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U.S. Patent 9,538,177

U.S. Patent 9,538,177 ("*Communication Advances*" or the "patent-at-issue") was filed on September 12, 2012 and claims the benefit of U.S. Provisional Pat. App. No. 61/553,350, filed on October 31, 2011, and U.S. Provisional Pat. App. No. 61/566,984, filed on December 5, 2011. Claim 10 of the patent-at-issue is generally directed to a buffering method for buffering context arrays of a multi-tile encoded picture having a plurality of tiles. The method comprises buffering a first context array and a second context array referenced for performing entropy decoding upon a first tile and a second tile of the multi-tile encoded picture, respectively. When entropy decoding of the first tile encounters a tile boundary, a multiplexing operation to switch between the buffered first context array and the buffered second context array is performed. Furthermore, entropy decoding of the second tile is started before the first tile is fully entropy decoded.

A primary reference, U.S. Patent 10,455,246 ("*Sun Patent Trust*"), was filed on November 5, 2018 and claims the benefit of U.S. Pat. App. No. 13/148,957, filed on October 13, 2010, and Japanese Pat. App. No. 2009-249538, filed on October 29, 2009. The patent generally relates to an image coding method for improving coding efficiency by using more appropriate probability information, including a first and a second coding step of coding a first set of blocks included in a first region and a second set of blocks included in a second region sequentially based on first probability information and a second probability information, respectively. In the first coding step, the first probability information is updated depending on data of a target block to be coded, after coding the target block and before coding a next target block. In the second coding step, the second probability information is updated depending on the first probability information updated in the first coding step, before coding the first target block.

A primary reference, U.S. Pat. App. Pub. 2023/0224463 ("*Misra*"), was filed on March 21, 2023 and claims the benefit of U.S. Pat. App. No. 13/174,564, filed on June 30, 2011. The patent generally relates to initialization of video encoders and decoders. The decoder receives a slice and identifies its type, and based upon this identification, initializes a context associated with the slice using a context initialization method. The decoder then decodes video frames using the slice and its associated initialized context.

A sample claim chart comparing claim 10 of *Communication Advances* to *Sun Patent Trust* and *Misra* is provided below.

US9538177 (“*Communication Advances*”)	**A. US10455246** (“*Sun Patent Trust*”) **B. US20230224463** (“*Misra*”)
10.pre. **A buffering method for buffering context arrays of a multi-tile encoded picture having a plurality of tiles**, the buffering method comprising:	**A. US10455246** “In accordance with another aspect of the present invention, **there is provided an image coding method of coding an image having a plurality of blocks, the image coding method including coding the blocks sequentially based on probability information indicating a data occurrence probability**, ...” *Sun Patent Trust* at col. 4:55-59 “**The symbol occurrence probability storage unit** 4 **stores probabilities of occurrence of symbols (symbol occurrence probabilities). The context control unit** 5 **determines which symbol occurrence probability is to be used among the symbol occurrence probabilities stored in the symbol occurrence probability storage unit** 4. **Then, the context control unit** 5 **reads the determined symbol occurrence probability from the symbol occurrence probability storage unit** 4. **The binary arithmetic encoder** 6 **performs arithmetic coding based on the symbol occurrence probability provided from the context control unit** 5.” *Sun Patent Trust* at col. 15:5-15 “It should be noted in the first embodiment that **the arithmetic coding method defined by H.264 standard is adopted. However, any other method can be adopted as long as the coding is performed based on the symbol occurrence probability table or data similar to the symbol occurrence probability table which is adaptively updated depending on image**.” *Sun Patent Trust* at col. 17:33-39 “It should also be noted in the first embodiment that **the image coding device codes image in units of macroblocks each having 16 pixels×16 pixels. However, the image coding device may code image in units each having 8 pixels×8 pixels, 32 pixels×32 pixels, or 64 pixels×16 pixels, for example**.” *Sun Patent Trust* at col. 17:40-45 **B. US20230224463** “**Context Model Selection: A context model is a probability model for one or more bins. The context model comprises, for each bin, the probability of the bin being a “1” or a “0.” The model may be chosen for a selection of available models depending on the statistics of recently coded data**

