmitting device **102** may send data in addition to encoded residual data for some pictures, some MBs, or some slices. Transmitting device **102** may signal information (e.g., a bit) at the network abstraction layer (e.g., as a picture level control field) that may indicate if DVC-based approach is used or if a regular compression may should be used for a specific picture.

[0294] FIG. **26** is a block diagram illustrating alternative example components of transmitting device **102** according to one or more techniques of this disclosure. In the example of FIG. **26**, transmitting device **102** performs digital encoding and analog encoding on video data. Transmitting device **102** transmits digitally encoded video data and analog encoded video data to receiving device **104** via channel **230**.

[0295] In the example of FIG. **26**, includes a video encoder **2600**, a residual generation unit **2602**, an analog encoder **2604**, a reliability sorting unit **2606**, an interleaving unit **2608**, a channel encoder **2610**, and a puncturing unit **2612**. Video encoder **2600** may obtain video data and operate in much the same way as video encoder **210** of FIG. **2**. As shown in the example of FIG. **26**A, video encoder **2600** may receive values of encoding parameters (e.g., encoding selection parameters) sent by receiving device **104**. In some examples, video encoder **2600** may send values of encoding parameters and/or encoding selection data to receiving device **104**. In this way, video encoder

2600 of transmitting device **102**, a video encoder of receiving device **104**, and video decoder of receiving device **104** may operate based on the same values of the encoding parameters.

[0296] Video encoder **2600** may also output the prediction data to residual generation unit **2602**. Additionally, video encoder **2600** may apply a higher level of quantization than video encoder **210**. Residual generation unit **2602** may generate residual data based on the prediction data and the video data.

[0297] Analog encoder **2604** may perform an analog encoding operation on the residual data. Example details of the analog encoding operation may be found in U.S. Pat. No. 11,553,184, filed Dec. 29, 2020, entitled "Hybrid Digital-Analog Modulation for Transmission of Video Data"; U.S. Pat. No. 11,431,962, filed Dec. 29, 2020, entitled "Analog Modulated Video Transmission with Variable Symbol Rate"; and U.S. Pat. No. 11,457,224, filed Dec. 29, 2020, entitled "Interlaced Coefficients in Hybrid Digital-Analog Modulation for Transmission of Video Data."

[0298] For instance, in some examples, analog encoder **2604** may generate coefficients based on the residual data. For example, analog encoder **2604** may binarize the residual data to generate coefficients. Analog encoder **2604** may quantize the coefficients. In other examples of generating coefficients based on video data, analog encoder **2604** may perform more, fewer, or different steps. For instance, in some examples, analog encoder **2604** does not perform a quantization step. In still other examples, analog encoder **2604** does not perform a step of binarizing the residual data.

[0299] Furthermore, analog encoder **2604** may generate coefficient vectors. Each of the coefficient vectors includes n of the coefficients. Analog encoder **2604** may generate the coefficient vectors in one of a variety of ways. For instance, in one example, analog encoder **2604** may generate a coefficient vector as a group of n consecutive coefficients according to a coefficient coding order. Various coefficient coding orders may be used, such as raster scan order, zigzag scan order, reverse raster scan order, vertical scan order, and so on. In some examples, a coefficient vector may include one or more negative coefficients and one or more positive coefficients (i.e., signed coefficients). In some examples, a coefficient vector only includes non-negative coefficients (i.e., unsigned coefficients).

[0300] For each of the coefficient vectors, analog encoder **2604** may determine an amplitude value for the coefficient vector based on a mapping pattern. For each respective allowed coefficient vector in a plurality of allowed coefficient vectors, the mapping pattern maps the respective allowed coefficient vector to a respective amplitude value in a plurality of amplitude values. The respective amplitude value is adjacent in an n-dimensional space to at least one other amplitude value in the plurality of amplitude values that is adjacent to the respective amplitude value in a monotonic number line of the amplitude values.

[0301] In some examples, to determine the amplitude value for the coefficient vector, analog encoder **2604** may determine a position in the n-dimensional space. Coordinates of the position in the n-dimensional space are based on the coefficients of the coefficient vector, and the mapping pattern maps different positions in the n-dimensional space to different amplitude values in the plurality of amplitude values. Analog encoder **2604** may determine the amplitude value for the coefficient vector as the amplitude value corresponding to the determined position in the n-dimensional space.

[0302] Analog encoder **2604** may modulate an analog signal based on the amplitude values for the coefficient vectors. For instance, analog encoder **2604** may determine an analog symbol based on a pair of the amplitude values. The analog symbol may correspond to a phase shift and a power of a point in an I-Q plane that having coordinates indicated by the amplitude value pair. Analog encoder **2604** may modulate the analog signal during a symbol sampling instant based on the determined phase shift and power. A modem (e.g., communication interface **118**) of transmitting device **102** may be configured to output the analog signal.

[0303] Furthermore, in the example of FIG. **26**A, reliability sorting unit **2606** may obtain the encoded video data generated by video encoder **2600**. Reliability sorting unit **2606** may obtain reliability side information from video encoder **2600**. In some examples, reliability sorting unit **2606** may receive values of channel and compression state feedback (CCSF) parameters. The values of the CCSF parameters may provide information about the conditions of channel **230** (e.g., signal-to-noise ratio, latency time, network bandwidth congestion, etc.). In some examples, the values of the CCSF parameters provide information related to the prediction reliability and quality. For example, the values of the CCSF parameters may include a decimation pattern indicator. In some examples, the values of the CCSF parameters may enable channel encoder **2610** to determine a decimation pattern.

[0304] Interleaving unit **2608** may perform an interleaving process that may ensure that reliable and unreliable bits are equally spread across code blocks. For example, encoded video data may be divided into code blocks. Channel encoder **2610** may generate separate sets of error correction data for each of the code blocks. Prior to channel encoder **2610** generating the error correction data, interleaving unit **2608** may interleave encoded video data among the code blocks according to a predefined interleaving pattern. For instance, encoded video data representing different adjacent pixels may be interleaved into different code blocks. A de-interleaving process performed at receiving device **104** reverses the interleaving process after application of the channel decoding process. Thus, if one of the code blocks is corrupted during transmission, the pixels decoded from the corrupted code block may be spatially dispersed within a picture among pixels decoded from uncorrupted code blocks.

[0305] Channel encoder **2610** of transmitting device **102** may perform a channel encoding process on the video data obtained from interleaving unit **2608**. Channel encoder **2610** may perform channel encoding process in accordance with any of the examples provided with respect to channel encoder **212** (FIG. **2**). Puncturing unit **2612** may perform a bit puncturing operation on error correction data generated by channel encoder **2610**. Puncturing unit **2612** may perform the bit puncturing operation on the error correction data in accordance with any of the examples provided with respect to puncturing unit **214** (FIG. **2**). Transmitting device **102** may transmit encoded video data and error correction data (e.g., bit-punctured error correction data) to receiving device **104** via channel **230**.

[0306] FIG. **27** is a block diagram illustrating example alternative components of receiving device **104** according to

one or more techniques of this disclosure. The version of receiving device **104** shown in FIG. **27** may be compatible with the version of transmitting device **102** shown in FIG. **26**. In the example of FIG. **27**, receiving device **104** includes an analog decoder **2700**, a de-puncturing unit **2702**, a channel decoder **2704**, a de-interleaving unit **2706**, a video decoder **2708**, a reconstruction unit **2710**, a picture estimation unit **2712**, a video encoder **2714**, a reliability unit **2716**, and a feedback unit **2718**.

[0307] Analog decoder **2700** may obtain analog encoded video data. Analog decoder **2700** may perform an analog decoding operation to reconstruct residual data. Example details of the analog decoding operation may be found in U.S. Pat. Nos. 11,553,184, 11,431,962, and 11,457,224.

[0308] For instance, in some examples, analog decoder **2700** may determine, based on an analog signal, amplitude values for a plurality of coefficient vectors. For instance, analog decoder **2700** may determine a phase shift and a power for a symbol sampling instant of the analog signal. Analog decoder **2700** may determine a point in an I-Q plane indicated by the determined phase shift and power. Analog decoder **2700** may then determine an amplitude value pair as the coordinates in the point in the I-Q plane.

[0309] For each of the coefficient vectors, analog decoder **2700** may determine coefficients in the coefficient vector based on the amplitude value for the coefficient vector and a mapping pattern. For each respective allowed coefficient vector in a plurality of allowed coefficient vectors, the mapping pattern may map the respective allowed coefficient vector to a respective amplitude value in a plurality of amplitude values. The respective amplitude value is adjacent in an n-dimensional space to at least one other amplitude value in the plurality of amplitude values that is adjacent to the respective amplitude value in a monotonic number line of the amplitude values. Each of the coefficient vectors may include n of the coefficients. The value n may be greater than or equal to 2. In some examples, analog decoder **2700** may determine the coefficients in the coefficient vector as coordinates of a position in the n-dimensional space that corresponds to the amplitude value. The mapping pattern maps different positions in the n-dimensional space to different amplitude values in the plurality of amplitude values. In some examples, the coefficient vector includes one or more negative coefficients and one or more positive coefficients. In other examples, the coefficient vector may include only non-negative coefficients.

