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(54) Title: SYSTEMS AND METHODS FOR DETERMINING TOKEN RATES WITHIN A RATE-DISTORTION OPTIMIZA-
TION HARDWARE PIPELINE

(57) Abstract:

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**SYSTEMS AND METHODS FOR DETERMINING TOKEN RATES WITHIN A RATE–
DISTORTION OPTIMIZATION HARDWARE PIPELINE**

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Patent Application 63/232,941, filed August 13, 2021, the disclosure of which is incorporated, in its entirety, by this reference.

TECHNICAL FIELD

[0002] The present disclosure generally relates to the field of systems and methods for determining token rates within a rate-distortion optimization hardware pipeline.

BACKGROUND

[0003] Modern video encoding standards, such as VP9, are generally based on hybrid coding frameworks that may compress video data by exploiting redundancies within the video data. Compression may be achieved by identifying and storing only differences within the video data, such as may occur between temporally proximate frames (i.e., inter-frame coding) and/or between spatially proximate pixels (i.e., intra-frame coding). Inter-frame compression uses data from one or more earlier or later frames in a sequence to describe a current frame. Intra-frame coding, on the other hand, uses only data from within the current frame to describe the current frame.

[0004] Modern video encoding standards may additionally employ compression techniques like quantization that may exploit perceptual features of human vision, such as by eliminating, reducing, and/or more heavily compressing aspects of source video data that may be less relevant to human visual perception than other aspects. For example, as human vision may generally be more sensitive to changes in brightness than changes in color, a video encoder using a particular video codec may use more data to encode changes in luminance than changes in color. In all, video encoders must balance various trade-offs between video quality, bit rate, processing costs, and/or available system resources to effectively encode and/or decode video data.

[0005] Conventional or traditional methods of making encoding decisions may involve simply choosing a result that yields the highest quality output image according to some quality standard. However, such methods may choose settings that may require more bits to encode video data while providing comparatively little quality benefit. As an example,

1 during a motion estimation portion of an encoding process, adding extra precision to
 2 representation of motion vectors of blocks might increase quality of an encoded output video,
 3 but the increase in quality might not be worth the extra bits necessary to encode the motion
 4 vectors with a higher precision.

5 **[0006]** As an additional example, during a basic encoding process, an encoder may
 6 divide each frame of video data into processing units. Depending on the codec, these
 7 processing units may be referred to as macroblocks (MB), coding units (CU) and/or coding
 8 tree units (CTU). Modern codecs may select a particular mode (i.e., a processing unit size
 9 and/or shape) from among several available modes for encoding video data. This mode
 10 decision may greatly impact an overall rate–distortion result for a particular output video file.

11 **[0007]** In order to determine or decide an optimal bit rate having an acceptable
 12 level of distortion, some modern codecs may use a technique called Lagrangian rate–
 13 distortion optimization. Rate–distortion optimization, also referred to as rate distortion
 14 optimized mode selection, or simply RDO, is a technique for choosing a coding mode of a
 15 macroblock based on a bitrate cost and distortion cost. In one expression, the bitrate cost R
 16 and distortion cost D may be combined into a single cost J :

$$J = D + \lambda R \quad (1)$$

18 **[0008]** An RDO mode selection algorithm may attempt to find a mode that may
 19 optimize (e.g., minimize) the joint cost J . A trade-off between R and D may be controlled by
 20 Lagrange multiplier λ . A smaller λ may emphasize minimizing D , allowing a higher bitrate,
 21 where a larger λ may tend to minimize R at with an expense of a higher distortion. Selecting
 22 an optimum λ for a particular sequence may be a computationally intense problem. In some
 23 examples, empirical approximations may provide an effective choice of λ in a practical mode
 24 selection scenario. In some examples, λ may be calculated as a function of a quantization
 25 parameter (QP).

26 **[0009]** Distortion (D) may be calculated as the Sum of Squared Distortion (SSD) in
 27 accordance with

$$D_{SSD} = \sum_{x,y} (b(x,y) - b'(x,y))^2 \quad (2)$$

29 where x, y are sample positions within a block, $b(x, y)$ are original sample values, and $b'(x, y)$
 30 are decoded sample values at each sample position. This is merely an example, however, as
 31 other distortion metrics, such as Sum of Absolute Differences (SAD) or Sum of Absolute

1 Transformed Differences (SATD) may be used in these or related distortion calculations.

2 [0010] An RDO mode selection algorithm may involve, for every macroblock and
3 for every available coding mode m , coding the macroblock using m and calculating R as a
4 number of bits required to code the macroblock. The macroblock may be reconstructed and
5 D , the distortion between the original and decoded macroblocks, may be determined. The
6 mode cost J_m may then be calculated, with a suitable choice of λ . The mode that gives the
7 minimum J_m may then be identified and selected.

8 [0011] Clearly, the above is a computationally intensive process, as there may be
9 hundreds of possible mode combinations. It may be necessary to code and decode a
10 macroblock hundreds of times to find a “best” mode for optimizing rate versus distortion.
11 Some systems may attempt to offload some of this high computational burden to specialized
12 hardware. Unfortunately, different video codecs may support different modes and/or may
13 employ different techniques for analyzing and/or encoding video data. Consequently, there
14 may be a high cost of redundancy in such specialized RDO hardware, particularly when that
15 specialized hardware may need to support multiple codecs. This redundancy may result in
16 hardware complexity and high power usage. Furthermore, conventional systems and
17 methods for determining possible token rates (i.e., rates at which video data may be encoded
18 via a particular transform operation) for RDO may be similarly inefficient or require multiple
19 computational steps. Hence, the instant application identifies and addresses a need for
20 improved systems and methods for determining token rates within a RDO hardware pipeline.

21 SUMMARY OF THE INVENTION

22 [0012] According to a first aspect of the present disclosure, there is provided a
23 method comprising: storing, within a hardware memory device included as part of a rate–
24 distortion optimization (RDO) hardware pipeline, at least one transform unit table that: is
25 pregenerated from a seed probability table for transformation of video data in accordance
26 with a video encoding standard; corresponds to a transform operation supported by the video
27 encoding standard; and corresponds to a transform unit included in the RDO hardware
28 pipeline; determining, by accessing the transform unit table, an RDO token rate for an
29 encoding of the video data by a hardware video encoding pipeline that includes the RDO
30 hardware pipeline; and selecting, based on the RDO token rate, a transform operation for the
31 encoding of the video data.

32 [0013] Preferably, selecting the transform operation comprises selecting, from a

1 plurality of transform operations supported by the video encoding standard, a transform
2 operation that, when used to encode the video data at the RDO token rate, meets a
3 predetermined threshold of a rate–distortion metric.

4 **[0014]** Preferably, the method according to the first aspect further comprises
5 encoding, via the hardware video encoding pipeline, the video data in accordance with the
6 video encoding standard using the selected transform operation.

7 **[0015]** Preferably, the transform unit is included in a plurality of transform units
8 included in the RDO hardware pipeline, each transform unit in the plurality of transform units
9 corresponding to a different transform operation supported by the video encoding standard.

10 **[0016]** Preferably, the transform unit table is included in a plurality of transform
11 unit tables stored within the hardware memory device, each transform unit table in the
12 plurality of transform unit tables corresponding to a different transform operation supported
13 by the video encoding standard.

14 **[0017]** Preferably, the video encoding standard comprises a VP9 video encoding
15 standard.

16 **[0018]** Preferably, the transform operation supported by the video encoding
17 standard comprises at least one of: a discrete cosine transform having dimensions of up to
18 thirty-two pixels by thirty-two pixels; or a discrete sine transform having dimensions of up to
19 thirty-two pixels by thirty-two pixels.

20 **[0019]** Preferably, the transform operation supported by the video encoding
21 standard comprises at least one of: a discrete cosine transform having dimensions of four
22 pixels by four pixels; a discrete cosine transform having dimensions of eight pixels by eight
23 pixels; a discrete cosine transform having dimensions of sixteen pixels by sixteen pixels; or a
24 discrete cosine transform having dimensions of thirty-two pixels by thirty-two pixels.

