

WHAT IS CLAIMED IS:

1. A method of coding data, the method comprising:

determining a plurality of estimator functions to be used to calculate a probability of a symbol having a particular value, wherein the symbol is to be binary arithmetic coded according to the probability, and wherein the estimator functions do not include division operations;

determining a plurality of weights for the plurality of estimator functions such that when the respective weights are applied to the estimator functions, a resulting sum of outputs of the plurality of estimator functions yields the probability;

calculating the probability of the symbol having the particular value, comprising:

executing the estimator functions without using the division operations to determine the outputs of the estimator functions; and

calculating a sum of the outputs as the probability; and

binary arithmetic coding the symbol according to the probability of the symbol having the particular value.

2. The method of claim 1, wherein calculating the probability comprises calculating the probability according to:

$$Q_1[k+1] = \begin{cases} Q_1[k] - \left\lfloor \frac{Q_1[k]}{2^{S_1}} \right\rfloor, & b[k] = 0 \\ Q_1[k] + \left\lfloor \frac{W_1 - Q_1[k]}{2^{S_1}} \right\rfloor, & b[k] = 1 \end{cases}$$

$$\vdots$$

$$Q_M[k+1] = \begin{cases} Q_M[k] - \left\lfloor \frac{Q_M[k]}{2^{S_M}} \right\rfloor, & b[k] = 0 \\ Q_M[k] + \left\lfloor \frac{W_M - Q_M[k]}{2^{S_M}} \right\rfloor, & b[k] = 1 \end{cases},$$

$$P[k+1] = \sum_{i=1}^M Q_i[k+1]$$

wherein $k+1$ represents a coding order of the symbol, $\{W_1, \dots, W_M\}$ comprises the weights, and $\{Q_1[k+1], \dots, Q_M[k+1]\}$ comprises the estimator functions, and wherein executing the estimator functions comprises performing right-shift operations instead of the division operations.

3. The method of claim 1, wherein calculating the probability comprises calculating the probability according to:

$$Q_1[k+1] = \begin{cases} Q_1[k] - \left\lfloor \frac{Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 0 \\ Q_1[k] + \left\lfloor \frac{W_1 - Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 1 \end{cases}$$

$$\vdots$$

$$Q_M[k+1] = \begin{cases} Q_M[k] - \left\lfloor \frac{Q_M[k]}{2^{S_M}} \right\rfloor, b[k] = 0 \\ Q_M[k] + \left\lfloor \frac{W_M - Q_M[k]}{2^{S_M}} \right\rfloor, b[k] = 1 \end{cases}$$

$$P[k+1] = \sum_{i=1}^M 2^{L-L_i} Q_i[k+1]$$

wherein $k+1$ represents a coding order of the symbol, $\{W_1, \dots, W_M\}$ comprises the weights, $\{S_1, \dots, S_M\}$ comprise shift parameters, and $\{Q_1[k+1], \dots, Q_M[k+1]\}$ comprises the estimator functions, and wherein executing the estimator functions comprises performing right-shift operations using the shift parameters instead of the division operations.

4. The method of claim 1, wherein calculating the probability comprises calculating the probability according to:

$$Q_1[k+1] = \begin{cases} Q_1[k] - \left\lfloor \frac{Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 0 \\ Q_1[k] + \left\lfloor \frac{2^{L-1} - Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 1 \end{cases}$$

$$Q_2[k+1] = \begin{cases} Q_2[k] - \left\lfloor \frac{Q_2[k]}{2^{S_2}} \right\rfloor, b[k] = 0 \\ Q_2[k] + \left\lfloor \frac{2^{L-1} - Q_2[k]}{2^{S_2}} \right\rfloor, b[k] = 1 \end{cases}$$

$$P[k+1] = Q_1[k+1] + Q_2[k+1]$$

wherein $k+1$ represents a coding order of the symbol, 2^{L-1} comprises the weights, $\{S_1, S_2\}$ comprise shift parameters, and $\{Q_1[k+1], Q_2[k+1]\}$ comprises the estimator functions, and wherein executing the estimator functions comprises performing right-shift operations using the shift parameters instead of the division operations.

5. The method of claim 1, further comprising maintaining a plurality of state elements Q_1 to Q_M for a finite state machine used to calculate the probability as the tuple $(P[k], Q_1[k], \dots, Q_M[k])$, wherein $P[k] = \sum_{i=1}^M 2^{L-L_i} Q_i[k]$.

6. The method of claim 5, further comprising computing $Q_1[k] = P[k] - \sum_{i=2}^M 2^{L-L_i} Q_i[k]$ only when Q_1 needs to be updated.

