CLAIMS

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

calculating a plurality of estimator functions to generate a respective plurality of outputs to be used to calculate a probability of a symbol having a particular value based on a prior value of the symbol, wherein the symbol is to be binary arithmetic coded according to the probability, and wherein calculating the estimator functions does not include performing division operations,

wherein calculating the plurality of estimator functions comprises using a plurality of weights and a plurality of shift parameters,

wherein, for the prior value of the symbol being non-zero, calculating a first of the estimator functions comprises subtracting, from a prior output of the first of the estimator functions, a value based on the prior output of the first of the estimator functions shifted by a first of the shift parameters, and adding a value based on a first of the weights shifted by the first shift parameter and

wherein, for the prior value of the symbol being non-zero, calculating a second of the estimator functions comprises subtracting, from a prior output of the second of the estimator functions, a value based on the prior output of the second of the estimator functions shifted by a second of the shift parameters, and adding a value based on a second of the weights shifted by the second shift parameter,

wherein the first of the shift parameters is different from the second of the shift parameters and the first of the weights is different from the second of the weights;

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

calculating a sum of the outputs of the estimator functions 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, …, W_M} comprises the weights, and {Q_1[k+1], … Q_M[k+1]} comprises the estimator functions, $P[k+1]$ comprises the probability of the symbol, {S_1, … S_M} comprise the shift parameters, $b[k]$ represents the prior value of the symbol, and wherein calculating the estimator functions comprises performing right-shift operations using the shift parameters instead of 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, …, W_M} comprises the weights, {S_1, … S_M} comprise shift parameters, $P[k+1]$ comprises the probability of the symbol, {Q_1[k+1], …, Q_M[k+1]} comprises the estimator functions, L comprises a number of bits to represent scaled probabilities, $\{L_i\}_{i=1}^{M}$ comprises a maximum numbers of bits needed for the representation of the estimator functions, $b[k]$ represents the prior value of the symbol, and wherein calculating the estimator functions comprises performing right-shift operations using the shift parameters instead of 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, L comprises a number of bits, 2^{L-1} comprises the weights, $\{S_1, S_2\}$ comprise shift parameters, $\{Q_1[k+1], Q_2[k+1]\}$ comprises the estimator functions, , $P[k+1]$ comprises the probability of the symbol, $b[k]$ represents the prior value of the symbol, and wherein calculating the estimator functions comprises performing right-shift operations using the shift parameters instead of 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], …, Q_M[k]), wherein P[k] = $\sum_{i=1}^{M} 2^{L-L_i} Q_i[k]$, wherein $P[k+1]$ comprises the probability of the symbol , L comprises a number of bits to represent scaled probabilities, $\{L_i\}_{i=1}^{M}$ comprises a maximum numbers of bits needed for the representation of the estimator functions.

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:

calculate a plurality of estimator functions to generate a respective plurality of

outputs to be used to calculate a probability of a symbol having a particular value based on a prior value of the symbol, wherein the symbol is to be binary arithmetic coded according to the probability, and wherein to calculate the estimator functions, the processor does not perform division operations;

wherein to calculate the plurality of estimator functions, the processor is configured to use a plurality of weights and a plurality of shift parameters,

wherein the processor is configured to calculate, for the prior value of the symbol being non-zero, a first of the estimator functions, the processor being further configured to subtract, from a prior output of the first of the estimator functions, a value based on the prior output of the first of the estimator functions shifted by a first of the shift parameters, and add a value based on a first of the weights shifted by the first shift parameter and

wherein the processor is configured to calculate, for the prior value of the symbol being non-zero, a second of the estimator functions, the processor being further configured to subtract, from a prior output of the second of the estimator functions, a value based on the prior output of the second of the estimator functions shifted by a second of the shift parameters, and add a value based on a second of the weights shifted by the second shift parameter,

wherein the first of the shift parameters is different from the second of the shift parameters and the first of the weights is different from the second of the weights;

calculate the probability of the symbol having the particular value, wherein to calculate the probability, the processor is configured to:

calculate a sum of the outputs of the estimator functions 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:

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

wherein k+1 represents a coding order of the symbol, $\{W_1, \ldots, W_M\}$ comprises the weights, and $\{Q_1[k+1], \ldots Q_M[k+1]\}$ comprises the estimator functions, $P[k+1]$ comprises the probability of the symbol, $\{S_1, \ldots S_M\}$ comprise the shift parameters, $b[k]$ represents the prior value of the symbol, and wherein to calculate the estimator functions the processor is further configured to perform right-shift operations using the shift parameters instead of division operations.

