

decoder processing loop such that both will generate identical predictions (e.g. intra- and inter predictions) and/or re-constructions for processing, i.e. coding, the subsequent blocks.

In the following embodiments of a video coding system 10, a video encoder 20 and a video decoder 30 are described based on Figs. 1 to 3.

Fig. 1A is a schematic block diagram illustrating an example coding system 10, e.g. a video coding system 10 (or short coding system 10) that may utilize techniques of this present application. Video encoder 20 (or short encoder 20) and video decoder 30 (or short decoder 30) of video coding system 10 represent examples of devices that may be configured to perform techniques in accordance with various examples described in the present application.

As shown in FIG. 1A, the coding system 10 comprises a source device 12 configured to provide encoded picture data 21 e.g. to a destination device 14 for decoding the encoded picture data 21.

The source device 12 comprises an encoder 20, and may additionally, i.e. optionally, comprise a picture source 16, a pre-processor (or pre-processing unit) 18, e.g. a picture pre-processor 18, and a communication interface or communication unit 22.

The picture source 16 may comprise or be any kind of picture capturing device, for example a camera for capturing a real-world picture, and/or any kind of a picture generating device, for example a computer-graphics processor for generating a computer animated picture, or any kind of other device for obtaining and/or providing a real-world picture, a computer generated picture (e.g. a screen content, a virtual reality (VR) picture) and/or any combination thereof (e.g. an augmented reality (AR) picture). The picture source may be any kind of memory or storage storing any of the aforementioned pictures.

In distinction to the pre-processor 18 and the processing performed by the pre-processing unit 18, the picture or picture data 17 may also be referred to as raw picture or raw picture data 17.

Pre-processor 18 is configured to receive the (raw) picture data 17 and to perform pre-processing on the picture data 17 to obtain a pre-processed picture 19 or pre-processed

The residual calculation unit 204, the transform processing unit 206, the quantization unit 208, the mode selection unit 260 may be referred to as forming a forward signal path of the encoder 20, whereas the inverse quantization unit 210, the inverse transform processing unit 212, the reconstruction unit 214, the buffer 216, the loop filter 220, the decoded picture buffer (DPB) 230, the inter prediction unit 244 and the intra-prediction unit 254 may be referred to as forming a backward signal path of the video encoder 20, wherein the backward signal path of the video encoder 20 corresponds to the signal path of the decoder (see video decoder 30 in Fig. 3). The inverse quantization unit 210, the inverse transform processing unit 212, the reconstruction unit 214, the loop filter 220, the decoded picture buffer (DPB) 230, the inter prediction unit 244 and the intra-prediction unit 254 are also referred to forming the “built-in decoder” of video encoder 20.

Pictures & Picture Partitioning (Pictures & Blocks)

The encoder 20 may be configured to receive, e.g. via input 201, a picture 17 (or picture data 17), e.g. picture of a sequence of pictures forming a video or video sequence. The received picture or picture data may also be a pre-processed picture 19 (or pre-processed picture data 19). For sake of simplicity the following description refers to the picture 17. The picture 17 may also be referred to as current picture or picture to be coded (in particular in video coding to distinguish the current picture from other pictures, e.g. previously encoded and/or decoded pictures of the same video sequence, i.e. the video sequence which also comprises the current picture).

A (digital) picture is or can be regarded as a two-dimensional array or matrix of samples with intensity values. A sample in the array may also be referred to as pixel (short form of picture element) or a pel. The number of samples in horizontal and vertical direction (or axis) of the array or picture define the size and/or resolution of the picture. For representation of color, typically three color components are employed, i.e. the picture may be represented or include three sample arrays. In RGB format or color space a picture comprises a corresponding red, green and blue sample array. However, in video coding each pixel is typically represented in a luminance and chrominance format or color space, e.g. YCbCr, which comprises a luminance component indicated by Y (sometimes also L is used instead) and two chrominance components indicated by Cb and Cr. The luminance (or short luma) component Y represents the brightness or grey level intensity (e.g. like in a grey-scale picture), while the two chrominance (or short chroma) components Cb and Cr represent the chromaticity or

The intra-prediction unit 254 is configured to use reconstructed samples of neighboring blocks of the same current picture to generate an intra-prediction block 265 according to an intra-prediction mode of the set of intra-prediction modes.

- 5 The intra prediction unit 254 (or in general the mode selection unit 260) is further configured to output intra-prediction parameters (or in general information indicative of the selected intra prediction mode for the block) to the entropy encoding unit 270 in form of syntax elements 266 for inclusion into the encoded picture data 21, so that, e.g., the video decoder 30 may receive and use the prediction parameters for decoding.