25 **[0020]** Preferably, the transform operation supported by the video encoding
26 standard comprises at least one of: a discrete sine transform having dimensions of four pixels
27 by four pixels; a discrete sine transform having dimensions of eight pixels by eight pixels; a
28 discrete sine transform having dimensions of sixteen pixels by sixteen pixels; or a discrete sine
29 transform having dimensions of thirty-two pixels by thirty-two pixels.

30 **[0021]** Preferably, the method according to the first aspect further comprises
31 generating the transform unit table from the seed probability table.

32 **[0022]** Preferably, the method according to the first aspect further comprises

1 generating, from the seed probability table, a plurality of transform unit tables that includes
2 the transform unit table, each transform unit table included in the plurality of transform unit
3 tables corresponding to a different transform operation supported by the RDO hardware
4 pipeline.

5 **[0023]** According to a second aspect of the present disclosure, there is provided a
6 system comprising: a storing module, stored in memory, that stores, within a hardware
7 memory device included as part of a rate-distortion optimization (RDO) hardware pipeline,
8 at least one transform unit table that: is pregenerated from a seed probability table for
9 transformation of video data in accordance with a video encoding standard; corresponds to
10 a transform operation supported by the video encoding standard; and corresponds to a
11 transform unit included in the RDO hardware pipeline; a determining module, stored in
12 memory, that determines, by accessing the transform unit table, an RDO token rate for an
13 encoding of the video data by a hardware video encoding pipeline that includes the RDO
14 hardware pipeline; a selecting module, stored in memory, that selects, based on the RDO
15 token rate, a transform operation for the encoding of the video data; and at least one physical
16 processor that executes the storing module, the determining module, and the selecting
17 module.

18 **[0024]** Preferably, the selecting module selects the transform operation by
19 selecting, from a plurality of transform operations supported by the video encoding standard,
20 a transform operation that, when used to encode the video data at the RDO token rate, meets
21 a predetermined threshold of a rate-distortion metric.

22 **[0025]** Preferably, the selecting module further encodes, via the hardware video
23 encoding pipeline, the video data in accordance with the video encoding standard using the
24 selected transform operation.

25 **[0026]** Preferably, the transform unit is included in a plurality of transform units
26 included in the RDO hardware pipeline, each transform unit in the plurality of transform units
27 corresponding to a different transform operation supported by the video encoding standard.

28 **[0027]** Preferably, the transform unit table is included in a plurality of transform
29 unit tables stored within the hardware memory device, each transform unit table in the
30 plurality of transform unit tables corresponding to a different transform operation supported
31 by the video encoding standard.

32 **[0028]** Preferably, the storing module further generates the transform unit table

1 from the seed probability table.

2 **[0029]** Preferably, the storing module further generates, from the seed probability
3 table, a plurality of transform unit tables that includes the transform unit table, each
4 transform unit table included in the plurality of transform unit tables corresponding to a
5 different transform operation supported by the RDO hardware pipeline.

6 **[0030]** According to a third aspect of the present disclosure, there is provided a
7 non-transitory computer-readable medium comprising computer-readable instructions that,
8 when executed by at least one processor of a computing system, cause the computing system
9 to perform the method according to the first aspect of the present disclosure.

10 **BRIEF DESCRIPTION OF THE DRAWINGS**

11 **[0031]** The accompanying drawings illustrate a number of exemplary
12 embodiments and are a part of the specification. Together with the following description,
13 these drawings demonstrate and explain various principles of the instant disclosure.

14 **[0032]** FIG. 1 is a block diagram of an example system for determining token rates
15 within a rate-distortion optimization (RDO) hardware pipeline.

16 **[0033]** FIG. 2 is a block diagram of an example implementation of a system for
17 determining token rates within a RDO hardware pipeline.

18 **[0034]** FIG. 3 is a flow diagram of an example method for determining token rates
19 within a RDO hardware pipeline as described herein.

20 **[0035]** FIG. 4 is a block diagram that illustrates generation of transform tables from
21 a seed probability table as described herein.

22 **[0036]** FIG. 5 is a block diagram that illustrates transform tables associated with
23 transform operations that may be included as part of one or more hardware pipelines as
24 described herein.

25 **[0037]** Throughout the drawings, identical reference characters and descriptions
26 indicate similar, but not necessarily identical, elements. While the exemplary embodiments
27 described herein are susceptible to various modifications and alternative forms, specific
28 embodiments have been shown by way of example in the drawings and will be described in
29 detail herein. However, the exemplary embodiments described herein are not intended to be
30 limited to the particular forms disclosed. Rather, the instant disclosure covers all
31 modifications, equivalents, and alternatives falling within the scope of the appended claims.

32 **DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS**

1 **[0038]** The present disclosure is generally directed to systems and methods for
2 determining token rates within a RDO hardware pipeline. As will be explained in greater detail
3 below, embodiments of the instant disclosure may store, within a hardware memory device
4 included as part of a RDO hardware pipeline, at least one transform unit table. The transform
5 unit table may be pregenerated from a seed probability table for transformation of video data
6 in accordance with a video encoding standard (e.g., VP9, H.264, H.265, etc.). The transform
7 unit table may correspond to a transform operation supported by the video encoding
8 standard, and may correspond to a transform unit, included in the RDO hardware pipeline,
9 that may be configured to execute at least part of the transform operation in hardware.

10 **[0039]** By accessing the pregenerated transform unit table, an embodiment may
11 determine an RDO token rate for an encoding of the video data by a hardware video encoding
12 pipeline that includes the RDO hardware pipeline. Based on the determined RDO token rate,
13 the embodiment may select a transform operation for the encoding of the video data (e.g., a
14 transform operation that meets a suitable rate–distortion metric).

15 **[0040]** Among other benefits, by using pregenerated transform unit tables to
16 determine an RDO token rate as part of an RDO operation rather than by determining the
17 token rate based on the seed probability table during the encoding process, embodiments of
18 the systems and methods described herein may reduce overall power consumption of the
19 RDO hardware pipeline, and hence may realize significant power savings over conventional
20 or traditional video encoding processes and/or systems.

21 **[0041]** The following will provide, with reference to FIGS. 1–2 and 4–5, detailed
22 descriptions of systems for determining token rates within a RDO hardware pipeline. Detailed
23 descriptions of corresponding computer-implemented methods will also be provided in
24 connection with FIG. 3.

25 **[0042]** FIG. 1 is a block diagram of an example system 100 for determining token
26 rates within a RDO hardware pipeline. As illustrated in this figure, example system 100 may
27 include one or more modules 102 for performing one or more tasks. As will be explained in
28 greater detail below, modules 102 may include a storing module 104 that may store, within a
29 hardware memory device included as part of a rate–distortion optimization (RDO) hardware
30 pipeline, at least one transform unit table. Example system 100 may additionally include a
31 determining module 106 that determines, by accessing the transform unit table, an RDO
32 token rate for an encoding of the video data by a hardware video encoding pipeline that

1 includes the RDO hardware pipeline. Additionally, example system 100 may also include a
2 selecting module 108 that selects, based on the RDO token rate, a transform operation for
3 the encoding of the video data.

4 **[0043]** As further illustrated in FIG. 1, example system 100 may also include one
5 or more memory devices, such as memory 120. Memory 120 generally represents any type
6 or form of volatile or non-volatile storage device or medium capable of storing data and/or
7 computer-readable instructions. In one example, memory 120 may store, load, and/or
8 maintain one or more of modules 102. Examples of memory 120 include, without limitation,
9 Random Access Memory (RAM), Read Only Memory (ROM), flash memory, Hard Disk Drives
10 (HDDs), Solid-State Drives (SSDs), optical disk drives, caches, variations or combinations of
11 one or more of the same, or any other suitable storage memory.