(cont.) 10.pre. **A buffering method for buffering context arrays of a multi-tile encoded picture having a plurality of tiles**, the buffering method comprising:	**symbols, usually based on the left and above neighboring symbols, if available.**" *Misra* at par. 0079 "**A decoder may fetch** 1300 **the next context and entropy decode** 1302 **the next significant transform coefficient from the bitstream using the fetched context. The decoded transform coefficient may be stored** 1304**, and a determination** 1306 **may be made as to whether or not there are remaining significant transform coefficients to be decoded. If there are** 1307**, then the next context may be fetched** 1300**, and the process may continue.**" *Misra* at par. 0227 "1. A method for decoding a video frame, the method comprising: **receiving a bitstream of video data**; . . . **initializing a CABAC context to be used for decoding one or more syntax elements associated with the slice**, wherein" *Misra* at claim 1 "15. The apparatus of claim 13, wherein **the one or more processors further configure the apparatus to partition the video frame into a plurality of slices comprising the slice.**" *Misra* at claim 15
10.a. **buffering a first context array referenced for performing entropy decoding upon a first tile of the multi-tile encoded picture**;	**A. US10455246** "In accordance with still another aspect of the present invention, **there is provided an image decoding method of decoding an image having a plurality of regions each including a plurality of blocks, the image decoding method including: decoding a first set of blocks included in a first region of the regions sequentially based on first probability information indicating a data occurrence probability**; and decoding a second set of blocks included in a second region of the regions sequentially based on second probability information indicating a data occurrence probability, the second region being different from the first region, ..." *Sun Patent Trust* at col. 7:4-14 "At the beginning, **the first decoding unit** 71 **sequentially decodes blocks included in the first region of the plurality of regions, based on first probability information indicating data occurrence probabilities** (S821). **After decoding of a target block to be decoded and before decoding of a next block to be decoded, the first decoding unit** 71 **updates the**

(cont.) 10.a. **buffering a first context array referenced for performing entropy decoding upon a first tile of the multi-tile encoded picture**;	**first probability information depending on data of the target block**." *Sun Patent Trust* at col. 47:24-31 "Then, **based on the symbol occurrence probability, the binary arithmetic decoder** 49 **arithmetic-decodes the target macroblock using a method defined by H.264 standard** (S702)." *Sun Patent Trust* at col. 43:43-46 **B. US20230224463** "**FIG. 3 shows an exemplary video picture** 90 **comprising eleven macroblocks in the horizontal direction and nine macroblocks in the vertical direction** (nine exemplary macroblocks labeled 91-99). **FIG. 3 shows three exemplary slices: a first slice denoted "SLICE #0"** 100, **a second slice denoted "SLICE #1"** 101 **and a third slice denoted "SLICE #2"** 102. **An H.264/AVC decoder may decode and reconstruct the three slices** 100, 101, 102 **in parallel. At the beginning of the decoding/reconstruction process for each slice, context models are initialized or reset and macroblocks in other slices are marked as unavailable for both entropy decoding and macroblock reconstruction**." *Misra* at par. 0070
10.b. **buffering a second context array referenced for performing entropy decoding upon a second tile of the multi-tile encoded picture when the first tile is currently decoded according to the buffered first context array**; and	**A. US10455246** "In accordance with still another aspect of the present invention, **there is provided an image decoding method of decoding an image having a plurality of regions each including a plurality of blocks, the image decoding method including:** decoding a first set of blocks included in a first region of the regions sequentially based on first probability information indicating a data occurrence probability; and **decoding a second set of blocks included in a second region of the regions sequentially based on second probability information indicating a data occurrence probability, the second region being different from the first region**, ..." *Sun Patent Trust* at col. 7:4-14 "**At the beginning, the first decoding unit** 71 **sequentially decodes blocks included in the first region of the plurality of regions, based on first probability information indicating data occurrence probabilities** (S821). After decoding of a target block to be decoded and before decoding of a next block to be decoded, the first decoding unit 71 updates the first probability information depending on data of the target block. **Next, the second decoding unit** 72 **sequentially decodes blocks included in a second region of the plurality of**