[0310] In some examples, as part of determining the coefficients, analog decoder **2700** may obtain sign values, where the sign values indicate positive/negative signs of the coefficients in the coefficient vector. In such examples, analog decoder **2700** may determine, based on the amplitude value for the coefficient vector and the mapping pattern, absolute values of the coefficients in the coefficient vector. Analog decoder **2700** may reconstruct the coefficients in the coefficient vector at least in part by applying the sign values to the absolute values of the coefficients in the coefficient vector. In some examples, as part of determining the coefficients, analog decoder **2700** may obtain data representing a shift value. In such examples, the shift value indicates a most-negative coefficient of the coefficients in the coefficient vector. Additionally, in such examples, analog decoder **2700** may determine, based on the amplitude value for the coefficient vector and the mapping pattern, intermediate values of the coefficients in the coefficient vector. Analog decoder **2700** may reconstruct the coefficients in the coefficient vector at least in part by adding the shift value to each of the intermediate values of the coefficients in the coefficient vector.

[0311] Furthermore, analog decoder **2700** may generate residual data based on the coefficients in the coefficient vectors. For instance, in one example, analog decoder **2700** may dequantize the coefficients of the coefficient vectors. In this example, analog decoder **2700** may perform a de-binarization process to convert the coefficients into digital sample values. For instance, analog decoder **2700** may apply an inverse DCT to the coefficients to convert the coefficients into digital sample values. In this way, analog decoder **2700** may generate digital residual sample values.

[0312] De-puncturing unit **2702** may obtain encoded video data and bit-punctured error correction data. De-puncturing unit **2702** may apply a de-puncturing process to the bit-punctured error correction data to reconstruct the error correction data. De-puncturing unit **2702** may apply the de-puncturing process in accordance with any of the examples provided elsewhere in this disclosure with respect to de-puncturing unit **220** of FIG. **2**.

[0313] Channel decoder **2704** may perform a channel decoding process that modifies encoded video data (e.g., encoded video data received via channel **230** or encoded video data generated by video encoder **2714** and, in some examples, modified by reliability unit **714**) based on the error correction data. Channel decoder **2704** may perform the channel decoding process in accordance with any of the examples provided elsewhere in this disclosure with respect to channel decoder **222** of FIG. **2**.

[0314] De-interleaving unit **2706** may perform a de-interleaving operation on the error-corrected encoded video data generated by channel decoder **2704**. For example, the de-interleaving process may reverse the interleaving process performed by interleaving unit **2608** of transmitting device **102**. For instance, the de-interleaving process may perform the de-interleaving process according to an interleaving pattern used by interleaving unit **2608**.

[0315] Video decoder **2708** may obtain encoded video data (e.g., de-interleaved encoded video data generated by de-interleaving unit **2706**). Video decoder **2708** may perform a video decoding process on the encoded video data to reconstruct pictures of the video data. The video decoding process performed by video decoder **2708** may be the same as that described in any of the examples provided elsewhere in this disclosure with respect to video decoder **224**. Reconstruction unit **2710** of receiving device **104** may add residual data generated by analog decoder **2700** to corresponding samples of the reconstructed video data generated by video decoder **2708**, thereby fully reconstructing pictures of the video data.

[0316] Furthermore, in the example of FIG. **27**, picture estimation unit **2712** may estimate one or more pictures based on previously reconstructed pictures. As previously mentioned in this disclosure, discussion of pictures may apply with respect to segments of pictures, such as slices. Picture estimation unit **2712** may estimate the pictures in accordance with any of the examples provided elsewhere in this disclosure with respect to picture estimation unit **226**. Video encoder **2714** may perform a video encoding process on the estimated pictures. As part of performing the video encoding process, video encoder **2714** may determine encoding selection data, such as encoding selection data

2100, as previously discussed. Receiving device **104** may transmit the encoding selection data to transmitting device **102**. In some examples, video encoder **2714** may send encoding parameters, such as those discussed with respect to FIG. **4** and FIG. **5**, to transmitting device **102** that video encoder **2600** of transmitting device **102** may perform a limited encoding process in the same way as video encoder **2714** of receiving device **104**. In some examples, video encoder **2714** may determine and send multiview encoding cues to transmitting device **102**.

[0317] Reliability unit **2716** may operate in much the same way as reliability unit **1002** (FIG. **10**). Feedback unit **2718** may send prediction quality feedback (e.g., CCSF parameters) based on the output of reliability unit **1002** to transmitting device **102**.

[0318] In some examples of this disclosure, video encoder **2600** of transmitting device **102** generate prediction data for a set of pictures and residual generation unit **2602** may generate residual data based on the first prediction data and the first set of pictures. Video encoder **2600** may apply transform the prediction data to generate transform blocks, quantize transform coefficients of the transform blocks, and apply entropy encoding to syntax elements representing the quantized transform coefficients to generate entropy encoded syntax elements. The first encoded video data may include the entropy encoded syntax elements. Channel encoder **2610** may perform a channel encoding process that generates error correction data for encoded video data, including the entropy encoded syntax elements. Analog encoder **2604** may perform analog modulation on the residual data to generate analog modulated residual data. A communication interface of transmitting device **102** may transmit the analog modulated residual data, the error correction data, and the encoded video data.

[0319] a communication interface of receiving device **104** may receive analog modulated residual data and receive, from the transmitting device, error correction data and decimated video data. The decimated video data may include encoded video data to which a decimation pattern has been applied. The encoded video data is generated based on a set of pictures of the video data. Channel decoder **2704** may apply an error correction process to generate error-corrected encoded video data based on the encoded video data and the error correction data. The error-corrected encoded video data includes entropy-encoded syntax elements representing quantized transform coefficients. Video decoder **2708** may perform the decoding process to reconstruct the second set of pictures based on the error-corrected encoded video data. As part of applying the decoding process to reconstruct the set of pictures, video decoder **2708** may apply entropy decoding to the syntax elements to obtain the quantized transform coefficients, inverse quantize the quantized transform coefficients to generate inverse quantized transform coefficients, and apply an inverse transform to the inverse quantized transform coefficients to generate prediction data. Analog decoder **2700** may demodulate the analog modulated residual data to obtain residual data. Reconstruction unit **2710** may reconstruct the set of pictures based on the prediction data and the residual data.

[0320] The following is a non-limiting list of clauses that are in accordance with one or more techniques of this disclosure.

[0321] Clause 1A. A method of decoding video data, the method comprising: obtaining, at a receiving device and from a transmitting device, error correction data, wherein the error correction data provides error correction information and is generated based on encoded video data of one or more blocks of a picture of the video data; generating, at the receiving device, prediction data for the picture using one or more coding tools not used for generating the encoded video data of the one or more blocks, wherein the prediction data for the picture comprises predictions of the blocks of the picture based at least in part on blocks of one or more previously reconstructed pictures of the video data; generating, at the receiving device, encoded video data based on the prediction data for the picture; generating, at the receiving device, error-corrected encoded video data using the error correction data to perform an error correction operation on the encoded video data; and performing, at the receiving device, a reconstruction operation that reconstructs the blocks of the picture based on the error-corrected encoded video data, wherein the reconstruction operation is controlled by values of one or more parameters.

[0322] Clause 2A. The method of clause 1A, further comprising receiving, at the receiving device and from the transmitting device, the values of the parameters.

[0323] Clause 3A. The method of clause 1A, further comprising determining, at the receiving device, the values of the parameters without receiving the values of the parameters from the transmitting device.

[0324] Clause 4A. The method of any of clauses 1A-3A, wherein: the parameters include one or more quantization parameters, generating the encoded video data comprises using the quantization parameters to quantize transform coefficients generated based on the prediction data for the picture, and performing the reconstruction operation comprises using the quantization parameters to inverse quantize transform coefficients of the error-corrected encoded video data.

[0325] Clause 5A. The method of clause 4A, wherein the method further comprises: calculating the quantization parameters based on an entropy ratio of quantized transform coefficients and unquantized transform coefficients.

[0326] Clause 6A. The method of any of clauses 1A-5A, wherein: the parameters include a transform size parameter, generating the encoded video data comprises applying, to sample domain data for the picture, a forward transform having a transform size indicated by the transform size parameter, and performing the reconstruction operation comprises applying, to transform coefficients of the error-corrected encoded video data, an inverse transform having the transform size indicated by the transform size parameter.

[0327] Clause 7A. The method of any of clauses 1A-6A, wherein: the parameters include a parameter that indicates a quantity of transform coefficients; generating the encoded video data comprises including in the encoded video data, a set of transform coefficients that includes the indicated quantity of transform coefficients, and performing the reconstruction operation

comprises parsing, from the error-corrected encoded video data, a set of transform coefficients that includes the indicated quantity of transform coefficients.

[0328] Clause 8A. The method of clause 7A, wherein: obtaining the encoded video data and the error correction data comprises receiving, at the receiving device, the encoded video data and the error correction data from the transmitting device via a communication channel, and the method further comprises applying an optimization process that determines a number of transform coefficients based on a signal-to-noise ratio of data transmitted on the communication channel.

[0329] Clause 9A. The method of any of clauses 1A-8A, wherein: the parameters include bit-width parameters for a plurality of index values, and for each respective index value of the plurality of index values: performing the reconstruction operation comprises parsing a first set of bits from the error-corrected encoded video data, wherein the first set of bits indicates a transform coefficient having the respective index value and a quantity of bits in the first set of bits is equal to a bit-width indicated by the bit-width parameter for the respective index value, generating the encoded video data comprises including a second set of bits in the encoded video data, wherein the second set of bits indicates a transform coefficient having the respective index value and the quantity of bits in the second set of bits is equal to the bit-width indicated by the bit-width parameter for the respective index value, and parsing a third set of bits from the error-corrected encoded video data, wherein the third set of bits indicates a transform coefficient having the respective index value and a quantity of bits in the third set of bits is equal to the bit-width indicated by the bit-width parameter for the respective index value.