12 **[0044]** As further illustrated in FIG. 1, example system 100 may also include one
13 or more physical processors, such as physical processor 130. Physical processor 130 generally
14 represents any type or form of hardware-implemented processing unit capable of
15 interpreting and/or executing computer-readable instructions. In one example, physical
16 processor 130 may access and/or modify one or more of modules 102 stored in memory 120.
17 Additionally or alternatively, physical processor 130 may execute one or more of modules 102
18 to facilitate determining token rates within a RDO hardware pipeline. Examples of physical
19 processor 130 include, without limitation, microprocessors, microcontrollers, central
20 processing units (CPUs), Field-Programmable Gate Arrays (FPGAs) that implement softcore
21 processors, Application-Specific Integrated Circuits (ASICs), portions of one or more of the
22 same, variations or combinations of one or more of the same, or any other suitable physical
23 processor.

24 **[0045]** As also shown in FIG. 1, example system 100 may further include one or
25 more data stores, such as data store 140, that may receive, store, and/or maintain video data
26 142. Data store 140 may represent portions of a single data store or computing device or a
27 plurality of datastores or computing devices. In some embodiments, data store 140 may be a
28 logical container for data and may be implemented in various forms (e.g., a database, a file, a
29 file system, a data structure, etc.). Examples of data store 140 may include, without limitation,
30 files, file systems, data stores, databases, and/or database management systems such as an
31 operational datastore (ODS), a relational database, a No SQL database, a NewSQL database,
32 and/or any other suitable organized collection of data.

1 **[0046]** In at least one example, data store 140 may include (e.g., store, host,
2 access, maintain, etc.) video data 142. As will be explained in greater detail below, in some
3 examples, video data 142 may include and/or represent any data that may be encoded via a
4 video encoding process, such as scene data, frame data, image data, and/or any other suitable
5 form of visual data, audio data, and/or audiovisual data.

6 **[0047]** Also shown in FIG. 1, example system 100 may include an RDO pipeline 150
7 that may store, cache, and/or maintain table data 152. As will be explained in greater detail
8 below in reference to FIG. 2, RDO pipeline 150 may include a hardware pipeline for
9 performing one or more portions of a rate–distortion optimization operation. Table data 152
10 may include any portion of a transform table, which may include any set of data that may be
11 accessed to determine a token rate for video data encoded using a particular transform
12 operation given a particular set of quantization parameters.

13 **[0048]** Table data 152 may be pregenerated from a seed probability table in
14 accordance with a video encoding standard. For example, a VP9 video encoding standard may
15 specify a seed probability table that may be used to identify a transform table that may
16 include a suitable token rate. The systems and methods described herein may store (e.g.,
17 within a suitable memory device, such as memory 120 and/or a memory device included as
18 part of the RDO hardware pipeline) a pregenerated transform table and may access the
19 pregenerated transform table during one or more operations of the RDO hardware pipeline.

20 **[0049]** Example system 100 in FIG. 1 may be implemented in a variety of ways. For
21 example, all or a portion of example system 100 may represent portions of an example system
22 200 (“system 200”) in FIG. 2. Example system 200 includes a hardware pipeline for RDO in
23 accordance with some embodiments described herein. In at least one example, one or more
24 components included in system 200 may implement hardware and/or software that may
25 perform and/or execute one or more functions of one or more of modules 102.

26 **[0050]** As illustrated in FIG. 2, example system 200 may include a hardware
27 distortion data pipeline 202, a hardware determination pipeline 204, and a hardware token
28 rate pipeline 206. Each of these parallel pipelines may include various modules that may
29 perform various functions within in an RDO workflow.

30 **[0051]** As further shown in FIG. 2, hardware distortion data pipeline 202 may
31 include a quantization module 208 that may generate a quantized data set based on a picture
32 parameter set 210 and a transformed data set, such as a transformed data set received from

transformation module 212.

[0052] In some examples, a picture parameter set (PPS) (e.g., PPS 210) may include a syntax and/or data structure that may contain syntax and/or data elements that may apply to an entire coded picture. In some examples, a PPS may be included within one or more network abstraction layer (NAL) units. A PPS NAL unit may include and/or contain parameters that may apply to the decoding of one or more individual pictures inside a coded video sequence. The possible contents and/or syntax of a PPS may be defined within a suitable video encoding standard (e.g., H.264/AVC, HEVC, VP9, etc.). Furthermore, in some examples, a PPS may include one or more quantization parameters (QP) for quantization of transformed residual data.

[0053] As will be described in greater detail below, the transformed data set (also referred to herein as “TX”) may include a residual frame data set (e.g., residual frame data 214) that has been transformed by transformation module in accordance with a transformation operation supported by a suitable video encoding process (e.g., H.264/AVC, VP9, etc.). In some examples, residual frame data 214 may include or represent a DCT difference between an input frame (e.g., a frame, a block, a macroblock, etc.) and an intra- or inter-predicted frame (e.g., a frame, a block, a macroblock, etc.).

[0054] In a quantization operation, less complex (e.g., integer) values may be selected to represent this DCT difference. These less complex quantized values may be more readily compressed than the computed DCT difference. A quantization process or operation may be mathematically expressed as:

$$C[x] = \text{sign}(x) \times \max\left(0, \text{floor}\left(\frac{|x|}{s} + 1 - z\right)\right) \quad (3)$$

where x may represent an initial transformed residual value, $C[x]$ may denote a quantized residual value, s may represent a quantization step (QStep) and z may represent rounding parameters. As human vision may not be sensitive to high-frequency components of a frame, according to the position of each transformed data, a quantizing process may apply a large quantization step s to such high-frequency components to reduce an overall bitrate of the encoded video stream.

[0055] Hence, quantization module 208 may generate, based on PPS 210 and a TX data set received from transformation module 212, a quantized (Q) data set. As shown in FIG. 1, this Q data set may be received by an inverse quantization module 216 within hardware

1 distortion data pipeline 202 and a token rate module 218 that may be included as part of
2 hardware token rate pipeline 206. Inverse quantization module 216 may generate an
3 inversely quantized (IQ) data set by executing an inverse quantization of the Q data set, and
4 inverse transformation module 220 may generate an inversely transformed (ITX) data set by
5 executing an inverse transformation of the IQ data set. Distortion module 222, included as
6 part of hardware determination pipeline 204, may then receive the ITX data set and
7 determine a distortion metric based on the ITX data set and residual frame data 214. Likewise,
8 the ITX data set may be passed from the RDO workflow to an intra-frame coding workflow at
9 module 224.

10 **[0056]** Distortion module 222 may determine a distortion metric based on the ITX
11 data set and the residual frame data set in any suitable way, using any suitable distortion
12 metric that may measure a degree of deviation of the ITX data set from residual frame data
13 214. For example, distortion module 222 may determine a mean squared error (MSE)
14 between the ITX data set and residual frame data 214. As other examples, distortion module
15 222 may determine a SSD, SAD, SATD, or other distortion metric. This determined distortion
16 metric may be used by RDO decision module 226 to determine whether to adjust an encoding
17 rate to optimize and/or reduce an amount of distortion in an encoded video stream or file.

18 **[0057]** As noted above, token rate pipeline 206 may determine, via token rate
19 module 218 and based on a Q data set (e.g., quantized data received from quantization
20 module 208), a token rate for an encoding of residual frame data 214 via a video encoding
21 pipeline (e.g., a video encoding pipeline that may include system 200). Token rate module
22 218 may determine the token rate in any suitable way. For example, as further noted above,
23 a rate and/or a suitable λ value may be calculated as a function of a (QP), and various
24 empirical approximations may be used to select λ and/or determine a rate R based on a
25 provided QP.

26 **[0058]** Token rate module 218 may determine a suitable token rate in different
27 ways for different video encoding standards. For example, for an H.264/AVC video encoding
28 standard, the token rate may be calculated via a series of look-up table checking. In
29 conventional H.264 implementations, an encoder may access a single look-up table to find a
30 suitable value for token rate calculation. In conventional VP9 implementations, an encoder
31 may use multiple levels of look-up tables generated from an initial seed probability table.

32 **[0059]** However, in the present system, token rate module 218 may access and/or

1 reference different pre-populated look-up tables depending on a size and/or type of
2 transform unit (TU) sub block under consideration. As an illustration, for VP9, an intra4 × 4
3 block, inter4 × 4 block, intra8 × 8 block, and inter8 × 8 block may each use a different look-up
4 table. These look-up tables may be pre-processed and stored within a suitable storage
5 medium accessible to token rate module 218. In this way, token rate module 218 may access
6 and/or reference a much smaller look-up table for each token rate calculation, which may
7 tremendously reduce computing resources and/or conserve electrical resources.