(cont.) 10.b. **buffering a second context array referenced for performing entropy decoding upon a second tile of the multi-tile encoded picture when the first tile is currently decoded according to the buffered first context array**; and	**regions, based on second probability information indicating data occurrence probabilities** (S822). **After decoding of a target block to be decoded and before decoding of a next block to be decoded, the second decoding unit** 72 **updates the second probability information depending on data of the target block**." *Sun Patent Trust* at col. 47:24-39 "Then, **based on the symbol occurrence probability, the binary arithmetic decoder** 49 **arithmetic-decodes the target macroblock using a method defined by H.264 standard** (S702)." *Sun Patent Trust* at col. 43:43-46 **B. US20230224463** "**FIG. 3 shows an exemplary video picture** 90 **comprising eleven macroblocks in the horizontal direction and nine macroblocks in the vertical direction** (nine exemplary macroblocks labeled 91-99). **FIG. 3 shows three exemplary slices: a first slice denoted "SLICE #0"** 100, **a second slice denoted "SLICE #1"** 101 **and a third slice denoted "SLICE #2"** 102. **An H.264/AVC decoder may decode and reconstruct the three slices** 100, 101, 102 **in parallel. At the beginning of the decoding/reconstruction process for each slice, context models are initialized or reset and macroblocks in other slices are marked as unavailable for both entropy decoding and macroblock reconstruction.**" *Misra* at par. 0070 "In these embodiments, **the decoder may be capable of parallel decoding and may define its own degree of parallelism, for example, consider a decoder comprising the capability of decoding N entropy slices in parallel**. . . . **After identifying** 170 **up to N entropy slices, each of the identified entropy slices may be independently entropy decoded. A first entropy slice may be decoded** 172-176. **The decoding** 172-176 **of the first entropy slice may comprise resetting the decoder state** 172. In some embodiments comprising CABAC entropy decoding, the CABAC state may be reset. **The neighbor information for the entropy decoding of the first entropy slice may be defined** 174, **and the first entropy slice data may be decoded** 176. **For each of the up to N entropy slices, these steps may be performed** (178-182 for the Nth entropy slice)." *Misra* at par. 0089 "In some embodiments of the present invention, **when there are more than N entropy slices, a decode thread may begin**

(cont.) 10.b. **buffering a second context array referenced for performing entropy decoding upon a second tile of the multi-tile encoded picture when the first tile is currently decoded according to the buffered first context array**; and	**entropy decoding a next entropy slice upon the completion of entropy decoding of an entropy slice. Thus when a thread finishes entropy decoding a low complexity entropy slice, the thread may commence decoding additional entropy slices without waiting for other threads to finish their decoding.**" *Misra* at par. 0090
10.c. **when entropy decoding of the first tile encounters a tile boundary, performing a multiplexing operation to switch between the buffered first context array and the buffered second context array**;	**A. US10455246** "**At the beginning, the first decoding unit** 71 **sequentially decodes blocks included in the first region of the plurality of regions, based on first probability information indicating data occurrence probabilities** (S821). **After decoding of a target block to be decoded and before decoding of a next block to be decoded, the first decoding unit** 71 **updates the first probability information depending on data of the target block**. **Next, the second decoding unit** 72 **sequentially decodes blocks included in a second region of the plurality of regions, based on second probability information indicating data occurrence probabilities** (S822). **After decoding of a target block to be decoded and before decoding of a next block to be decoded, the second decoding unit** 72 **updates the second probability information depending on data of the target block**. **Furthermore, prior to decoding of the first block to be decoded, the second decoding unit** 72 **updates the second probability information based on the first probability information updated by the first decoding unit** 71." *Sun Patent Trust* at col. 47:24-43 "Moreover, **a symbol occurrence probability table should be exchanged between the arithmetic coding unit** 1 **and the arithmetic coding unit** 2 **only when a macroblock is coded based on information of a macroblock in a different slice**." *Sun Patent Trust* at col. 37:8-11 "**The neighbor information memory** 46 **stores information of neighboring macroblocks of a target macroblock**." *Sun Patent Trust* at col. 42:37-39 "Then, **the context control unit** 48 **controls a context using a method defined by H.264 standard** (S701). **The context control refers to processing of reading a symbol occurrence probability corresponding to a target macroblock to be**