[0330] Clause 10A. The method of any of clauses 1A-9A, wherein the method further comprises prior to generating the error-corrected encoded video data, performing the bit depuncturing operation on the error correction data.

[0331] Clause 11A. The method of any of clauses 1A-10A, wherein the parameters include one or more of: a color space, a transform size, quantization parameters, a number of transform coefficients in the first encoded video data, or a number of bits per transform coefficient in the first encoded video data.

[0332] Clause 12A. The method of any of clauses 1A-11A, wherein: a decimation pattern defines a pattern of anchor transform blocks and non-anchor transform blocks in the picture, the method further comprises receiving, at the receiving device, systemic bits of the anchor transform blocks and not systemic bits of the non-anchor transform blocks, the systemic bits of the anchor transform blocks represent transform coefficients in the anchor transform blocks, the systemic bits of the non-anchor transform blocks represent reduced bit depth versions of original transform coefficients in the non-anchor transform blocks; the error correction data includes error correction data for the anchor transform blocks and error correction data for the non-anchor transform blocks, wherein the error correction data for the non-anchor transform blocks are based on the original transform coefficients in the non-anchor transform blocks, generating the error-corrected encoded video data comprises: using the error correction data for the anchor transform blocks to perform error correction on the systemic bits of the anchor transform blocks; and using the error correction data for the non-anchor transform blocks to perform error correction on portions of the encoded video data corresponding to the non-anchor transform blocks.

[0333] Clause 13A. The method of clause 12A, further comprising: determining, at the receiving device, the decimation pattern; and sending, at the receiving device, the decimation pattern to the transmitting device.

[0334] Clause 14A. The method of any of clauses 1A-13A, wherein: a decimation pattern defines a pattern of anchor transform blocks and non-anchor transform blocks in the picture, transform coefficients in the non-anchor transform blocks have reduced bit depths relative to the anchor transform blocks, receiving, at the receiving device, systemic bits of the anchor transform blocks, systemic bits of the non-anchor transform blocks, and a correlation matrix, the systemic bits of the anchor transform blocks represent transform coefficients in the anchor transform blocks, the systemic bits of the non-anchor transform blocks represent reduced bit depth versions of original transform coefficients in the non-anchor transform blocks; performing the reconstruction operation comprises, for each non-anchor transform coefficient in the non-anchor transform blocks: calculating, at the receiving device, an interpolated value of the non-anchor transform coefficient based on the correlation matrix and a corresponding anchor transform coefficient; and calculating, at the receiving device, a reconstructed value of the non-anchor transform coefficient based on the interpolated value of the non-anchor transform coefficient and a value of the non-anchor transform coefficient in the error-corrected encoded video data.

[0335] Clause 15A. A method of encoding video data, the method comprising: obtaining, at a transmitting device, video data from a video source; generating, at the transmitting device, based on a set of parameters, encoded video data of a first picture of the video data and encoded video data of a second picture of the video data; performing, at the transmitting device, channel encoding on the encoded video data of the first picture and the encoded video data of the second picture to generate error correction data for the first picture and error correction data for the second picture; and transmitting, at the transmitting device, the encoded video data of the first picture, error correction data for the first picture, and error correction data for the second picture.

[0336] Clause 16A. The method of clause 15A, further comprising transmitting, at the transmitting device and to a receiving device, values of the parameters.

[0337] Clause 17A. The method of clause 16A, wherein: the parameters include one or more quantization parameters, and generating the encoded video data comprises using the quantization parameters to quantize transform coefficients of the first picture and transform coefficients of the second picture.

[0338] Clause 18A. The method of any of clauses 16A-17A, wherein: the parameters include a transform size parameter, and generating the encoded video data comprises applying a forward transform to blocks of

residual data of the first picture and block of residual data of the second picture, wherein the forward transform has a transform size indicated by the transform size parameter.

[0339] Clause 19A. The method of any of clauses 16A-18A, wherein: the parameters include a parameter that indicates a quantity of transform coefficients, and generating the encoded video data of the first picture and the encoded video data of the second picture comprises including in the encoded video data of the first picture and the encoded video data of the second picture comprises, sets of transform coefficients that includes the indicated quantity of transform coefficients.

[0340] Clause 20A. The method of any of clauses 16A-10A, wherein the parameters include one or more of: a color space, a transform size, quantization parameters, a number of transform coefficients in the encoded video data, or a number of bits per transform coefficient in the encoded video data.

[0341] Clause 21A. A method of encoding video data, the method comprising: obtaining, at a transmitting device, video data from a video source; generating, at the transmitting device, transform blocks based on the video data; determining, at the transmitting device, which of the transform blocks are anchor transform blocks; calculating, at the transmitting device, a correlation matrix for a transform block set; generating, at the transmitting device, bit-reduced non-anchor transform matrixes; and transmitting, at the transmitting device, the anchor transform blocks, the non-anchor transform blocks, and the correlation matrix to a receiving device.

[0342] Clause 22A. The method of clause 21A, further comprising receiving, at the transmitting device, an indication of a decimation pattern from the receiving device.

[0343] Clause 23A. A device comprising: a memory configured to store video data; a communication interface; and one or more processing implemented in circuitry and coupled to the memory, the one or more processors configured to perform the methods of any of clauses 1A-22A.

[0344] Clause 24A. A device comprising means for performing the methods of any of clauses 1A-22A.

[0345] Clause 25A. A computer-readable data storage medium having instructions stored thereon that, when executed, cause a device to perform the methods of any of clauses 1A-22A.

[0346] Clause 1B. A device for processing video data, the device comprising: a memory configured to store video data; and a communication interface configured to obtain error correction data from a transmitting device, wherein the error correction data provides error correction information regarding a picture of the video data; one or more processing implemented in circuitry and coupled to the memory, the one or more processors configured to: generate prediction data for the picture, wherein the prediction data for the picture comprises predictions of blocks of the picture based at least in part on one or more previously reconstructed pictures of the video data; generate encoded video data based on the prediction data for the picture, wherein the encoded video data includes transform blocks that comprises transform coefficients; scale bits of the transform coefficients of the transform blocks based on reliability values for bit positions; generate error-corrected encoded video data using the error correction data to perform an error correction operation on the scaled bits of the transform coefficients of the transform blocks; and reconstruct the picture based on the error-corrected encoded video data.

[0347] Clause 2B. The device of clause 1B, wherein the one or more processors are further configured to generate the reliability values at the receiving device.

[0348] Clause 3B. The device of clause 2B, wherein the one or more processors are configured to generate the reliability values based on statistics regarding occurrence of errors in the bit positions.

[0349] Clause 4B. The device of any of clauses 2B or 3B, wherein the one or more processors are configured to generate the reliability values based on reliability characteristics for individual regions of pictures of the video data.

[0350] Clause 5B. The device of any of clauses 2B-4B, wherein the one or more processors are configured to generate the reliability values based on a noise model.

[0351] Clause 6B. The device of any of clauses 1B-5B, wherein the communication interface is further configured to send the reliability values to the transmitting device.

[0352] Clause 7B. The device of any of clause 1B-5B, wherein the communication interface is further configured to receive the reliability values from the transmitting device.

[0353] Clause 8B. A device for processing video data, the method comprising: a memory configured to store video data; and one or more processing implemented in circuitry and coupled to the memory, the one or more processors configured to: obtain video data; obtain prediction quality feedback, wherein the prediction quality feedback is based on reliability of estimated pictures generated by a receiving device; adapt one or more of video encoding parameters or channel encoding parameters based on the prediction quality feedback; perform a video encoding process to generate encoded video data based on one or more pictures of the obtained video data, wherein the video encoding process is controlled by the video encoding parameters; perform a channel encoding process on the encoded video data to generate channel encoded data, wherein the channel encoding process is controlled by the channel encoding parameters; and a communication interface configured to transmit the channel encoded data to the receiving device.

[0354] Clause 9B. The device of clause 8B, wherein: the video encoding parameters include a quantization parameter, the one or more processors are configured to, as part of adapting the video encoding parameters, adapt the quantization parameter, and the one or more processors are configured to, as part of performing the video encoding process, use the quantization parameter to quantize transform coefficients of transform blocks of the one or more pictures.

[0355] Clause 10B. The device of any of clauses 8B-9B, wherein: the channel encoding parameters include a low density parity check (LDPC) graph, the one or more processors are configured to, as part of adapting

the channel encoding parameters, adapt the LPDC graph, and the one or more processors are configured to, as part of performing the channel encoding process, use the LDPC graph to generate codewords included in the channel encoded data.

[0356] Clause 11B. The device of any of clauses 8B-10B, wherein: the channel encoded data includes error correction data, one or more processors are further configured to adapt one or more bit puncturing parameters based on the prediction quality feedback, and the one or more processors are configured to perform a bit puncturing process on the error correction data, wherein the bit puncturing process is controlled by the one or more bit puncturing parameters.