8 **[0060]** FIG. 3 is a flow diagram of an example computer-implemented method 300
9 for determining token rates within a RDO hardware pipeline as described herein. The steps
10 shown in FIG. 3 may be performed by any suitable computer-executable code, computing
11 hardware, and/or computing system, including system 100 in FIG. 1, system 200 in FIG. 2,
12 and/or variations or combinations of one or more of the same. In one example, each of the
13 steps shown in FIG. 3 may represent an algorithm whose structure includes and/or is
14 represented by multiple sub-steps, examples of which are provided herein.

15 **[0061]** As illustrated in FIG. 3, at step 310, one or more of the systems described
16 herein may store, within a hardware memory device included as part of a RDO hardware
17 pipeline, at least one transform unit table. The transform unit table may (1) be pregenerated
18 from a seed probability table for transformation of video data in accordance with a video
19 encoding standard, (2) correspond to a transform operation supported by the video encoding
20 standard, and (3) correspond to a transform unit included in the RDO hardware pipeline. For
21 example, as described above, storing module 104 may cause one or more components
22 included in system 200 (e.g., token rate module 218) to store, within a hardware memory
23 device included as part of a RDO hardware pipeline (e.g., as part of or accessible to token rate
24 module 218), at least one transform unit table.

25 **[0062]** By way of illustration, FIG. 4 is a block diagram 400 that illustrates
26 generation of transform tables from a seed probability table. As shown in FIG. 4, seed
27 probability transform table 402 may include data that may enable an RDO system to identify
28 a token rate for an RDO operation. As shown in FIG. 4, seed probability table 402 may be used
29 to generate transform tables 404(a) through 404(h), each of which may be associated with a
30 transform operation 406 (e.g., transform operation 406(a) through 406(h)) supported by a
31 video encoding standard (e.g., VP9) and/or a transform unit included in an RDO hardware
32 pipeline (e.g., as shown in FIG. 2). Each of transform tables 404 may be stored within a

1 memory device included in and/or accessible to token rate module 218, and token rate
2 module 218 may access at least one of transform tables 404 to determine a token rate
3 associated with one or more transform operations 406.

4 **[0063]** FIG. 4 may also show various transform partition sizes and operations that
5 may be included as part of one or more hardware pipelines as described herein. As shown, a
6 transformation module (e.g., transformation module 212) may support, for inter-prediction
7 and/or intra-prediction via an H.264/AVC video encoding standard and/or a VP9 video
8 encoding standard, various partition sizes and/or discrete cosine transform block sizes.
9 Furthermore, in some examples, a transformation module may support, for intra-prediction
10 via a VP9 video encoding standard, discrete sine transforms having various block sizes.

11 **[0064]** Returning to FIG. 3, at step 320, one or more of the systems described
12 herein may determine, by accessing the transform unit table, an RDO token rate for an
13 encoding of the video data by a hardware video encoding pipeline that includes the RDO
14 hardware pipeline. For example, determining module 106 may cause one or more
15 components included in system 200 (e.g., token rate module 218) to determine, by accessing
16 the transform unit table, an RDO token rate for an encoding of the video data by a hardware
17 video encoding pipeline that includes the RDO hardware pipeline.

18 **[0065]** As a further illustration, FIG. 5 is a block diagram 500 that illustrates
19 transform tables associated with transform operations that may be included as part of one or
20 more hardware pipelines as described herein. Each of transform tables 502 (e.g., transform
21 table 502(a) through 502(d)) may be associated with a different transform operation 504 (e.g.,
22 transform operations 504(a) through 504(b)), and may be stored within a memory device
23 accessible to token rate module 218. During an encoding of video data (e.g., video data 142),
24 token rate module 218 may access a transform table 502 to determine a token rate associated
25 with a transform operation 504. For example, if the transform operation is a four pixel by four
26 pixel intra transform, token rate module 218 may determine an RDO token rate for the
27 encoding by accessing transform table 502(a), which is associated with transform operation
28 504(a) (i.e., intra transform having a block size of 4×4).

29 **[0066]** Returning to FIG. 3, at step 330, one or more of the systems described
30 herein may select, based on the RDO token rate, a transform operation for the encoding of
31 the video data. For example, selecting module 108 may cause one or more components
32 included in system 200 (e.g., RDO decision module 226) to select a transform operation for

1 the encoding of the video data based on the RDO token rate. As described above in reference
2 to FIG. 2, RDO decision module 226 may determine whether to adjust an encoding rate to
3 optimize and/or reduce an amount of distortion in an encoded video stream or file. Hence, if
4 a token rate determined by token rate module 218 corresponds to a transform operation
5 that, when used to encode the video data at the RDO token rate, meets a predetermined
6 rate-distortion metric, selecting module 108 may cause RDO decision module 226 to select
7 the transform operation to encode the video data.

8 **[0067]** As discussed throughout the instant disclosure, the disclosed systems and
9 methods may provide one or more advantages over traditional options for RDO. In
10 conventional software implementations of RDO, an RDO token rate may be calculated by a
11 series of look up table checking. In software implementations of VP9, an initial seed
12 probability table is read and the results mapped to a much larger intermediate mapped
13 probability table. The bigger table may then be fed into each transform unit partition for a
14 final token rate calculation.

15 **[0068]** Conversely, embodiments of the systems and methods described herein
16 may pre-read in the seed probability table and then pre-generate multiple (e.g., 8) different,
17 potentially much smaller tables, each mapped to a different transform unit. Embodiments
18 may then store the generated transform tables internally (e.g., within the hardware pipeline).
19 Then, during encoding, each transform unit may only need to access a much smaller lookup
20 table (e.g., one or more of transform tables 404 and/or transform tables 502). This may
21 tremendously reduce the hardware resources required for RDO and/or may greatly conserve
22 electrical resources over conventional and/or software based RDO solutions. In some
23 examples, embodiments of the systems and methods described herein may result in up to 30
24 times (e.g., up to 30×) reduction in power consumption over conventional or traditional RDO
25 solutions.

26 **[0069] Example Embodiments**

27 **[0070]** Example 1: A method comprising (1) storing, within a hardware memory
28 device included as part of a rate-distortion optimization (RDO) hardware pipeline, at least
29 one transform unit table that (a) is pregenerated from a seed probability table for
30 transformation of video data in accordance with a video encoding standard, (b) corresponds
31 to a transform operation supported by the video encoding standard, and (c) corresponds to a
32 transform unit included in the RDO hardware pipeline, (2) determining, by accessing the

1 transform unit table, an RDO token rate for an encoding of the video data by a hardware video
2 encoding pipeline that includes the RDO hardware pipeline; and (3) selecting, based on the
3 RDO token rate, a transform operation for the encoding of the video data.

4 **[0071]** Example 2: The computer-implemented method of example 1, wherein
5 selecting the transform operation comprises selecting, from a plurality of transform
6 operations supported by the video encoding standard, a transform operation that, when used
7 to encode the video data at the RDO token rate, meets a predetermined threshold of a rate–
8 distortion metric.

9 **[0072]** Example 3: The computer-implemented method of any of examples 1 and
10 2, further comprising encoding, via the hardware video encoding pipeline, the video data in
11 accordance with the video encoding standard using the selected transform operation.

12 **[0073]** Example 4: The computer-implemented method of any of examples 1–3,
13 wherein the transform unit is included in a plurality of transform units included in the RDO
14 hardware pipeline, each transform unit in the plurality of transform units corresponding to a
15 different transform operation supported by the video encoding standard.

16 **[0074]** Example 5: The computer-implemented method of any of examples 1–4,
17 wherein the transform unit table is included in a plurality of transform unit tables stored
18 within the hardware memory device, each transform unit table in the plurality of transform
19 unit tables corresponding to a different transform operation supported by the video encoding
20 standard.

21 **[0075]** Example 6: The computer-implemented method of any of examples 15,
22 wherein the video encoding standard comprises a VP9 video encoding standard.