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Inter-Prediction

The set of (or possible) inter-prediction modes depends on the available reference pictures (i.e. previous at least partially decoded pictures, e.g. stored in DPB 230) and other inter-prediction parameters, e.g. whether the whole reference picture or only a part, e.g. a search

15 window area around the area of the current block, of the reference picture is used for searching for a best matching reference block, and/or e.g. whether pixel interpolation is applied, e.g. half/semi-pel and/or quarter-pel interpolation, or not.

Additional to the above prediction modes, skip mode and/or direct mode may be applied.

- 20 The inter prediction unit 244 may include a motion estimation (ME) unit and a motion compensation (MC) unit (both not shown in Fig.2). The motion estimation unit may be configured to receive or obtain the picture block 203 (current picture block 203 of the current picture 17) and a decoded picture 231, or at least one or a plurality of previously reconstructed blocks, e.g. reconstructed blocks of one or a plurality of other/different
- 25 previously decoded pictures 231, for motion estimation. E.g. a video sequence may comprise the current picture and the previously decoded pictures 231, or in other words, the current picture and the previously decoded pictures 231 may be part of or form a sequence of pictures forming a video sequence.

- 30 The encoder 20 may, e.g., be configured to select a reference block from a plurality of reference blocks of the same or different pictures of the plurality of other pictures and provide a reference picture (or reference picture index) and/or an offset (spatial offset) between the position (x, y coordinates) of the reference block and the position of the current

Decoder and Decoding Method

Fig. 3 shows an example of a video decoder 30 that is configured to implement the techniques of this present application. The video decoder 30 is configured to receive encoded picture data 21 (e.g. encoded bitstream 21), e.g. encoded by encoder 20, to obtain a decoded picture 331. The encoded picture data or bitstream comprises information for decoding the encoded picture data, e.g. data that represents picture blocks of an encoded video slice and associated syntax elements.

10 In the example of FIG. 3, the decoder 30 comprises an entropy decoding unit 304, an inverse quantization unit 310, an inverse transform processing unit 312, a reconstruction unit 314 (e.g. a summer 314), a loop filter 320, a decoded picture buffer (DPB) 330, an inter prediction unit 344 and an intra prediction unit 354. Inter prediction unit 344 may be or include a motion compensation unit. Video decoder 30 may, in some examples, perform a
15 decoding pass generally reciprocal to the encoding pass described with respect to video encoder 100 from FIG. 2.

As explained with regard to the encoder 20, the inverse quantization unit 210, the inverse transform processing unit 212, the reconstruction unit 214 the loop filter 220, the decoded picture buffer (DPB) 230, the inter prediction unit 344 and the intra prediction unit 354 are
20 also referred to as forming the “built-in decoder” of video encoder 20. Accordingly, the inverse quantization unit 310 may be identical in function to the inverse quantization unit 110, the inverse transform processing unit 312 may be identical in function to the inverse transform processing unit 212, the reconstruction unit 314 may be identical in function to
25 reconstruction unit 214, the loop filter 320 may be identical in function to the loop filter 220, and the decoded picture buffer 330 may be identical in function to the decoded picture buffer 230. Therefore, the explanations provided for the respective units and functions of the video
20 encoder apply correspondingly to the respective units and functions of the video decoder 30.

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Entropy Decoding

The entropy decoding unit 304 is configured to parse the bitstream 21 (or in general encoded picture data 21) and perform, for example, entropy decoding to the encoded picture data 21 to

Alternatively, the coding module 470 is implemented as instructions stored in the memory 460 and executed by the processor 430.

The memory 460 may comprise one or more disks, tape drives, and solid-state drives and may be used as an over-flow data storage device, to store programs when such programs are selected for execution, and to store instructions and data that are read during program execution. The memory 460 may be, for example, volatile and/or non-volatile and may be a read-only memory (ROM), random access memory (RAM), ternary content-addressable memory (TCAM), and/or static random-access memory (SRAM).

Fig. 5 is a simplified block diagram of an apparatus 500 that may be used as either or both of the source device 12 and the destination device 14 from Fig. 1A according to an exemplary embodiment.

A processor 502 in the apparatus 500 can be a central processing unit. Alternatively, the processor 502 can be any other type of device, or multiple devices, capable of manipulating or processing information now-existing or hereafter developed. Although the disclosed implementations can be practiced with a single processor as shown, e.g., the processor 502, advantages in speed and efficiency can be achieved using more than one processor.