[0357] Clause 11B. A method of processing video data, the method comprising: obtaining error correction data at a receiving device and from a transmitting device, wherein the error correction data provides error correction information regarding a picture of the video data; generating, at the receiving device, prediction data for the picture, wherein the prediction data for the picture comprises predictions of blocks of the picture based at least in part on one or more previously reconstructed pictures of the video data; generating, at the receiving device, encoded video data based on the prediction data for the picture, wherein the encoded video data includes transform blocks that comprises transform coefficients; scaling, at the receiving device, bits of the transform coefficients of the transform blocks based on reliability values for bit positions; generating, at the receiving device, error-corrected encoded video data using the error correction data to perform an error correction operation on the scaled bits of the transform coefficients of the transform blocks; and reconstructing, at the receiving device, the picture based on the error-corrected encoded video data.

[0358] Clause 12B. The method of clause 11B, further comprising generating the reliability values at the receiving device.

[0359] Clause 13B. The method of clause 12B, wherein generating the reliability values comprises generating, at the receiving device, the reliability values based on statistics regarding occurrence of errors in the bit positions.

[0360] Clause 14B. The method of any of clauses 12B or 13B, wherein generating the reliability values comprises generating, at the receiving device, the reliability values based on reliability characteristics for individual regions of pictures of the video data.

[0361] Clause 15B. The method of any of clauses 12B-14B, wherein generating the reliability values comprises generating, at the receiving device, the reliability values based on a noise model.

[0362] Clause 16B. The method of any of clauses 11B-15B, further comprising sending, at the receiving device, the reliability values to the transmitting device.

[0363] Clause 17B. The method of any of clause 11B-15B, further comprising receiving, at the receiving device, the reliability values from the transmitting device.

[0364] Clause 18B. A method of processing video data, the method comprising: obtaining video data; obtaining prediction quality feedback, wherein the prediction quality feedback is based on reliability of estimated pictures generated by a receiving device; adapting one or more of video encoding parameters or channel encoding parameters based on the prediction quality feedback; performing a video encoding process to generate encoded video data based on one or more pictures of the obtained video data, wherein the video encoding process is controlled by the video encoding parameters; performing a channel encoding process on the encoded video data to generate channel encoded data, wherein the channel encoding process is controlled by the channel encoding parameters; and transmitting the channel encoded data to the receiving device.

[0365] Clause 19B. The method of clause 18B, wherein: the video encoding parameters include a quantization parameter, adapting the video encoding parameters comprises adapting the quantization parameter, and performing the video encoding process comprises using the quantization parameter to quantize transform coefficients of transform blocks of the one or more pictures.

[0366] Clause 20B. The method of any of clauses 18B-19B, wherein: the channel encoding parameters include a low density parity check (LDPC) graph, adapting the channel encoding parameters comprises adapting the LPDC graph, and performing the channel encoding process comprises using the LDPC graph to generate codewords included in the channel encoded data.

[0367] Clause 21B. The method of any of clauses 18B-20B, wherein: the channel encoded data includes error correction data, and the method further comprises: adapting one or more bit puncturing parameters based on the prediction quality feedback, and performing a bit puncturing process on the error correction data, wherein the bit puncturing process is controlled by the one or more bit puncturing parameters.

[0368] Clause 22B. A device comprising means for performing the methods of any of clauses 11B-21B.

[0369] Clause 23B. A computer-readable data storage medium having instructions stored thereon that, when executed, cause a device to perform the methods of any of clauses 11B-21B.

[0370] Clause 1C. A device comprising: a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: obtain a first set of multiview pictures of the video data, wherein the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; transmit first encoded video data to a receiving device, wherein the first encoded video data is based on the first set of multiview pictures; receive multiview encoding cues from the receiving device; obtain a second set of multiview pictures of the video data, wherein the second set of multiview pictures includes third pictures and fourth pictures, the third pictures being from the first viewpoint and the fourth pictures being from the second viewpoint; perform, based on the multiview encoding cues received from the receiving device, a multiview encoding process on the second set of multiview pictures to generate second encoded video data, wherein the multiview

encoding process reduces inter-view redundancy between the third pictures and the fourth pictures; and transmit the second encoded video data to the receiving device.

[0371] Clause 2C. The device of clause 1, wherein the one or more processors are further configured to: after transmitting the second encoded video data to the receiving device, receive updated multiview encoding cues from the receiving device; obtain a third set of multiview pictures of the video data, wherein the third set of multiview pictures includes fifth pictures and sixth pictures, the fifth pictures being from the first viewpoint and the sixth pictures being from the second viewpoint; encode the third set of multiview pictures based on the updated multiview encoding cues received from the receiving device to generate third encoded video data; and transmit the third encoded video data to the receiving device.

[0372] Clause 3C. The device of any of clauses 1C-2C, wherein the multiview encoding cues include one or more of: a relative shift between blocks of the first pictures and the second pictures, a brightness correction between the first pictures and the second pictures, an inter block shift between an anchor block and a reconstructed block, or motion data for reference shift.

[0373] Clause 4C. The device of any of clauses 1C-3C, wherein: the device is an extended reality (XR) headset, the one or more processors are configured to: receive virtual element data from the receiving device generated based on the first and second sets of multiview pictures; and output the virtual element data for display in a XR scene.

[0374] Clause 5C. A device comprising: a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: obtain first encoded video data from a transmitting device, wherein the first encoded video data is based on a first set of multiview pictures of the video data, the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; determine multiview encoding cues based on the first encoded video data; transmit the multiview encoding cues to the transmitting device; and obtain second encoded video data from the transmitting device, wherein the second encoded video data is based on a second set of multiview pictures that includes third pictures and fourth pictures, the second encoded video data being encoded using a multiview encoding process that reduces inter-view redundancy between the third pictures and the fourth pictures based on the multiview encoding cues.

[0375] Clause 6C. The device of clause 5C, wherein the one or more processors are further configured to decode the second encoded video data.

[0376] Clause 7C. The device of any of clauses 5C-6C, wherein the multiview encoding cues are first multiview encoding cues and the one or more processors are further configured to: determine second multiview encoding cues based on the second encoded video data; transmit the second multiview encoding cues to the transmitting device; obtain third encoded video data from the transmitting device, wherein the third encoded video data is based on a third set of multiview pictures that includes fifth pictures and sixth pictures, the third encoded video data being encoded using the multiview encoding process that reduces inter-view redundancy between the fifth pictures and the sixth pictures based on the second multiview encoding cues.

[0377] Clause 8C. The device of any of clauses 5C-7C, wherein: the multiview encoding cues include a depth map indicating depths of objects represented in the first and second pictures, and the one or more processors are configured to, as part of determining the multiview encoding cues, determine the depth map based on the first and second pictures.

[0378] Clause 9C. The device of clauses 5C-8C, wherein the multiview encoding cues includes one or more illumination compensation factors, and the one or more processors are configured to, as part of determining the multiview encoding cues, determine the illumination compensation factors based on the first and second pictures.

[0379] Clause 10C. The device of any of clauses 5C-9C, wherein: the transmitting device is an extended reality (XR) headset, and the one or more processors are further configured to: process the second set of pictures to generate virtual element data; and transmit the virtual element data to the XR headset.

[0380] Clause 11C. A method of processing video data, the method comprising: obtaining a first set of multiview pictures of the video data, wherein the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; transmitting first encoded video data to a receiving device, wherein the first encoded video data is based on the first set of multiview pictures; receiving multiview encoding cues from the receiving device; obtaining a second set of multiview pictures of the video data, wherein the second set of multiview pictures includes third pictures and fourth pictures, the third pictures being from the first viewpoint and the fourth pictures being from the second viewpoint; performing, based on the multiview encoding cues received from the receiving device, a multiview encoding process on the second set of multiview pictures to generate second encoded video data, wherein the multiview encoding process reduces inter-view redundancy between the third pictures and the fourth pictures; and transmitting the second encoded video data to the receiving device.

[0381] Clause 12C. The method of clause 11C, further comprising: after transmitting the second encoded video data to the receiving device, receiving updated multiview encoding cues from the receiving device; obtaining a third set of multiview pictures of the video data, wherein the third set of multiview pictures includes fifth pictures and sixth pictures, the fifth pictures being from the first viewpoint and the sixth pictures being from the second viewpoint; encoding the third set of multiview pictures based on the updated multiview encoding cues received from the receiving device to generate third encoded video data; and transmitting the third encoded video data to the receiving device.

[0382] Clause 13C. The method of any of clauses 11C-12C, wherein the multiview encoding cues include

one or more of: a relative shift between blocks of the first pictures and the second pictures, a brightness correction between the first pictures and the second pictures, an inter block shift between an anchor block and a reconstructed block, or motion data for reference shift.

[0383] Clause 14C. The method of any of clauses 11C-13C, wherein the method further comprises: receiving virtual element data from the receiving device generated based on the first and second sets of multiview pictures; and outputting the virtual element data for display in an extended reality (XR) scene.

[0384] Clause 15C. A method of processing video data, the method comprising: obtaining first encoded video data from a transmitting device, wherein the first encoded video data is based on a first set of multiview pictures of the video data, the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; determining multiview encoding cues based on the first encoded video data; transmitting the multiview encoding cues to the transmitting device; obtaining second encoded video data from the transmitting device, wherein the second encoded video data is based on a second set of multiview pictures that includes third pictures and fourth pictures, the second encoded video data being encoded using a multiview encoding process that reduces inter-view redundancy between the third pictures and the fourth pictures based on the multiview encoding cues.

[0385] Clause 16C. The method of clause 15C, further comprising decoding the second encoded video data.