7. The method of claim 1, wherein calculating the probability comprises calculating the probability without performing multiplication operations.
8. The method of claim 1, wherein binary arithmetic coding the symbol comprises binary arithmetic encoding the symbol, comprising:
 - determining whether a value of the symbol has the particular value; and
 - generating data representative of whether the value of the symbol has the particular value using the probability.
9. The method of claim 1, wherein binary arithmetic coding the symbol comprises binary arithmetic decoding the symbol, comprising:
 - receiving data representative of whether a value of the symbol has the particular value; and
 - determining the value of the symbol according to the received data using the probability.
10. The method of claim 1, wherein the symbol comprises a bin of a syntax element of video data.
11. The method of claim 10, further comprising decoding the video data using the syntax element, comprising:
 - forming one or more prediction blocks;
 - decoding transform coefficients;
 - inverse transforming the transformation coefficients to form one or more residual blocks; and
 - combining residual samples of the residual blocks with prediction samples of the prediction blocks to decode blocks of pictures of the video data,wherein the syntax element represents one of a prediction mode, one of the transformation coefficients, or partitioning information for partitioning the pictures into the blocks.

12. The method of claim 10, further comprising encoding the video data using the syntax element, comprising:
- forming one or more prediction blocks;
 - subtracting the prediction blocks from uncoded blocks to produce residual blocks;
 - transforming residual samples of the residual blocks to form transformation coefficients; and
 - encoding the transform coefficients,
- wherein the syntax element represents one of a prediction mode, one of the transformation coefficients, or partitioning information for partitioning the pictures into the blocks.
13. A device for coding data, the device comprising:
- a memory configured to store data; and
 - a processor implemented in circuitry and configured to:
 - determine a plurality of estimator functions to be used to calculate a probability of a symbol having a particular value, wherein the symbol is to be binary arithmetic coded according to the probability, and wherein the estimator functions do not include division operations;
 - determine a plurality of weights for the plurality of estimator functions such that when the respective weights are applied to the estimator functions, a resulting sum of outputs of the plurality of estimator functions yields the probability;
 - calculate the probability of the symbol having the particular value, wherein to calculate the probability, the processor is configured to:
 - execute the estimator functions without using the division operations to determine the outputs of the estimator functions; and
 - calculate a sum of the outputs as the probability; and
 - binary arithmetic code the symbol according to the probability of the symbol having the particular value.

14. The device of claim 13, wherein the processor is configured to calculate the probability according to:

$$\begin{aligned}
 Q_1[k+1] &= \begin{cases} Q_1[k] - \left\lfloor \frac{Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 0 \\ Q_1[k] + \left\lfloor \frac{W_1 - Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 1 \end{cases} \\
 &\vdots \\
 Q_M[k+1] &= \begin{cases} Q_M[k] - \left\lfloor \frac{Q_M[k]}{2^{S_M}} \right\rfloor, b[k] = 0 \\ Q_M[k] + \left\lfloor \frac{W_M - Q_M[k]}{2^{S_M}} \right\rfloor, b[k] = 1 \end{cases} \\
 P[k+1] &= \sum_{i=1}^M Q_i[k+1]
 \end{aligned}$$

wherein $k+1$ represents a coding order of the symbol, $\{W_1, \dots, W_M\}$ comprises the weights, $\{S_1, \dots, S_M\}$ comprise shift parameters, and $\{Q_1[k+1], \dots, Q_M[k+1]\}$ comprises the estimator functions, and wherein executing the estimator functions comprises performing right-shift operations using the shift parameters instead of the division operations.

15. The device of claim 13, wherein the processor is configured to calculate the probability according to:

$$\begin{aligned}
 Q_1[k+1] &= \begin{cases} Q_1[k] - \left\lfloor \frac{Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 0 \\ Q_1[k] + \left\lfloor \frac{W_1 - Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 1 \end{cases} \\
 &\vdots \\
 Q_M[k+1] &= \begin{cases} Q_M[k] - \left\lfloor \frac{Q_M[k]}{2^{S_M}} \right\rfloor, b[k] = 0 \\ Q_M[k] + \left\lfloor \frac{W_M - Q_M[k]}{2^{S_M}} \right\rfloor, b[k] = 1 \end{cases} \\
 P[k+1] &= \sum_{i=1}^M 2^{L-L_i} Q_i[k+1]
 \end{aligned}$$

wherein $k+1$ represents a coding order of the symbol, $\{W_1, \dots, W_M\}$ comprises the weights, $\{S_1, \dots, S_M\}$ comprise shift parameters, and $\{Q_1[k+1], \dots, Q_M[k+1]\}$ comprises the estimator functions, and wherein executing the estimator functions comprises performing right-shift operations using the shift parameters instead of the division operations.