23 **[0076]** Example 7: The computer-implemented method of example 6, wherein the
24 transform operation supported by the video encoding standard comprises at least one of (1)
25 a discrete cosine transform having dimensions of up to thirty-two pixels by thirty-two pixels,
26 or (2) a discrete sine transform having dimensions of up to thirty-two pixels by thirty-two
27 pixels.

28 **[0077]** Example 8: The computer-implemented method of example 7, wherein the
29 transform operation supported by the video encoding standard comprises at least one of (1)
30 a discrete cosine transform having dimensions of four pixels by four pixels, (2) a discrete
31 cosine transform having dimensions of eight pixels by eight pixels, (3) a discrete cosine
32 transform having dimensions of sixteen pixels by sixteen pixels, or (4) a discrete cosine

1 transform having dimensions of thirty-two pixels by thirty-two pixels.

2 **[0078]** Example 9: The computer-implemented method of example 8, wherein the
3 transform operation supported by the video encoding standard comprises at least one of (1)
4 a discrete sine transform having dimensions of four pixels by four pixels, (2) a discrete sine
5 transform having dimensions of eight pixels by eight pixels, (3) a discrete sine transform
6 having dimensions of sixteen pixels by sixteen pixels, or (4) a discrete sine transform having
7 dimensions of thirty-two pixels by thirty-two pixels.

8 **[0079]** Example 10: The computer-implemented method of any of examples 1–9,
9 further comprising generating the transform unit table from the seed probability table.

10 **[0080]** Example 11: The computer-implemented method of any of examples 1–10,
11 further comprising generating, from the seed probability table, a plurality of transform unit
12 tables that includes the transform unit table, each transform unit table included in the
13 plurality of transform unit tables corresponding to a different transform operation supported
14 by the RDO hardware pipeline.

15 **[0081]** Example 12: A system comprising (1) a storing module, stored in memory,
16 that stores, within a hardware memory device included as part of a rate–distortion
17 optimization (RDO) hardware pipeline, at least one transform unit table that: (a) is
18 pregenerated from a seed probability table for transformation of video data in accordance
19 with a video encoding standard, (b) corresponds to a transform operation supported by the
20 video encoding standard, and (c) corresponds to a transform unit included in the RDO
21 hardware pipeline, (2) a determining module, stored in memory, that determines, by
22 accessing the transform unit table, an RDO token rate for an encoding of the video data by a
23 hardware video encoding pipeline that includes the RDO hardware pipeline, (3) a selecting
24 module, stored in memory, that selects, based on the RDO token rate, a transform operation
25 for the encoding of the video data, and (4) at least one physical processor that executes the
26 storing module, the determining module, and the selecting module.

27 **[0082]** Example 13: The system of example 12, wherein the selecting module
28 selects the transform operation by selecting, from a plurality of transform operations
29 supported by the video encoding standard, a transform operation that, when used to encode
30 the video data at the RDO token rate, meets a predetermined threshold of a rate–distortion
31 metric.

32 **[0083]** Example 14: The system of any of examples 12 and 13, wherein the

1 selecting module further encodes, via the hardware video encoding pipeline, the video data
2 in accordance with the video encoding standard using the selected transform operation.

3 **[0084]** Example 15: The system of any of example 12–14, wherein the transform
4 unit is included in a plurality of transform units included in the RDO hardware pipeline, each
5 transform unit in the plurality of transform units corresponding to a different transform
6 operation supported by the video encoding standard.

7 **[0085]** Example 16: The system of any of examples 12–15, wherein the transform
8 unit table is included in a plurality of transform unit tables stored within the hardware
9 memory device, each transform unit table in the plurality of transform unit tables
10 corresponding to a different transform operation supported by the video encoding standard.

11 **[0086]** Example 17: The system of example 16, wherein the transform operation
12 supported by the video encoding standard comprises at least one of (1) a discrete cosine
13 transform having dimensions of up to thirty-two pixels by thirty-two pixels, or (2) a discrete
14 sine transform having dimensions of up to thirty-two pixels by thirty-two pixels.

15 **[0087]** Example 18: The system of any of examples 12–17, wherein the storing
16 module further generates the transform unit table from the seed probability table.

17 **[0088]** Example 19: The system of any of examples 12–18, wherein the storing
18 module further generates, from the seed probability table, a plurality of transform unit tables
19 that includes the transform unit table, each transform unit table included in the plurality of
20 transform unit tables corresponding to a different transform operation supported by the RDO
21 hardware pipeline.

22 **[0089]** Example 20: A non-transitory computer-readable medium comprising
23 computer-readable instructions that, when executed by at least one processor of a computing
24 system, cause the computing system to (1) store, within a hardware memory device included
25 as part of a rate–distortion optimization (RDO) hardware pipeline, at least one transform unit
26 table that (a) is pregenerated from a seed probability table for transformation of video data
27 in accordance with a video encoding standard, (b) corresponds to a transform operation
28 supported by the video encoding standard, and (c) corresponds to a transform unit included
29 in the RDO hardware pipeline, (2) determine, by accessing the transform unit table, an RDO
30 token rate for an encoding of the video data by a hardware video encoding pipeline that
31 includes the RDO hardware pipeline, and (3) select, based on the RDO token rate, a transform
32 operation for the encoding of the video data.

1 **[0090]** As detailed above, the computing devices and systems described and/or
2 illustrated herein broadly represent any type or form of computing device or system capable
3 of executing computer-readable instructions, such as those contained within the modules
4 described herein. In their most basic configuration, these computing device(s) may each
5 include at least one memory device and at least one physical processor.

6 **[0091]** Although illustrated as separate elements, the modules described and/or
7 illustrated herein may represent portions of a single module or application. In addition, in
8 certain embodiments one or more of these modules may represent one or more software
9 applications or programs that, when executed by a computing device, may cause the
10 computing device to perform one or more tasks. For example, one or more of the modules
11 described and/or illustrated herein may represent modules stored and configured to run on
12 one or more of the computing devices or systems described and/or illustrated herein. One or
13 more of these modules may also represent all or portions of one or more special-purpose
14 computers configured to perform one or more tasks.

15 **[0092]** In addition, one or more of the modules described herein may transform
16 data, physical devices, and/or representations of physical devices from one form to another.
17 For example, one or more of the modules recited herein may video data to be transformed,
18 transform the video data, output a result of the transformation to perform an RDO function,
19 use the result of the transformation to compress video data, and store the result of the
20 transformation to compress additional video data. Additionally or alternatively, one or more
21 of the modules recited herein may transform a processor, volatile memory, non-volatile
22 memory, and/or any other portion of a physical computing device from one form to another
23 by executing on the computing device, storing data on the computing device, and/or
24 otherwise interacting with the computing device.

25 **[0093]** The term “processor” or “physical processor,” as used herein, generally
26 refers to or represents any type or form of hardware-implemented processing unit capable
27 of interpreting and/or executing computer-readable instructions. In one example, a physical
28 processor may access and/or modify one or more of the modules described herein.
29 Additionally or alternatively, a physical processor may execute one or more of the modules
30 described herein to facilitate one or more RDO processes. Examples of a physical processor
31 include, without limitation, microprocessors, microcontrollers, central processing units
32 (CPUs), Field-Programmable Gate Arrays (FPGAs) that implement softcore processors,

1 Application-Specific Integrated Circuits (ASICs), portions of one or more of the same,
2 variations or combinations of one or more of the same, or any other suitable physical
3 processor.

4 **[0094]** The term “memory,” as used herein, generally refers to or represents any
5 type or form of volatile or non-volatile storage device or medium capable of storing data
6 and/or computer-readable instructions. In one example, memory 120 may store, load, and/or
7 maintain one or more of modules 102. Examples of memory 120 include, without limitation,
8 Random Access Memory (RAM), Read Only Memory (ROM), flash memory, Hard Disk Drives
9 (HDDs), Solid-State Drives (SSDs), optical disk drives, caches, variations or combinations of
10 one or more of the same, or any other suitable storage memory.