[0386] Clause 17C. The method of any of clauses 15C-16C, wherein the multiview encoding cues are first multiview encoding cues and the method further comprises: determining second multiview encoding cues based on the second encoded video data; transmitting the second multiview encoding cues to the transmitting device; obtaining third encoded video data from the transmitting device, wherein the third encoded video data is based on a third set of multiview pictures that includes fifth pictures and sixth pictures, the third encoded video data being encoded using the multiview encoding process that reduces inter-view redundancy between the fifth pictures and the sixth pictures based on the second multiview encoding cues.

[0387] Clause 18C. The method of any of clauses 15C-17C, wherein: the multiview encoding cues include a depth map indicating depths of objects represented in the first and second pictures, and determining the multiview encoding cues comprises determining the depth map based on the first and second pictures.

[0388] Clause 19C. The method of clauses 15C-18C, wherein the multiview encoding cues includes one or more illumination compensation factors, and determining the multiview encoding cues comprises determining the illumination compensation factors based on the first and second pictures.

[0389] Clause 20C. The method of any of clauses 15C-19C, wherein: the transmitting device is an extended reality (XR) headset, and the method further comprises: processing the second set of pictures to generate virtual element data; and transmitting the virtual element data to the XR headset.

[0390] Clause 21C. A device comprising: means for obtaining a first set of multiview pictures of video data, wherein the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; means for transmitting first encoded video data to a receiving device, wherein the first encoded video data is based on the first set of multiview pictures; means for receiving multiview encoding cues from the receiving device; means for obtaining a second set of multiview pictures of the video data, wherein the second set of multiview pictures includes third pictures and fourth pictures, the third pictures being from the first viewpoint and the fourth pictures being from the second viewpoint; means for performing, based on the multiview encoding cues received from the receiving device, a multiview encoding process on the second set of multiview pictures to generate second encoded video data, wherein the multiview encoding process reduces inter-view redundancy between the third pictures and the fourth pictures; and means for transmitting the second encoded video data to the receiving device.

[0391] Clause 22C. A device comprising: means for obtaining first encoded video data from a transmitting device, wherein the first encoded video data is based on a first set of multiview pictures of the video data, the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint; means for determining multiview encoding cues based on the first encoded video data; means for transmitting the multiview encoding cues to the transmitting device; means for obtaining second encoded video data from the transmitting device, wherein the second encoded video data is based on a second set of multiview pictures that includes third pictures and fourth pictures, the second encoded video data being encoded using a multiview encoding process that reduces inter-view redundancy between the third pictures and the fourth pictures based on the multiview encoding cues.

[0392] Clause 1D. A device comprising: a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: encode a first set of pictures of the video data to generate first encoded video data; transmit the first encoded video data to a receiving device; receive, from the receiving device, a decimation pattern indication that indicates a decimation pattern determined based on the first set of pictures, the decimation pattern being a pattern of encoded video data non-transmission; encode a second set of pictures of the video data to generate second encoded video data; apply the decimation pattern to the second encoded video data to generate decimated video data; and transmit the decimated video data to the receiving device.

[0393] Clause 2D. The device of clause 1D, wherein the one or more processors are configured to: generate first error correction data based on the first encoded video data; transmit the first error correction data to the

receiving device; generate second error correction data based on the second encoded video data; and transmit the second error correction data to the receiving device.

[0394] Clause 3D. The device of any of clauses 1D-2D, wherein the decimation pattern indicates a pattern of skipping transmission of encoded video data of full pictures.

[0395] Clause 4D. The device of any of clauses 1D-3D, wherein the decimation pattern indicates a pattern of skipping transmission of encoded video data of specific regions within pictures.

[0396] Clause 5D. The device of any of clauses 1D-4D, wherein the video data is multiview video data and the decimation pattern indicates a pattern of skipping transmission of encoded video data of pictures from specific views.

[0397] Clause 6D. The device of any of clauses 1D-5D, wherein: the decimation pattern indication is a first decimation pattern indication, the pattern of encoded video data non-transmission is a first pattern of encoded video data non-transmission, the decimated video data is first decimated video data, and the one or more processors are further configured to: encode a third set of pictures of the video data to generate third encoded video data; determine a second decimation pattern indicating a second pattern of encoded video data non-transmission; apply the second decimation pattern to the third encoded video data to generate second decimated video data; transmit the second decimated video data to the receiving device; and transmit a second decimation pattern indication to the receiving device, the second decimation pattern indication indicating that the second decimation pattern was applied to the third encoded video data.

[0398] Clause 7D. The device of any of clauses 1D-6D, wherein: the one or more processors are configured to, as part of encoding the first set of pictures: generate first prediction data for the first set of pictures; generate residual data based on the first prediction data and the first set of pictures; apply transform the first prediction data to generate transform blocks; quantize transform coefficients of the transform blocks; apply entropy encoding to syntax elements representing the quantized transform coefficients to generate first entropy encoded syntax elements, wherein the first encoded video data includes the first entropy encoded syntax elements; the one or more processors are further configured to perform analog modulation on the residual data to generate first analog modulated residual data, and the device further comprises a communication interface configured to transmit the first analog modulated residual data, and the first encoded video data.

[0399] Clause 8D. The device of any of clauses 1D-7D, wherein: the device is an extended reality (XR) headset and comprises a display system, and the one or more processors are further configured to: receive virtual element data from the receiving device; and the display system is configured to display one or more virtual elements in an XR scene based on the virtual element data.

[0400] Clause 9D. A device comprising: a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: receive, from a transmitting device, first encoded video data; perform a decoding process to reconstruct a first set of pictures based on the first encoded video data; determine, based on the first set of pictures, a decimation pattern that indicates a pattern of encoded video data non-transmission; transmit, to the transmitting device, a decimation pattern indication that indicates the determined decimation pattern; receive, from the transmitting device, decimated video data, wherein the decimated video data comprises second encoded video data to which the decimation pattern has been applied, wherein the second encoded video data is generated based on a second set of pictures of the video data; and perform the decoding process to reconstruct the second set of pictures based on the second encoded video data.

[0401] Clause 10D. The device of clause 9D, wherein the one or more processors are further configured to: receive, from a transmitting device, first error correction data; apply an error correction process to modify the first encoded video data based on the first error correction data to generate first error-corrected encoded video data; wherein the one or more processors are configured to perform the decoding process to reconstruct the first set of pictures based on the first error-corrected encoded video data; wherein the one or more processors are further configured to: receive, from the transmitting device, second error correction data; apply the error correction process to generate second error-corrected encoded video data based on the second encoded video data and the second error correction data; and wherein the one or more processors are configured to perform the decoding process to reconstruct the second set of pictures based on the second error-corrected encoded video data.

[0402] Clause 11D. The device of any of clauses 9D-10D, wherein the decimation pattern indicates a pattern of skipping transmission of encoded video data of full pictures.

[0403] Clause 12D. The device of any of clauses 9D-11D, wherein the one or more processors are configured to, as part of determining the decimation pattern: apply the decimation pattern to the first encoded video data to generate decimated encoded video data; apply an error correction process to modify the decimated encoded video data based on the first error correction data to generate trial error-corrected video data; apply the decoding process to reconstruct the first set of pictures based on the trial error-corrected video data; determine whether the decimation pattern satisfies a criterion based on a comparison of the first set of pictures as reconstructed based on the trial error-corrected video data and the first set of pictures as reconstructed based on the first video data.

[0404] Clause 13D. The device of any of clauses 9D-12D, wherein the decimation pattern indicates a pattern of skipping transmission of encoded video data of specified regions within pictures.

[0405] Clause 14D. The device of any of clauses 9D-13D, wherein the video data is multiview video data and the decimation pattern indicates a pattern of skipping transmission of encoded video data of pictures from specified views.

[0406] Clause 15D. The device of any of clauses 9D-14D, wherein: the decimation pattern indication is

a first decimation pattern indication, the pattern of encoded video data non-transmission is a first pattern of encoded video data non-transmission, the decimated video data is first decimated video data, and the one or more processors are further configured to: receive a second decimation pattern indication indicating a second pattern of encoded video data non-transmission; receive, from the transmitting device, second decimated video data, wherein the second decimated video data comprises third encoded video data to which the second decimation pattern has been applied, wherein the third encoded video data is generated based on a third set of pictures of the video data; and apply the decoding process to reconstruct the third set of pictures based on the third encoded video data.

[0407] Clause 16D. The device of any of clauses 9D-15D, wherein: the device further comprises a communication interface configured to receive analog modulated residual data, the second encoded video data includes entropy-encoded syntax elements representing quantized transform coefficients; the one or more processors are configured to, as part of applying the decoding process to reconstruct the second set of pictures: apply entropy decoding to the syntax elements to obtain the quantized transform coefficients; inverse quantize the quantized transform coefficients to generate inverse quantized transform coefficients; apply an inverse transform to the inverse quantized transform coefficients to generate prediction data; demodulate the analog modulated residual data to obtain residual data; and reconstruct the second set of pictures based on the prediction data and the residual data.

[0408] Clause 17D. The device of any of clauses 9D-16D, wherein: the one or more processors are further configured to process the second set of pictures to generate virtual element data, and the transmitting device is an extended reality (XR) headset configured to display one or more virtual elements in a XR scene based on the virtual element data.

[0409] Clause 18D. A method comprising: encoding a first set of pictures of video data to generate first encoded video data; transmitting the first encoded video data to a receiving device; receiving, from the receiving device, a decimation pattern indication that indicates a decimation pattern determined based on the first set of pictures, the decimation pattern being a pattern of encoded video data non-transmission; encoding a second set of pictures of the video data to generate second encoded video data; applying the decimation pattern to the second encoded video data to generate decimated video data; and transmitting the decimated video data to the receiving device.