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

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

wherein k+1 represents a coding order of the symbol, $\{W_1, \ldots, W_M\}$ comprises the weights, $\{S_1, \ldots S_M\}$ comprise shift parameters, $P[k+1]$ comprises the probability of the symbol, $\{Q_1[k+1], \ldots, Q_M[k+1]\}$ comprises the estimator functions, L comprises a number of bits to represent scaled probabilities, $\{L_i\}_{i=1}^{M}$ comprises a maximum numbers of bits needed for the representation of the estimator functions, $b[k]$ represents the prior value of the symbol, and wherein to calculate, the estimator functions the processor is further configured to perform right-shift operations using the shift parameters instead of 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, L comprises a number of bits, 2^{L-1} comprises the weights, $\{S_1, S_2\}$ comprise shift parameters, $\{Q_1[k+1], Q_2[k+1]\}$ comprises the estimator functions, , $P[k+1]$ comprises the probability of the symbol, $b[k]$ represents the prior value of the symbol,, and wherein to calculate, the estimator functions the processor is further configured to perform right-shift operations using the shift parameters instead of 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], …, Q_M[k]), wherein P[k] = $\sum_{i=1}^{M} 2^{L-L_i} Q_i[k]$, wherein $P[k+1]$ comprises the probability of the symbol , L comprises a number of bits to represent scaled probabilities, $\{L_i\}_{i=1}^{M}$ comprises a maximum numbers of bits needed for the representation of the estimator functions.

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 non-transitory computer-readable storage medium having stored thereon instructions that, when executed, cause a processor to:

calculate a plurality of estimator functions to generate a respective plurality of outputs to be used to calculate a probability of a symbol having a particular value based on a prior value of the symbol, wherein the symbol is to be binary arithmetic coded according to the probability, and wherein to calculate the estimator functions does not include division operations,

wherein to calculate the plurality of estimator functions the processor is caused to use a plurality of weights and a plurality of shift parameters,

wherein the processor is caused to calculate, for the prior value of the symbol being non-zero, a first of the estimator functions, the processor being further caused to subtract, from a prior output of the first of the estimator functions, a value based on the prior output of the first of the estimator functions shifted by a first of the shift parameters, and add a value based on a first of the weights shifted by the first shift parameter and

wherein the processor is caused to calculate, for the prior value of the symbol being non-zero, a second of the estimator functions, the processor being further caused to subtract, from a prior output of the second of the estimator functions, a value based on the prior output of the second of the estimator functions shifted by a second of the shift parameters, and add a value based on a second of the weights shifted by the second shift parameter,

wherein the first of the shift parameters is different from the second of the shift parameters and the first of the weights is different from the second of the weights;

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

calculate a sum of the outputs of the estimator functions as the probability;

and

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

28. The non-transitory 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:

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

$$\vdots$$

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

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

wherein k+1 represents a coding order of the symbol, $\{W_1, \ldots, W_M\}$ comprises the weights, and $\{Q_1[k+1], \ldots Q_M[k+1]\}$ comprises the estimator functions, $P[k+1]$ comprises the probability of the symbol, $\{S_1, \ldots S_M\}$ comprise the shift parameters, $b[k]$ represents the prior value of the symbol, and wherein to calculate the estimator functions the processor is further caused to perform right-shift operations using the shift parameters instead of division operations.

29. The non-transitory 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:

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

$$\vdots$$

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

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

wherein k+1 represents a coding order of the symbol, $\{W_1, \ldots, W_M\}$ comprises the weights, $\{S_1, \ldots S_M\}$ comprise shift parameters, $P[k+1]$ comprises the probability of the symbol, $\{Q_1[k+1], \ldots, Q_M[k+1]\}$ comprises the estimator functions, L comprises a number of bits to represent scaled probabilities, $\{L_i\}_{i=1}^{M}$ comprises a maximum numbers of bits needed for the representation of the estimator functions, $b[k]$ represents the prior value of the symbol, and wherein to calculate, the estimator functions the processor is further caused to perform right-shift operations using the shift parameters instead of division operations.

30. The non-transitory 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, L comprises a number of bits, 2^{L-1} comprises the weights, $\{S_1, S_2\}$ comprise shift parameters, $\{Q_1[k+1], Q_2[k+1]\}$ comprises the estimator functions, , $P[k+1]$ comprises the probability of the symbol, $b[k]$ represents the prior value of the symbol,, and wherein to calculate, the estimator functions the processor is further caused to perform right-shift operations using the shift parameters instead of division operations.

31. The non-transitory 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], …, Q_M[k]), wherein P[k] = $\sum_{i=1}^{M} 2^{L-L_i} Q_i[k]$, wherein $P[k+1]$ comprises the probability of the symbol , L comprises a number of bits to represent scaled probabilities, $\{L_i\}_{i=1}^{M}$ comprises a maximum numbers of bits needed for the representation of the estimator functions.

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