11 **[0095]** The term “computer-readable medium,” as used herein, generally refers to
12 any form of device, carrier, or medium capable of storing or carrying computer-readable
13 instructions. Examples of computer-readable media include, without limitation, transmission-
14 type media, such as carrier waves, and non-transitory-type media, such as magnetic-storage
15 media (e.g., hard disk drives, tape drives, and floppy disks), optical-storage media (e.g.,
16 Compact Disks (CDs), Digital Video Disks (DVDs), and BLU-RAY disks), electronic-storage media
17 (e.g., solid-state drives and flash media), and other distribution systems.

18 **[0096]** The process parameters and sequence of the steps described and/or
19 illustrated herein are given by way of example only and can be varied as desired. For example,
20 while the steps illustrated and/or described herein may be shown or discussed in a particular
21 order, these steps do not necessarily need to be performed in the order illustrated or
22 discussed. The various exemplary methods described and/or illustrated herein may also omit
23 one or more of the steps described or illustrated herein or include additional steps in addition
24 to those disclosed.

25 **[0097]** The preceding description has been provided to enable others skilled in the
26 art to best utilize various aspects of the exemplary embodiments disclosed herein. This
27 exemplary description is not intended to be exhaustive or to be limited to any precise form
28 disclosed. Many modifications and variations are possible without departing from the spirit
29 and scope of the instant disclosure. The embodiments disclosed herein should be considered
30 in all respects illustrative and not restrictive. Reference should be made to the appended
31 claims and their equivalents in determining the scope of the instant disclosure.

32 **[0098]** Unless otherwise noted, the terms “connected to” and “coupled to” (and

1 their derivatives), as used in the specification and claims, are to be construed as permitting
2 both direct and indirect (i.e., via other elements or components) connection. In addition, the
3 terms “a” or “an,” as used in the specification and claims, are to be construed as meaning “at
4 least one of.” Finally, for ease of use, the terms “including” and “having” (and their
5 derivatives), as used in the specification and claims, are interchangeable with and have the
6 same meaning as the word “comprising.”

CLAIMS:

- 1 **CLAIMS:**
- 2 1. A method comprising, by a computing system:
- 3 storing, within a hardware memory device included as part of a rate–distortion
- 4 optimization (RDO) hardware pipeline, at least one transform unit table that:
- 5 is pregenerated from a seed probability table for transformation of video data
- 6 in accordance with a video encoding standard;
- 7 corresponds to a transform operation supported by the video encoding
- 8 standard; and
- 9 corresponds to a transform unit included in the RDO hardware pipeline;
- 10 determining, by accessing the transform unit table, an RDO token rate for an
- 11 encoding of the video data by a hardware video encoding pipeline that includes the RDO
- 12 hardware pipeline; and
- 13 selecting, based on the RDO token rate, a transform operation for the encoding of
- 14 the video data.
- 15 2. The method of claim 1, wherein selecting the transform operation comprises
- 16 selecting, from a plurality of transform operations supported by the video encoding
- 17 standard, a transform operation that, when used to encode the video data at the RDO token
- 18 rate, meets a predetermined threshold of a rate–distortion metric.
- 19 3. The method of claim 1, further comprising encoding, via the hardware video
- 20 encoding pipeline, the video data in accordance with the video encoding standard using the
- 21 selected transform operation.
- 22 4. The method of claim 1, wherein the transform unit is included in a plurality of
- 23 transform units included in the RDO hardware pipeline, each transform unit in the plurality
- 24 of transform units corresponding to a different transform operation supported by the video
- 25 encoding standard.
- 26 5. The method of claim 1, wherein the transform unit table is included in a
- 27 plurality of transform unit tables stored within the hardware memory device, each transform
- 28 unit table in the plurality of transform unit tables corresponding to a different transform
- 29 operation supported by the video encoding standard.
- 30 6. The method of claim 1, wherein the video encoding standard comprises a VP9
- 31 video encoding standard; and optionally,
- 32 wherein the transform operation supported by the video encoding standard

comprises at least one of:

a discrete cosine transform having dimensions of up to thirty-two pixels by thirty-two pixels; or

a discrete sine transform having dimensions of up to thirty-two pixels by thirty-two pixels; and optionally,

wherein the transform operation supported by the video encoding standard comprises at least one of:

a discrete cosine transform having dimensions of four pixels by four pixels;

a discrete cosine transform having dimensions of eight pixels by eight pixels;

a discrete cosine transform having dimensions of sixteen pixels by sixteen pixels; or

a discrete cosine transform having dimensions of thirty-two pixels by thirty-two pixels; and optionally,

wherein the transform operation supported by the video encoding standard comprises at least one of:

a discrete sine transform having dimensions of four pixels by four pixels;

a discrete sine transform having dimensions of eight pixels by eight pixels;

a discrete sine transform having dimensions of sixteen pixels by sixteen pixels; or

a discrete sine transform having dimensions of thirty-two pixels by thirty-two pixels.

7. The method of claim 1, further comprising generating the transform unit table from the seed probability table.

8. The method of claim 1, further comprising generating, from the seed probability table, a plurality of transform unit tables that includes the transform unit table, each transform unit table included in the plurality of transform unit tables corresponding to a different transform operation supported by the RDO hardware pipeline.

9. A system comprising:

a storing module, stored in memory, that stores, within a hardware memory device included as part of a rate-distortion optimization (RDO) hardware pipeline, at least one transform unit table that:

is pregenerated from a seed probability table for transformation of video data in accordance with a video encoding standard;

corresponds to a transform operation supported by the video encoding standard; and

1 corresponds to a transform unit included in the RDO hardware pipeline;
2 a determining module, stored in memory, that determines, by accessing the
3 transform unit table, an RDO token rate for an encoding of the video data by a hardware
4 video encoding pipeline that includes the RDO hardware pipeline;
5 a selecting module, stored in memory, that selects, based on the RDO token rate, a
6 transform operation for the encoding of the video data; and
7 at least one physical processor that executes the storing module, the determining
8 module, and the selecting module.

9 10. The system of claim 9, wherein the selecting module selects the transform
10 operation by selecting, from a plurality of transform operations supported by the video
11 encoding standard, a transform operation that, when used to encode the video data at the
12 RDO token rate, meets a predetermined threshold of a rate-distortion metric; and/or
13 wherein the selecting module further encodes, via the hardware video encoding
14 pipeline, the video data in accordance with the video encoding standard using the
15 selected transform operation.

16 11. The system of claim 9, wherein the transform unit is included in a plurality of
17 transform units included in the RDO hardware pipeline, each transform unit in the plurality
18 of transform units corresponding to a different transform operation supported by the video
19 encoding standard.

20 12. The system of claim 9, wherein the transform unit table is included in a
21 plurality of transform unit tables stored within the hardware memory device, each transform
22 unit table in the plurality of transform unit tables corresponding to a different transform
23 operation supported by the video encoding standard.

24 13. The system of claim 9, wherein the storing module further generates the
25 transform unit table from the seed probability table.

26 14. The system of claim 9, wherein the storing module further generates, from
27 the seed probability table, a plurality of transform unit tables that includes the transform
28 unit table, each transform unit table included in the plurality of transform unit tables
29 corresponding to a different transform operation supported by the RDO hardware pipeline.

30 15. A non-transitory computer-readable medium comprising computer-readable
31 instructions that, when executed by at least one processor of a computing system, cause the
32 computing system to perform the method of any of claims 1 to 8.