[0410] Clause 19D. The method of clause 18D, further comprising: generating first error correction data based on the first encoded video data; transmitting the first error correction data to the receiving device; generating second error correction data based on the second encoded video data; and transmitting the second error correction data to the receiving device.

[0411] Clause 20D. The method of any of clauses 18D-19D, wherein the decimation pattern indicates a pattern of skipping transmission of encoded video data of full pictures.

[0412] Clause 21D. The method of any of clauses 18D-20D, wherein the decimation pattern indicates a pattern of skipping transmission of encoded video data of specific regions within pictures.

[0413] Clause 22D. The method of any of clauses 18D-21D, wherein the video data is multiview video data and the decimation pattern indicates a pattern of skipping transmission of encoded video data of pictures from specific views.

[0414] Clause 23D. The method of any of clauses 18D-22D, wherein: the decimation pattern indication is a first decimation pattern indication, the pattern of encoded video data non-transmission is a first pattern of encoded video data non-transmission, the decimated video data is first decimated video data, and the method further comprises: encoding a third set of pictures of the video data to generate third encoded video data; determining a second decimation pattern indicating a second pattern of encoded video data non-transmission; applying the second decimation pattern to the third encoded video data to generate second decimated video data; transmitting the second decimated video data to the receiving device; and transmitting a second decimation pattern indication to the receiving device, the second decimation pattern indication indicating that the second decimation pattern was applied to the third encoded video data.

[0415] Clause 24D. The method of any of clauses 18D-23D, wherein: encoding the first set of pictures comprises: generating first prediction data for the first set of pictures; generating residual data based on the first prediction data and the first set of pictures; applying transform the first prediction data to generate transform blocks; quantizing transform coefficients of the transform blocks; applying entropy encoding to syntax elements representing the quantized transform coefficients to generate first entropy encoded syntax elements, wherein the first encoded video data includes the first entropy encoded syntax elements; the method further comprises: performing analog modulation on the residual data to generate first analog modulated residual data, and transmitting the first analog modulated residual data and the first encoded video data.

[0416] Clause 25D The method of any of clauses 18D-24D, wherein the method further comprises: receiving virtual element data from the receiving device; and displaying one or more virtual elements in an extended reality (XR) scene based on the virtual element data.

[0417] Clause 26D. A method comprising: receiving, from a transmitting device, first encoded video data; applying a decoding process to reconstruct a first set of pictures based on the first encoded video data; determining, based on the first set of pictures, a decimation pattern that indicates a pattern of encoded video data non-transmission; transmitting, to the transmitting device, a decimation pattern indication that indicates the determined decimation pattern; receiving, from the transmitting device, decimated video data, wherein the decimated video data comprises second encoded video data to which the decimation pattern has been applied, wherein the second encoded video data is generated based on a second set of pictures of the video data; and

performing the decoding process to reconstruct the second set of pictures based on the second encoded video data.

[0418] Clause 27D. The method of clause 26D, wherein the method further comprises: receiving, from a transmitting device, first error correction data; applying an error correction process to modify the first encoded video data based on the first error correction data to generate first error-corrected encoded video data; wherein performing the decoding process to reconstruct the first set of pictures comprises performing the decoding process to reconstruct the first set of pictures based on the first error-corrected encoded video data; wherein the method further comprises: receiving, from the transmitting device, second error correction data; applying the error correction process to generate second error-corrected encoded video data based on the second encoded video data and the second error correction data; and wherein performing the decoding process to reconstruct the second set of pictures comprises performing the decoding process to reconstruct the second set of pictures based on the second error-corrected encoded video data.

[0419] Clause 28D. The method of any of clauses 26D-27D, wherein the decimation pattern indicates a pattern of skipping transmission of encoded video data of full pictures.

[0420] Clause 29D. The method of any of clauses 26D-28D, wherein determining the decimation pattern comprises: applying the decimation pattern to the first encoded video data to generate decimated encoded video data; apply an error correction process to modify the decimated encoded video data based on the first error correction data to generate trial error-corrected video data; applying the decoding process to reconstruct the first set of pictures based on the trial error-corrected video data; determining whether the decimation pattern satisfies a criterion based on a comparison of the first set of pictures as reconstructed based on the trial error-corrected video data and the first set of pictures as reconstructed based on the first video data.

[0421] Clause 30D. The method of any of clauses 26D-29D, wherein the decimation pattern indicates a pattern of skipping transmission of encoded video data of specified regions within pictures.

[0422] Clause 31D. The method of any of clauses 26D-30D, wherein the video data is multiview video data and the decimation pattern indicates a pattern of skipping transmission of encoded video data of pictures from specified views.

[0423] Clause 32D. The method of any of clauses 26D-31D, wherein: the decimation pattern indication is a first decimation pattern indication, the pattern of encoded video data non-transmission is a first pattern of encoded video data non-transmission, the decimated video data is first decimated video data, and the method further comprises: receiving a second decimation pattern indication indicating a second pattern of encoded video data non-transmission; receiving, from the transmitting device, second decimated video data, wherein the second decimated video data comprises third encoded video data to which the second decimation pattern has been applied, wherein the third encoded video data is generated based on a third set of pictures of the video data; and applying the decoding process to reconstruct the third set of pictures based on the third encoded video data.

[0424] Clause 33D. The method of any of clauses 26D-32D, wherein: the method further comprises receiving analog modulated residual data, the second encoded video data includes entropy-encoded syntax elements representing quantized transform coefficients; applying the decoding process to reconstruct the second set of pictures comprises: applying entropy decoding to the syntax elements to obtain the quantized transform coefficients; inverse quantizing the quantized transform coefficients to generate inverse quantized transform coefficients; applying an inverse transform to the inverse quantized transform coefficients to generate prediction data; demodulating the analog modulated residual data to obtain residual data; reconstruct the second set of pictures based on the prediction data and the residual data.

[0425] Clause 34D. The method of any of clauses 26D-33D, wherein: the method further comprises processing the second set of pictures to generate virtual element data, and the transmitting device is an extended reality (XR) headset configured to display one or more virtual elements in a XR scene based on the virtual element data.

[0426] Clause 35D. A device comprising: means for encoding a first set of pictures of video data to generate first encoded video data; means for transmitting the first encoded video data to a receiving device; means for receiving, from the receiving device, a decimation pattern indication that indicates a decimation pattern determined based on the first set of pictures, the decimation pattern being a pattern of encoded video data non-transmission; means for encoding a second set of pictures of the video data to generate second encoded video data; means for applying the decimation pattern to the second encoded video data to generate decimated video data; and means for transmitting the decimated video data to the receiving device.

[0427] Clause 36D. A device comprising: means for receiving, from a transmitting device, first encoded video data; means for performing a decoding process to reconstruct a first set of pictures based on the first encoded video data; means for determining, based on the first set of pictures, a decimation pattern that indicates a pattern of encoded video data non-transmission; means for transmitting, to the transmitting device, a decimation pattern indication that indicates the determined decimation pattern; means for receiving, from the transmitting device, decimated video data, wherein the decimated video data comprises second encoded video data to which the decimation pattern has been applied, wherein the second encoded video data is generated based on a second set of pictures of the video data; and means for performing the decoding process to reconstruct the second set of pictures based on the second encoded video data.

[0428] Clause 1E. A device comprising: a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: encode a first picture of the video data to generate first encoded video data; transmit the first encoded video

data to a receiving device; receive, from the receiving device, encoding selection data for a second picture of the video data, wherein: the encoding selection data for the second picture indicate encoding selections used to encode an estimate of the second picture, and the second picture follows the first picture in decoding order; encode the second picture based on the encoding selection data for the second picture to generate second encoded video data; and transmit the second encoded video data to the receiving device.

[0429] Clause 2E. The device of clause 1E, wherein: the encoding selection data received from the receiving device include motion parameters for blocks of the second picture, the one or more processors are configured to, as part of encoding the second picture, perform motion compensation based on the motion parameters for the blocks of the second picture to generate predictive blocks, and the second encoded video data includes encoded video data based on the predictive blocks.

[0430] Clause 3E. The device of any of clauses 1E-2E, wherein: the encoding selection data received from the receiving device include intra prediction parameters for blocks of the second picture, the one or more processors are configured to, as part of encoding the second picture, perform intra prediction based on the intra prediction parameters for the blocks of the second picture to generate predictive blocks, and the second encoded video data includes encoded video data based on the predictive blocks.

[0431] Clause 4E. The device of any of clauses 1E-3E, wherein the second encoded video data does not include the encoding selection data.

[0432] Clause 5E. The device of any of clauses 1E-4E, wherein the one or more processors are configured to entropy decode the encoding selection data for the second picture prior.

[0433] Clause 6E. The device of any of clauses 1E-5E, wherein the one or more processors are further configured to: generate first error correction data based on the first encoded video data; and transmit the first encoded video data and the first error correction data to the receiving device.

[0434] Clause 7E. The device of any of clauses 1E-6E, wherein the one or more processors are further configured to: based on determining that encoding selection data for a third picture are not received from the receiving device prior to expiration of a time limit, encode the third picture without use the encoding selection data for the third picture.