16. The device of claim 13, wherein the processor is configured to calculate the probability according to:

$$Q_1[k+1] = \begin{cases} Q_1[k] - \left\lfloor \frac{Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 0 \\ Q_1[k] + \left\lfloor \frac{2^{L-1} - Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 1 \end{cases},$$

$$Q_2[k+1] = \begin{cases} Q_2[k] - \left\lfloor \frac{Q_2[k]}{2^{S_2}} \right\rfloor, b[k] = 0 \\ Q_2[k] + \left\lfloor \frac{2^{L-1} - Q_2[k]}{2^{S_2}} \right\rfloor, b[k] = 1 \end{cases},$$

$$P[k+1] = Q_1[k+1] + Q_2[k+1]$$

wherein $k+1$ represents a coding order of the symbol, 2^{L-1} comprises the weights, $\{S_1, S_2\}$ comprise shift parameters, and $\{Q_1[k+1], Q_2[k+1]\}$ comprises the estimator functions, and wherein executing the estimator functions comprises performing right-shift operations using the shift parameters instead of the division operations.

17. The device of claim 13, wherein the processor is further configured to maintain a plurality of state elements Q_1 to Q_M for a finite state machine used to calculate the probability as the tuple $(P[k], Q_1[k], \dots, Q_M[k])$, wherein $P[k] = \sum_{i=1}^M 2^{L-L_i} Q_i[k]$.

18. The device of claim 17, wherein the processor is further configured to compute $Q_1[k] = P[k] - \sum_{i=2}^M 2^{L-L_i} Q_i[k]$ only when Q_1 needs to be updated.

19. The device of claim 13, wherein the processor is further configured to calculate the probability without performing multiplication operations.

20. The device of claim 13, wherein the processor is configured to binary arithmetic encode the symbol, and to binary arithmetic encode the symbol, the processor is configured to:

determine whether a value of the symbol has the particular value; and
generate data representative of whether the value of the symbol has the particular value using the probability.

21. The device of claim 13, wherein the processor is configured to binary arithmetic decode the symbol, and to binary arithmetic decode the symbol, the processor is configured to:

- receive data representative of whether a value of the symbol has the particular value; and

- determine the value of the symbol according to the received data using the probability.

22. The device of claim 13, wherein the symbol comprises a bin of a syntax element of video data.

23. The device of claim 22, further comprising a display configured to display decoded video data, and wherein the processor is further configured to decode the video data using the syntax element, wherein to decode the video data, the processor is configured to:

- form one or more prediction blocks;

- decode transform coefficients;

- inverse transform the transformation coefficients to form one or more residual blocks; and

- combine residual samples of the residual blocks with prediction samples of the prediction blocks to decode blocks of pictures of the video data,

- wherein the syntax element represents one of a prediction mode, one of the transformation coefficients, or partitioning information for partitioning the pictures into the blocks.

24. The device of claim 13, further comprising a camera configured to capture video data, and wherein the processor is further configured to encode the video data using the syntax element, wherein to decode the video data, the processor is configured to:

form one or more prediction blocks;

subtract the prediction blocks from uncoded blocks to produce residual blocks;

transform residual samples of the residual blocks to form transformation coefficients; and

encode the transform coefficients,

wherein the syntax element represents one of a prediction mode, one of the transformation coefficients, or partitioning information for partitioning the pictures into the blocks.

25. The device of claim 13, wherein the device comprises one or more of a camera, a computer, a mobile device, a broadcast receiver device, or a set-top box.

26. The device of claim 13, wherein the device comprises at least one of:

an integrated circuit;

a microprocessor; or

a wireless communication device that includes the one or more means.

27. A computer-readable storage medium having stored thereon instructions that, when executed, cause a processor to:

determine a plurality of estimator functions to be used to calculate a probability of a symbol having a particular value, wherein the symbol is to be binary arithmetic coded according to the probability, and wherein the estimator functions do not include division operations;

determine a plurality of weights for the plurality of estimator functions such that when the respective weights are applied to the estimator functions, a resulting sum of outputs of the plurality of estimator functions yields the probability;

calculate the probability of the symbol having the particular value, comprising instructions that cause the processor to:

execute the estimator functions without using the division operations to

determine the outputs of the estimator functions; and

calculate a sum of the outputs as the probability; and

binary arithmetic code the symbol according to the probability of the symbol having the particular value.