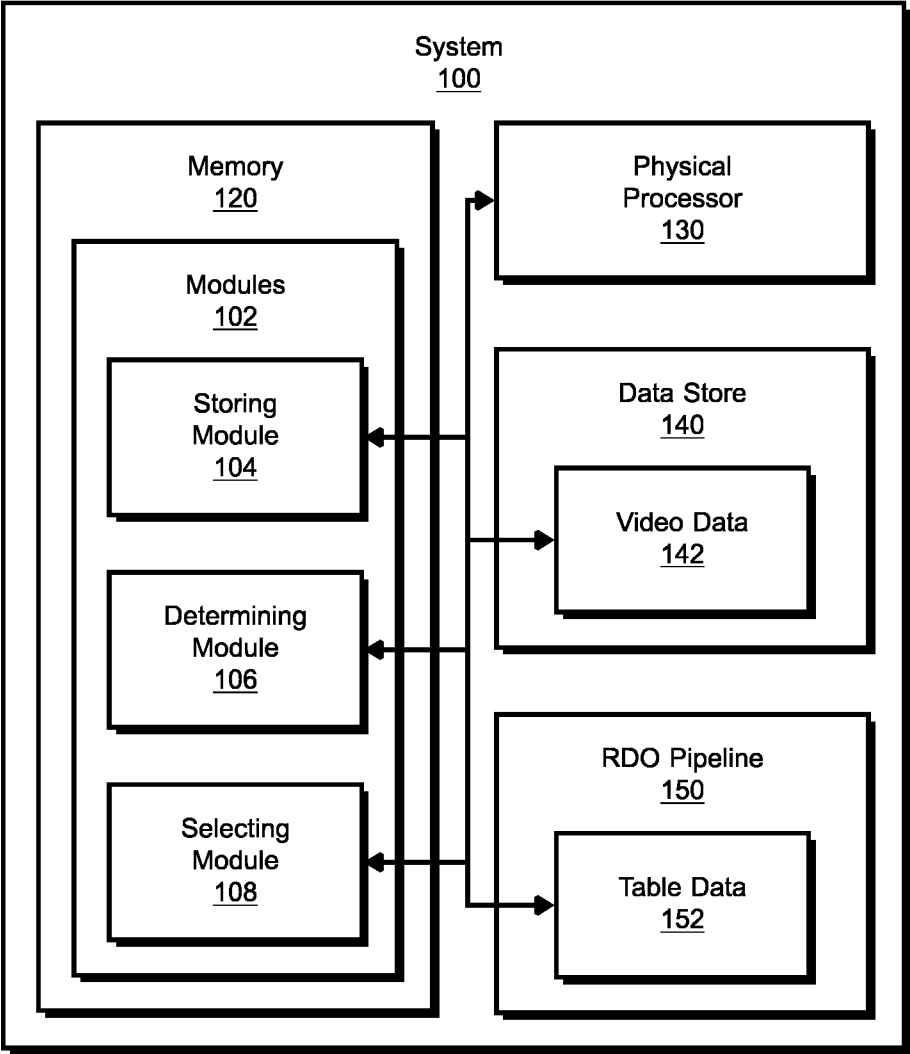


FIG. 1

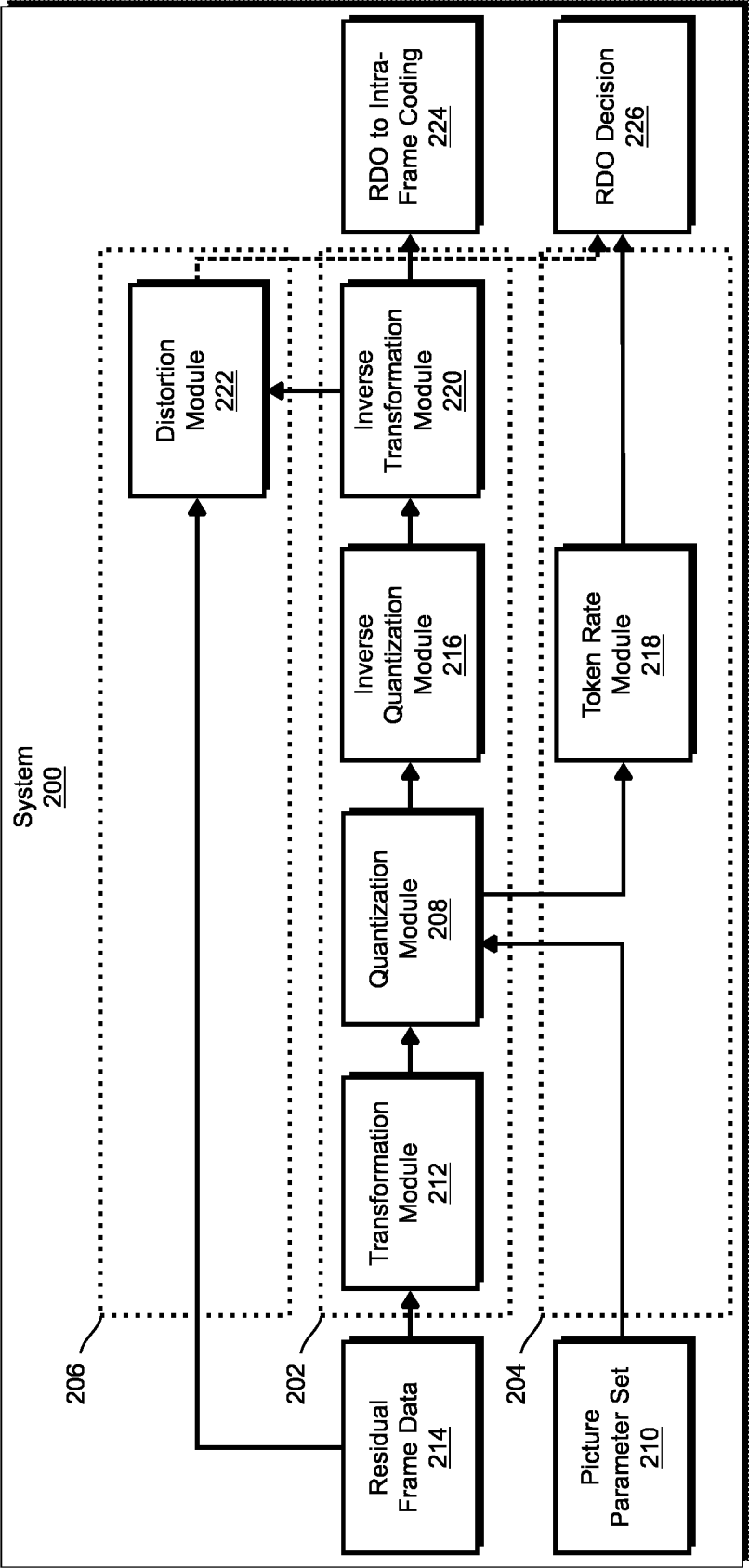
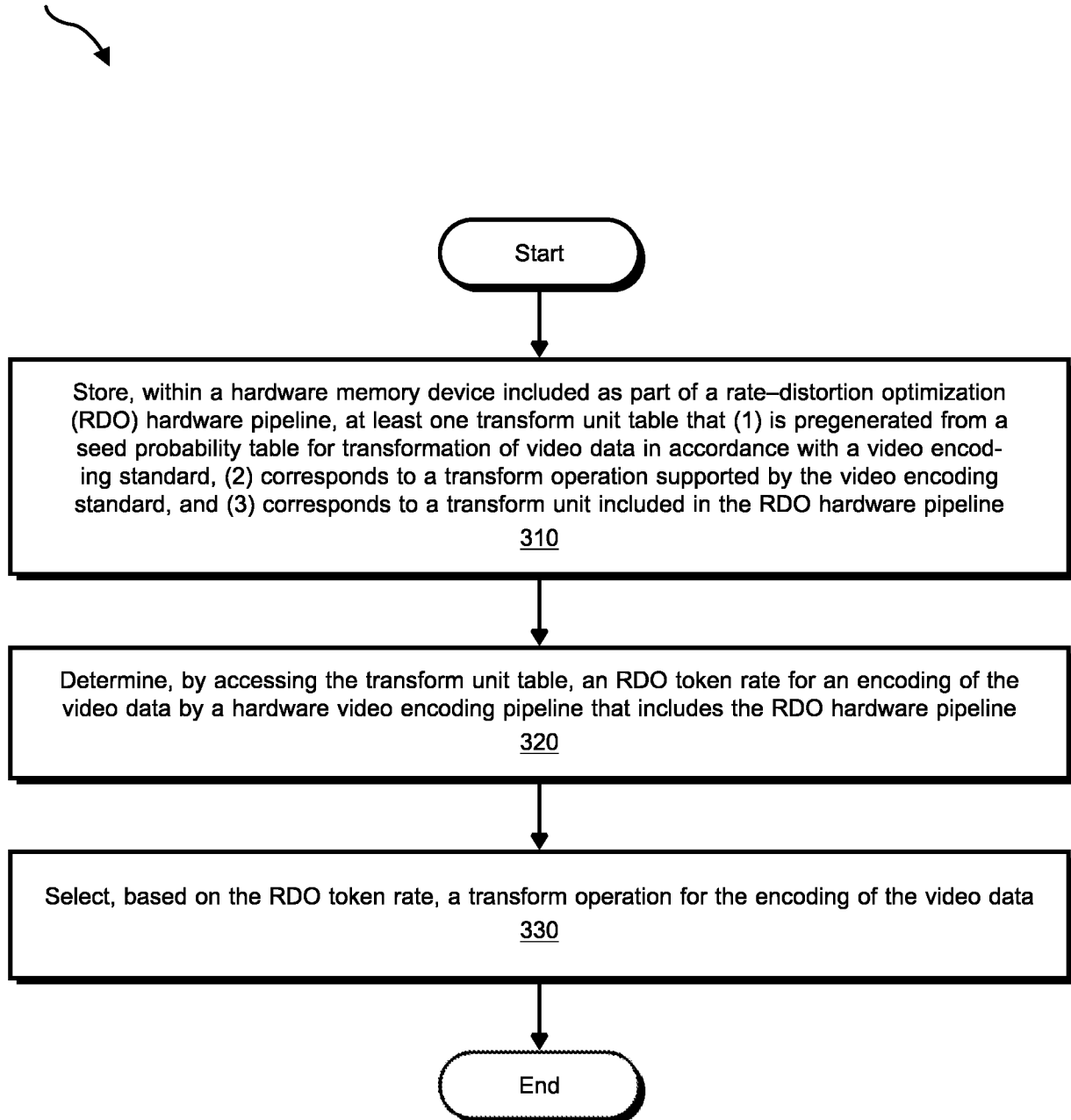