[0435] Clause 8E. The device of any of clauses 1E-7E, wherein the one or more processors are further configured to: receive encoding selection data for a third picture of the video data, wherein the encoding selection data for the third picture indicates encoding selections used to encode an estimate of the third picture; encode the third picture based on the encoding selection data for the third picture to generate third encoded video data; apply a channel encoding process that generates error correction data for the third encoded video data; and transmit the error correction data for the third encoded video data to the receiving device without transmitting a least a portion of the third encoded video data.

[0436] Clause 9E. The device of any of clauses 1E-8E, wherein: the device is an extended reality (XR) headset and comprises a display system, and the one or more processors are further configured to: receive virtual element data from the receiving device; and the display system is configured to display one or more virtual elements in an XR scene based on the virtual element data.

[0437] Clause 10E. A device comprising: a memory configured to store video data; and one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to: receive first encoded video data from a transmitting device; reconstruct a first picture of the video data based on the first encoded video data; estimate a second picture of the video data based on the first picture, the second picture being a picture occurring after the first picture in decoding order; generate encoding selection data for the estimated second picture, wherein the encoding selection data indicate encoding selections used to encode the estimated second picture; transmit, to the transmitting device, the encoding selection data for the second picture; receive second encoded video data from the transmitting device; and reconstruct the second picture based on the second encoded video data.

[0438] Clause 11E. The device of clause 10E, wherein: the one or more processors are configured to, as part of encoding the estimated second picture, perform motion compensation based on motion parameters for the blocks of the second picture to generate predictive blocks, and the encoding selection data includes the motion parameters for blocks of the second picture, the second encoded video data includes encoded video data based on the predictive blocks.

[0439] Clause 12E. The device of any of clauses 10E-11E, wherein: the one or more processors are configured to, as part of encoding the second picture, perform intra prediction based on the intra prediction parameters for the blocks of the second picture to generate predictive blocks, the encoding selection data includes intra prediction parameters for blocks of the second picture, and the second encoded video data includes encoded video data based on the predictive blocks.

[0440] Clause 13E. The device of any of clauses 10E-12E, wherein: the second encoded video data does not include the encoding selection data; and the one or more processors are configured to, as part of applying the decoding process, use the encoding selection data to reconstruct the second picture based on the second encoded video data.

[0441] Clause 14E. The device of any of clauses 10E-13E, wherein the one or more processors are configured to entropy encode the encoding selection data for the second picture prior to transmitting the encoding selection data for the second picture.

[0442] Clause 15E. The device of any of clauses 10E-14E, wherein: the one or more processors are further configured to: estimate a third picture of the video data based on one or more of the first or second pictures; perform an encoding process that encodes the estimated third picture to generate third encoded video data, wherein third encoding selection data indicates encoding selections used to encode the estimated third picture; transmit the third encoding selection data to

transmitting device; receive, from the transmitting device, error correction data for the third picture; apply an error correction process to generate error-corrected encoded video data for the third picture based on the error correction data for the third picture and the third encoded video data; and apply a decoding process that reconstructs the third picture based on the error-corrected encoded video data for the third picture.

[0443] Clause 16E. The device of clause 15E, wherein: the error-corrected encoded video data for the third picture does not include the third encoding selection data, and the one or more processors are configured to, as part of applying the decoding process, use the third encoding selection data to reconstruct the third picture based on the error-corrected encoded video data for the third picture.

[0444] Clause 17E. The device of any of clauses 10E-16E, wherein the one or more processors are configured to: apply a channel encoding process to the encoding selection data for the second picture to generate error correction data for the encoding selection data for the second picture; and transmit, to the transmitting device, the error correction data for the encoding selection data for the second picture.

[0445] Clause 18E. The device of any of clauses 10E-17E, wherein device includes a communication interface configured to modulate the encoding selection data at a lower modulation order as compared to other data transmissions in a data link between the device and the transmitting device.

[0446] Clause 19E. The device of any of clauses 10E-18E, wherein: the one or more processors are further configured to process the second set of pictures to generate virtual element data, and the transmitting device is an extended reality (XR) headset configured to display one or more virtual elements in a XR scene based on the virtual element data.

[0447] Clause 20E. A method of processing video data, the method comprising: encoding a first picture of the video data to generate first encoded video data; transmitting the first encoded video data to a receiving device; receiving, from the receiving device, encoding selection data for a second picture of the video data, wherein: the encoding selection data for the second picture indicate encoding selections used to encode an estimate of the second picture, and the second picture follows the first picture in decoding order; encoding the second picture based on the encoding selection data for the second picture to generate second encoded video data; and transmitting the second encoded video data to the receiving device.

[0448] Clause 21E. The method of clause 20E, wherein: the encoding selection data received from the receiving device include motion parameters for blocks of the second picture, encoding the second picture comprises performing motion compensation based on the motion parameters for the blocks of the second picture to generate predictive blocks, and the second encoded video data includes encoded video data based on the predictive blocks.

[0449] Clause 22E. The method of any of clauses 20E-21E, wherein: the encoding selection data received from the receiving device include intra prediction parameters for blocks of the second picture, encoding the second picture comprises performing intra prediction based on the intra prediction parameters for the blocks of the second picture to generate predictive blocks, and the second encoded video data includes encoded video data based on the predictive blocks.

[0450] Clause 23E. The method of any of clauses 20E-22E, wherein the second encoded video data does not include the encoding selection data.

[0451] Clause 24E. The method of any of clauses 20E-23E, further comprising entropy decoding the encoding selection data for the second picture prior.

[0452] Clause 25E. The method of any of clauses 20E-24E, further comprising: generating first error correction data based on the first encoded video data; and transmitting the first encoded video data and the first error correction data to the receiving device.

[0453] Clause 26E. The method of any of clauses 20E-25E, further comprising: based on determining that encoding selection data for a third picture are not received from the receiving device prior to expiration of a time limit, encoding the third picture without use the encoding selection data for the third picture.

[0454] Clause 27E. The method of any of clauses 20E-26E, further comprising: receiving encoding selection data for a third picture of the video data, wherein the encoding selection data for the third picture indicates encoding selections used to encode an estimate of the third picture; encoding the third picture based on the encoding selection data for the third picture to generate third encoded video data; applying a channel encoding process that generates error correction data for the third encoded video data; and transmitting the error correction data for the third encoded video data to the receiving device without transmitting a least a portion of the third encoded video data.

[0455] Clause 28E. The method of any of clauses 20E-27E, wherein: the device is an extended reality (XR) headset and comprises a display system, and the method further comprises: receiving virtual element data from the receiving device; and displaying, on the display system, one or more virtual elements in an XR scene based on the virtual element data.

[0456] Clause 29E. A method of processing video data, the method comprising: receiving first encoded video data from a transmitting device; reconstructing a first picture of the video data based on the first encoded video data; estimating a second picture of the video data based on the first picture, the second picture being a picture occurring after the first picture in decoding order; generating encoding selection data for the estimated second picture, wherein the encoding selection data indicate encoding selections used to encode the estimated second picture; transmitting, to the transmitting device, the encoding selection data for the second picture; receiving second encoded video data from the transmitting device; and reconstructing the second picture based on the second encoded video data.

[0457] Clause 30E. The method of clause 29E, wherein: encoding the estimated second picture comprises performing motion compensation based on motion parameters for the blocks of the second picture to generate predictive blocks, and the encoding selection data includes the motion parameters for blocks of the second

picture, the second encoded video data includes encoded video data based on the predictive blocks.

[0458] Clause 31E. The method of any of clauses 29E-30E, wherein: encoding the second picture comprises performing intra prediction based on the intra prediction parameters for the blocks of the second picture to generate predictive blocks, the encoding selection data includes intra prediction parameters for blocks of the second picture, and the second encoded video data includes encoded video data based on the predictive blocks.

[0459] Clause 32E. The method of any of clauses 29E-31E, wherein: the second encoded video data does not include the encoding selection data; and applying the decoding process comprises using the encoding selection data to reconstruct the second picture based on the second encoded video data.

[0460] Clause 33E. The method of any of clauses 29E-32E, wherein entropy encoding the encoding selection data for the second picture occurs prior to transmitting the encoding selection data for the second picture.

[0461] Clause 34E. The method of any of clauses 29E-33E, further comprising: estimating a third picture of the video data based on one or more of the first or second pictures; performing an encoding process that encodes the estimated third picture to generate third encoded video data, wherein third encoding selection data indicates encoding selections used to encode the estimated third picture; transmitting the third encoding selection data to transmitting device; receiving, from the transmitting device, error correction data for the third picture; applying an error correction process to generate error-corrected encoded video data for the third picture based on the error correction data for the third picture and the third encoded video data; and applying a decoding process that reconstructs the third picture based on the error-corrected encoded video data for the third picture.

[0462] Clause 35E. The method of any of clauses 34E, wherein: the error-corrected encoded video data for the third picture does not include the third encoding selection data, and applying the decoding process comprises using the third encoding selection data to reconstruct the third picture based on the error-corrected encoded video data for the third picture.

[0463] Clause 36E. The method of any of clauses 29E-35E, further comprising: applying a channel encoding process to the encoding selection data for the second picture to generate error correction data for the encoding selection data for the second picture; and transmitting, to the transmitting device, the error correction data for the encoding selection data for the second picture.

[0464] Clause 37E. The method of any of clauses 29E-36E, further comprising modulating the encoding selection data at a lower modulation order as compared to other data transmissions in a data link between the device and the transmitting device.