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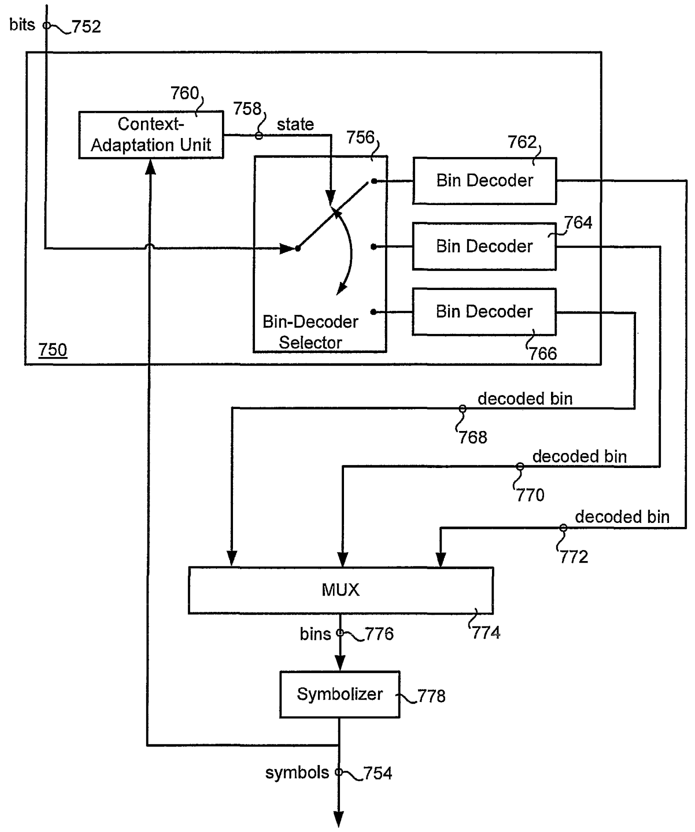
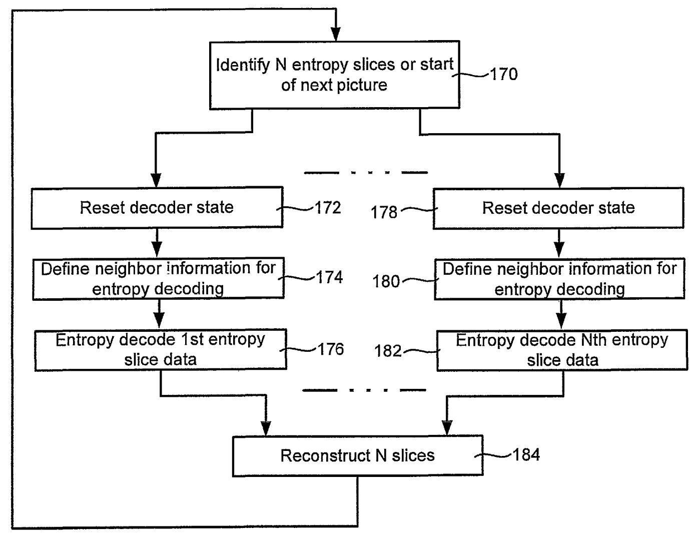
(cont.) 10.c. **when entropy decoding of the first tile encounters a tile boundary, performing a multiplexing operation to switch between the buffered first context array and the buffered second context array**;	**decoded from the symbol occurrence probability storage unit** 47 **based on information of neighboring macroblock(s) of the target macroblock (neighbor information) and a bit position to be decoded, and then providing the symbol occurrence probability to the binary arithmetic decoder** 49. **Then, based on the symbol occurrence probability, the binary arithmetic decoder** 49 **arithmetic-decodes the target macroblock using a method defined by H.264 standard** (S702).” *Sun Patent Trust* at col. 43:34-46 **B. US20230224463** “**At the beginning of the decoding**/**reconstruction process for each slice, context models are initialized or reset and macroblocks in other slices are marked as unavailable for both entropy decoding and macroblock reconstruction.**” *Misra* at par. 0070 “**Context Model Selection: A context model is a probability model for one or more bins. The context model comprises, for each bin, the probability of the bin being a “1” or a “0.” The model may be chosen for a selection of available models depending on the statistics of recently coded data symbols, usually based on the left and above neighboring symbols, if available.**” *Misra* at par. 0079 “**Context adaptation may refer to the process of selecting, based on neighboring symbol values, a context model state, also referred to as a state, associated with a bin and updating a model probability distribution assigned to the given symbols. The location of the neighboring symbols may be defined according to a context template.**” *Misra* at par. 0082 “**The context-adaptation unit** 760 **may generate the context state** 758 **based on the previously decoded symbols** 754 **made available to the context-adaptation unit** 760. **The bin-decoder selector** 756 **may assign a bin-decoder** 762, 764, 766 **based on the context state** 756. **The bit to be decoded** 752 **may be passed by the bin-decoder selector** 756 **to the selected bin decoder. The bin decoders** 762, 764, 766 **may generate decoded bins** 768, 770, 772 **which may be multiplexed by a multiplexer** 774 **and the multiplexed bins** 776 **may be sent to a symbolizer** 778 **which may generate the symbols** 754 **associated with the bins** 776.” *Misra* at par. 0151