28. The computer-readable storage medium of claim 27, wherein the instructions that cause the processor to calculate the probability comprise instructions that cause the processor to calculate the probability according to:

$$\begin{aligned}
 Q_1[k+1] &= \begin{cases} Q_1[k] - \left\lfloor \frac{Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 0 \\ Q_1[k] + \left\lfloor \frac{W_1 - Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 1 \end{cases} \\
 &\vdots \\
 Q_M[k+1] &= \begin{cases} Q_M[k] - \left\lfloor \frac{Q_M[k]}{2^{S_M}} \right\rfloor, b[k] = 0 \\ Q_M[k] + \left\lfloor \frac{W_M - Q_M[k]}{2^{S_M}} \right\rfloor, b[k] = 1 \end{cases} \\
 P[k+1] &= \sum_{i=1}^M Q_i[k+1]
 \end{aligned}$$

wherein k+1 represents a coding order of the symbol, $\{W_1, \dots, W_M\}$ comprises the weights, $\{S_1, \dots, S_M\}$ comprise shift parameters, and $\{Q_1[k+1], \dots, Q_M[k+1]\}$ comprises the estimator functions, and wherein executing the estimator functions comprises performing right-shift operations using the shift parameters instead of the division operations.

29. The computer-readable storage medium of claim 27, wherein the instructions that cause the processor to calculate the probability comprise instructions that cause the processor to calculate the probability according to:

$$\begin{aligned}
 Q_1[k+1] &= \begin{cases} Q_1[k] - \left\lfloor \frac{Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 0 \\ Q_1[k] + \left\lfloor \frac{W_1 - Q_1[k]}{2^{S_1}} \right\rfloor, b[k] = 1 \end{cases} \\
 &\vdots \\
 Q_M[k+1] &= \begin{cases} Q_M[k] - \left\lfloor \frac{Q_M[k]}{2^{S_M}} \right\rfloor, b[k] = 0 \\ Q_M[k] + \left\lfloor \frac{W_M - Q_M[k]}{2^{S_M}} \right\rfloor, b[k] = 1 \end{cases} \\
 P[k+1] &= \sum_{i=1}^M 2^{L-L_i} Q_i[k+1]
 \end{aligned}$$

wherein k+1 represents a coding order of the symbol, $\{W_1, \dots, W_M\}$ comprises the weights, $\{S_1, \dots, S_M\}$ comprise shift parameters, and $\{Q_1[k+1], \dots, Q_M[k+1]\}$ comprises the estimator functions, and wherein executing the estimator functions comprises performing right-shift operations using the shift parameters instead of the division operations.

30. The computer-readable storage medium of claim 27, wherein the instructions that cause the processor to calculate the probability comprise instructions that cause the processor to calculate the probability according to:

$$Q_1[k+1] = \begin{cases} Q_1[k] - \left\lfloor \frac{Q_1[k]}{2^{S_1}} \right\rfloor, & b[k] = 0 \\ Q_1[k] + \left\lfloor \frac{2^{L-1} - Q_1[k]}{2^{S_1}} \right\rfloor, & b[k] = 1 \end{cases}$$

$$Q_2[k+1] = \begin{cases} Q_2[k] - \left\lfloor \frac{Q_2[k]}{2^{S_2}} \right\rfloor, & b[k] = 0 \\ Q_2[k] + \left\lfloor \frac{2^{L-1} - Q_2[k]}{2^{S_2}} \right\rfloor, & b[k] = 1 \end{cases},$$

$$P[k+1] = Q_1[k+1] + Q_2[k+1]$$

wherein $k+1$ represents a coding order of the symbol, 2^{L-1} comprises the weights, $\{S_1, S_2\}$ comprise shift parameters, and $\{Q_1[k+1], Q_2[k+1]\}$ comprises the estimator functions, and wherein executing the estimator functions comprises performing right-shift operations using the shift parameters instead of the division operations.

31. The computer-readable storage medium of claim 27, further comprising instructions that cause the processor to maintain a plurality of state elements Q_1 to Q_M for a finite state machine used to calculate the probability as the tuple $(P[k], Q_1[k], \dots, Q_M[k])$, wherein $P[k] = \sum_{i=1}^M 2^{L-L_i} Q_i[k]$.

32. The computer-readable storage medium of claim 27, wherein the instructions that cause the processor to calculate the probability comprise instructions that cause the processor to calculate the probability without performing multiplication operations.

33. The computer-readable storage medium of claim 27, wherein the symbol comprises a bin of a syntax element of video data.

34. A device for coding video data, the device comprising:

means for determining a plurality of estimator functions to be used to calculate a probability of a symbol having a particular value, wherein the symbol is to be binary arithmetic coded according to the probability, and wherein the estimator functions do not include division operations;

means for determining a plurality of weights for the plurality of estimator functions such that when the respective weights are applied to the estimator functions, a resulting sum of outputs of the plurality of estimator functions yields the probability;

means for calculating the probability of the symbol having the particular value, comprising:

means for executing the estimator functions without using the division operations to determine the outputs of the estimator functions; and

means for calculating a sum of the outputs as the probability; and

means for binary arithmetic coding the symbol according to the probability of the symbol having the particular value.