[0465] Clause 38E. The method of any of clauses 29E-37E, wherein: further comprising processing the second set of pictures to generate virtual element data, and the transmitting device is an extended reality (XR) headset configured to display one or more virtual elements in a XR scene based on the virtual element data.

[0466] Clause 39E. A device comprising: means for encoding a first picture of the video data to generate first encoded video data; means for transmitting the first encoded video data to a receiving device; means for receiving, from the receiving device, encoding selection data for a second picture of the video data, wherein: the encoding selection data for the second picture indicate encoding selections used to encode an estimate of the second picture, and the second picture follows the first picture in decoding order; means for encoding the second picture based on the encoding selection data for the second picture to generate second encoded video data; and means for transmitting the second encoded video data to the receiving device.

[0467] Clause 40E. A device comprising: means for receiving first encoded video data from a transmitting device; means for reconstructing a first picture of the video data based on the first encoded video data; means for estimating a second picture of the video data based on the first picture, the second picture being a picture occurring after the first picture in decoding order; means for generating encoding selection data for the second picture, wherein the encoding selection data for the second picture indicate encoding selections used to encode the second picture; means for transmitting, to the transmitting device, the encoding selection data for the second picture; means for receiving second encoded video data from the transmitting device; and means for reconstructing the second picture based on the second encoded video data.

[0468] It is to be recognized that depending on the example, certain acts or events of any of the techniques described herein can be performed in a different sequence, may be added, merged, or left out altogether (e.g., not all described acts or events are necessary for the practice of the techniques). Moreover, in certain examples, acts or events may be performed concurrently, e.g., through multi-threaded processing, interrupt processing, or multiple processors, rather than sequentially.

[0469] 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 on 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.

[0470] 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 transitory media, but are instead directed to non-transitory, 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.

[0471] Instructions may be executed by one or more processors (e.g., programmable processors), such as one or more digital signal processors (DSPs), general purpose microprocessors, application specific integrated circuits (ASICs), field programmable gate arrays (FPGAs), or other equivalent integrated or discrete logic circuitry. Accordingly, the terms "processor" and "processing circuitry," as used herein may refer to any of the foregoing structures 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.

[0472] 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 units. Rather, as described above, various 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.

[0473] Various examples have been described. These and other examples are within the scope of the following claims.

What is claimed is:

1. A device comprising:

a memory configured to store video data; and

one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to:

obtain a first set of multiview pictures of the video data, wherein the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint;

transmit first encoded video data to a receiving device, wherein the first encoded video data is based on the first set of multiview pictures;

receive multiview encoding cues from the receiving device;

obtain a second set of multiview pictures of the video data, wherein the second set of multiview pictures includes third pictures and fourth pictures, the third pictures being from the first viewpoint and the fourth pictures being from the second viewpoint;

perform, based on the multiview encoding cues received from the receiving device, a multiview encoding process on the second set of multiview pictures to generate second encoded video data, wherein the multiview encoding process reduces inter-view redundancy between the third pictures and the fourth pictures; and

transmit the second encoded video data to the receiving device.

2. The device of claim **1**, wherein the one or more processors are further configured to,

after transmitting the second encoded video data to the receiving device, receive updated multiview encoding cues from the receiving device;

obtain a third set of multiview pictures of the video data, wherein the third set of multiview pictures includes fifth pictures and sixth pictures, the fifth pictures being from the first viewpoint and the sixth pictures being from the second viewpoint;

encode the third set of multiview pictures based on the updated multiview encoding cues received from the receiving device to generate third encoded video data; and

transmit the third encoded video data to the receiving device.

3. The device of claim **1**, wherein the multiview encoding cues include one or more of:

a relative shift between blocks of the first pictures and the second pictures,

a brightness correction between the first pictures and the second pictures,

an inter block shift between an anchor block and a reconstructed block, or motion data for reference shift.

4. The device of claim **1**, wherein:

the device is an extended reality (XR) headset,

the one or more processors are configured to:

receive virtual element data from the receiving device generated based on the first and second sets of multiview pictures; and

output the virtual element data for display in a XR scene.

5. A device comprising:

a memory configured to store video data; and

one or more processors implemented in circuitry and coupled to the memory, the one or more processors configured to:

obtain first encoded video data from a transmitting device, wherein the first encoded video data is based on a first set of multiview pictures of the video data, the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint;

determine multiview encoding cues based on the first encoded video data;

transmit the multiview encoding cues to the transmitting device; and

obtain second encoded video data from the transmitting device, wherein the second encoded video data is based on a second set of multiview pictures that includes third pictures and fourth pictures, the second encoded video data being encoded using a multiview encoding process that reduces inter-view redundancy between the third pictures and the fourth pictures based on the multiview encoding cues.

6. The device of claim **5**, wherein the one or more processors are further configured to decode the second encoded video data.

7. The device of claim **5**, wherein the multiview encoding cues are first multiview encoding cues and the one or more processors are further configured to:

determine second multiview encoding cues based on the second encoded video data;

transmit the second multiview encoding cues to the transmitting device; and

obtain third encoded video data from the transmitting device, wherein the third encoded video data is based on a third set of multiview pictures that includes fifth pictures and sixth pictures, the third encoded video data being encoded using the multiview encoding process that reduces inter-view redundancy between the fifth pictures and the sixth pictures based on the second multiview encoding cues.

8. The device of claim **5**, wherein:

the multiview encoding cues include a depth map indicating depths of objects represented in the first and second pictures, and

the one or more processors are configured to, as part of determining the multiview encoding cues, determine the depth map based on the first and second pictures.

9. The device of claim **5**, wherein the multiview encoding cues includes one or more illumination compensation factors, and

the one or more processors are configured to, as part of determining the multiview encoding cues, determine the illumination compensation factors based on the first and second pictures.

10. The device of claim **5**, wherein:

the transmitting device is an extended reality (XR) headset, and

the one or more processors are further configured to:

process the second set of pictures to generate virtual element data; and

transmit the virtual element data to the XR headset.

11. A method of processing video data, the method comprising:

obtaining a first set of multiview pictures of the video data, wherein the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint;

transmitting first encoded video data to a receiving device, wherein the first encoded video data is based on the first set of multiview pictures;

receiving multiview encoding cues from the receiving device;

obtaining a second set of multiview pictures of the video data, wherein the second set of multiview pictures includes third pictures and fourth pictures, the third pictures being from the first viewpoint and the fourth pictures being from the second viewpoint;

performing, based on the multiview encoding cues received from the receiving device, a multiview encoding process on the second set of multiview pictures to generate second encoded video data, wherein the multiview encoding process reduces inter-view redundancy between the third pictures and the fourth pictures; and

transmitting the second encoded video data to the receiving device.

12. The method of claim **11**, further comprising:

after transmitting the second encoded video data to the receiving device, receiving updated multiview encoding cues from the receiving device;

obtaining a third set of multiview pictures of the video data, wherein the third set of multiview pictures includes fifth pictures and sixth pictures, the fifth pictures being from the first viewpoint and the sixth pictures being from the second viewpoint;

encoding the third set of multiview pictures based on the updated multiview encoding cues received from the receiving device to generate third encoded video data; and

transmitting the third encoded video data to the receiving device.

13. The method of claim **11**, wherein the multiview encoding cues include one or more of:

a relative shift between blocks of the first pictures and the second pictures,

a brightness correction between the first pictures and the second pictures,

an inter block shift between an anchor block and a reconstructed block, or motion data for reference shift.

14. The method of claim **11**, wherein the method further comprises:

receiving virtual element data from the receiving device generated based on the first and second sets of multiview pictures; and

outputting the virtual element data for display in an extended reality (XR) scene.

15. A method of processing video data, the method comprising:

obtaining first encoded video data from a transmitting device, wherein the first encoded video data is based on a first set of multiview pictures of the video data, the first set of multiview pictures includes first pictures and second pictures, the first pictures being from a first viewpoint and the second pictures being from a second viewpoint;

determining multiview encoding cues based on the first encoded video data;

transmitting the multiview encoding cues to the transmitting device; and

obtaining second encoded video data from the transmitting device, wherein the second encoded video data is based on a second set of multiview pictures that includes third pictures and fourth pictures, the second encoded video data being encoded using a multiview encoding process that reduces inter-view redundancy between the third pictures and the fourth pictures based on the multiview encoding cues.

16. The method of claim **15**, further comprising decoding the second encoded video data.

17. The method of claim **15**, wherein the multiview encoding cues are first multiview encoding cues and the method further comprises:

determining second multiview encoding cues based on the second encoded video data;

transmitting the second multiview encoding cues to the transmitting device; and

obtaining third encoded video data from the transmitting device, wherein the third encoded video data is based on a third set of multiview pictures that includes fifth pictures and sixth pictures, the third encoded video data being encoded using the multiview encoding process that reduces inter-view redundancy between the fifth pictures and the sixth pictures based on the second multiview encoding cues.

18. The method of claim **15**, wherein:

the multiview encoding cues include a depth map indicating depths of objects represented in the first and second pictures, and

determining the multiview encoding cues comprises determining the depth map based on the first and second pictures.

19. The method of claim **15**, wherein the multiview encoding cues includes one or more illumination compensation factors, and

determining the multiview encoding cues comprises determining the illumination compensation factors based on the first and second pictures.

20. The method of claim **15**, wherein:

the transmitting device is an extended reality (XR) headset, and

the method further comprises:

processing the second set of pictures to generate virtual element data; and

transmitting the virtual element data to the XR headset.

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