(cont.) 10.c. **when entropy decoding of the first tile encounters a tile boundary, performing a multiplexing operation to switch between the buffered first context array and the buffered second context array**;	 FIG. 22 "In some embodiments, **the context models may be reset based on the context models of a neighboring macroblock if the neighboring macroblock is within the entropy slice and default values if the neighboring macroblock is not within the entropy slice**. **For example, the context models** may be **reset based on the context models of the macroblock above the current macroblock if the macroblock above the current macroblock is in the same entropy slice, but set to default values if the macroblock above the current macroblock is not in the same entropy slice**." *Misra* at par. 0195
10.d. **wherein entropy decoding** of **the second tile is started before the first tile is fully entropy decoded**.	**B. US20230224463** "**FIG. 3 shows three exemplary slices: a first slice denoted "SLICE #0"** 100, **a second slice denoted "SLICE #1"** 101 **and a third slice denoted "SLICE #2"** 102. **An H.264/AVC decoder may decode and reconstruct the three slices** 100, 101, 102 **in parallel**." *Misra* at par. 0070 "**Each entropy slice** 114, 115, 116 **may be entropy decoded in parallel**." *Misra* at par. 0084

(cont.) 10.d. **wherein entropy decoding of the second tile is started before the first tile is fully entropy decoded.**	 FIG. 7 "In these embodiments, **the decoder may be capable of parallel decoding and may define its own degree of parallelism, for example, consider a decoder comprising the capability of decoding N entropy slices in parallel**. . . . **After identifying** 170 **up to N entropy slices, each of the identified entropy slices may be independently entropy decoded. A first entropy slice may be decoded** 172-176. **The decoding** 172-176 **of the first entropy slice may comprise resetting the decoder state** 172. In some embodiments comprising CABAC entropy decoding, the CABAC state may be reset. **The neighbor information for the entropy decoding of the first entropy slice may be defined** 174, **and the first entropy slice data may be decoded** 176. **For each of the up to N entropy slices, these steps may be performed** (178-182 for the Nth entropy slice)." *Misra* at par. 0089 "In some embodiments of the present invention, **when there are more than N entropy slices, a decode thread may begin entropy decoding a next entropy slice upon the completion of entropy decoding of an entropy slice. Thus when a thread finishes entropy decoding a low complexity entropy slice, the thread may commence decoding additional entropy slices without waiting for other threads to finish their decoding**." *Misra* at par. 0090