FIG. 2

3/5

300

**FIG. 3**

400 ↗

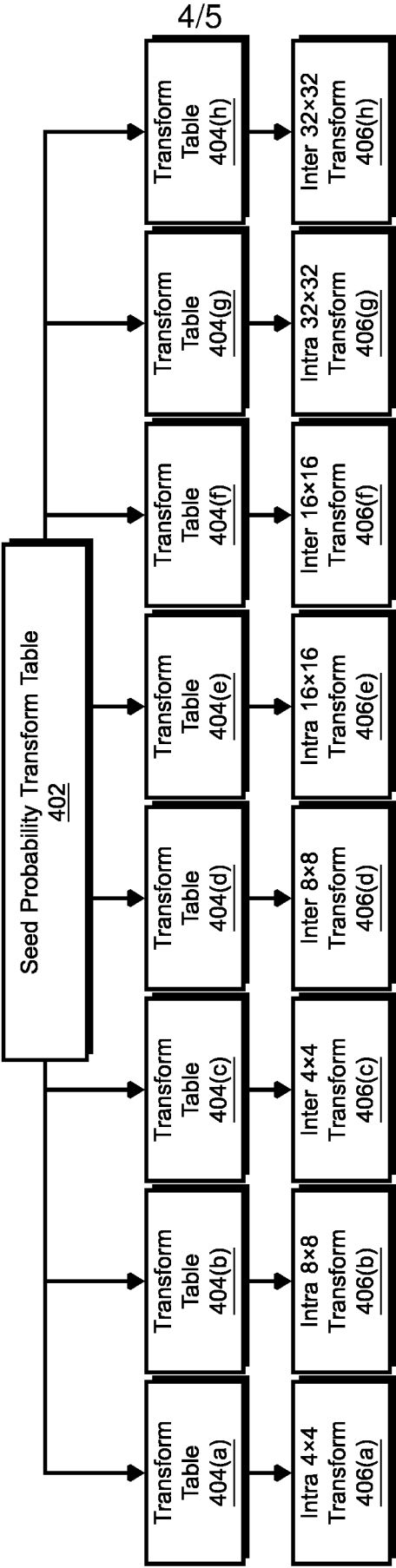


FIG. 4

500 ↗

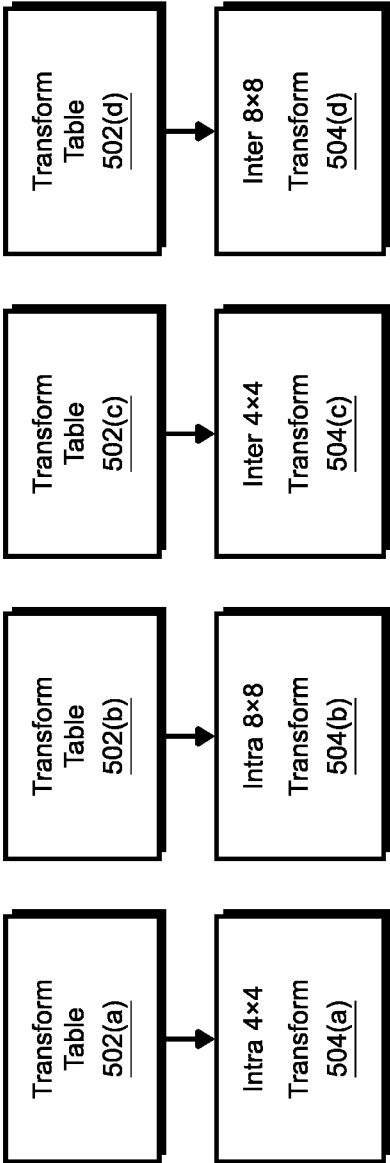


FIG. 5

PATENT COOPERATION TREATY

PCT

DECLARATION OF NON-ESTABLISHMENT OF INTERNATIONAL SEARCH REPORT

(PCT Article 17(2)(a), Rules 13^{ter}.1(c) and Rule 39)

Applicant's or agent's file reference P243230-WO-01	IMPORTANT DECLARATION	Date of mailing(day/month/year) 24 January 2023 (24-01-2023)
International application No. PCT/US2022/040276	International filing date(day/month/year) 14 August 2022 (14-08-2022)	(Earliest) Priority date(day/month/year) 13 August 2021 (13-08-2021)
International Patent Classification (IPC) or both national classification and IPC H04N19/42 H04N19/50 H04N19/147		
Applicant META PLATFORMS, INC.		

This International Searching Authority hereby declares, according to Article 17(2)(a), that **no international search report will be established** on the international application for the reasons indicated below

1. ☐ The subject matter of the international application relates to:
 - a. ☐ scientific theories
 - b. ☐ mathematical theories
 - c. ☐ plant varieties
 - d. ☐ animal varieties
 - e. ☐ essentially biological processes for the production of plants and animals, other than microbiological processes and the products of such processes
 - f. ☐ schemes, rules or methods of doing business
 - g. ☐ schemes, rules or methods of performing purely mental acts
 - h. ☐ schemes, rules or methods of playing games
 - i. ☐ methods for treatment of the human body by surgery or therapy
 - j. ☐ methods for treatment of the animal body by surgery or therapy
 - k. ☐ diagnostic methods practised on the human or animal body
 - l. ☐ mere presentations of information
 - m. ☐ computer programs for which this International Searching Authority is not equipped to search prior art
2. ☐ The failure of the following parts of the international application to comply with prescribed requirements prevents a meaningful search from being carried out:

☒ the description
☒ the claims
☒ the drawings
3. ☒ A meaningful search could not be carried out without the sequence listing; the applicant did not, within the prescribed time limit:

☐ furnish a sequence listing complying with WIPO Standard ST.26, and such listing was not available to the International Searching Authority in a form, language and manner acceptable to it.

☐ pay the required late furnishing fee for the furnishing of a sequence listing in response to an invitation under Rule 13^{ter}.1(a).

4. Further comments:

Name and mailing address of the International Searching Authority  European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040 Fax: (+31-70) 340-3016	Authorized officer BAKVIS, John Tel: +31 (0)70 340-3230
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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 203

See reasoning under item III for reasons for no search.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) PCT declaration be overcome.