A memory 504 in the apparatus 500 can be a read only memory (ROM) device or a random access memory (RAM) device in an implementation. Any other suitable type of storage device can be used as the memory 504. The memory 504 can include code and data 506 that is accessed by the processor 502 using a bus 512. The memory 504 can further include an operating system 508 and application programs 510, the application programs 510 including at least one program that permits the processor 502 to perform the methods described here. For example, the application programs 510 can include applications 1 through N, which further include a video coding application that performs the methods described here. The apparatus 500 can also include one or more output devices, such as a display 518. The display 518 may be, in one example, a touch sensitive display that combines a display with a touch sensitive element that is operable to sense touch inputs. The display 518 can be coupled to the processor 502 via the bus 512.

Table 3. Another Exemplary LUT generated using a flowchart shown in Fig. 9 in case when “ctr=ctr+(step>>1)” is skipped

lut_shift	col							
	0	1	2	3	4	5	6	7
-1	65536	32768	21845	16384	13107	10922	9362	8192
0	7281	6553	5957	5461	5041	4681	4369	4096
1	3855	3449	3120	2849	2621	2427	2259	2114
2	1985	1771	1598	1456	1337	1236	1149	1074
3	1008	897	809	736	675	624	579	541
4	508	451	407	370	339	313	291	271
5	255	226	204	185	170	157	145	136

When deriving the value of “col”, msb may be less than or equal to “col_{max}”. In this case, the value of “col” is set equal to the “col_{max}” least significant bits of the input difference 1001.

In practical implementations the LUT index is a one dimensional one. It’s typically understood that the LUTs shown in Table 2 and Table 3 could be addressed linearly using index set equal to:

$$\max(\text{lut_shift}, 0) \cdot (1 \ll \text{col}_{\max}) + \text{col}.$$

Both LUTs shown in Table 2 and Table 3 store values that are very different in their magnitude. Hence it is reasonable to have a similar number of bits for all the values stored in the LUT. The value being fetched from the LUT could further be left-shifted in accordance with the value of lut_shift. The only exception from this rule are the first four values that have different precision with the last four values within this row. However, this problem could be solved by an additional LUT that stores this additional shifts for the first four values. In this embodiment, the value of multiplier is restored from the value fetched from the LUT as follows:

$$m = \text{LUT}[\text{idx}] \ll m_s$$

where $m_s = 6 - (\text{lut_shift} + 1) + \delta$. The value of δ is set equal to 3, 2, 1, 1, respectively for “idx” values less or equal to 4. Look up table for this embodiment is given in Table 4.

Table 4. Another Exemplary LUT generated using a flowchart shown in Fig. 9 in case of equal precision within ranges.

lut_shift	col							
	0	1	2	3	4	5	6	7
-1	128	128	171	128	205	171	146	128

CLAIMS

1. A method of intra predicting a chroma sample of a block by applying a cross-component
5 linear model, comprising:
 - obtaining reconstructed luma samples;
 - determining maximum and minimum luma sample values based on the reconstructed luma samples;
 - obtaining a difference of the maximum and minimum luma sample values;
 - 10 determining a position of a most-significant bit of the difference of the maximum and minimum luma sample values;
 - fetching a value out of a lookup table (LUT) by using a set of bits as an index, the set of bits following the position of the most-significant bit of the difference of the maximum and minimum luma sample values;
 - 15 obtaining linear model parameters α and β based on the fetched value; and
 - calculating a predicted chroma sample value by using the obtained linear model parameters α and β .
2. The method of claim 1, wherein the position of the most-significant bit of the difference of
20 the maximum and minimum luma sample values is obtained as a logarithm of two of the difference.
3. The method of claim 1 or 2, wherein determining the set of bits following the position of the most-significant bit of the difference results in the set of bits comprising four bits.
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4. The method of any one of claims 1-3, wherein the most-significant bit is a first non-zero bit.
5. The method of any one of claims 1-4, wherein the method comprises:
 - obtaining the linear model parameters α and β , based on the fetched value and a difference of
30 maximum and minimum values of reconstructed chroma samples.
6. The method of claim 5, wherein the method comprises:
 - obtaining the linear model parameters α and β by multiplying the fetched value by the difference of the maximum and minimum values of the reconstructed chroma samples.

7. The method of any one of claims 1-6, wherein the LUT comprises at least three values: a first value, a second value, and a third value;

among the three values, the first value and the second value are included in two neighboring entries of the LUT, and the second value and the third value are included in two neighboring entries of the LUT.

8. The method of claim 7, wherein a difference between the first value and the second value equals to a difference between the second value and the third value.

9. The method of claim 7, wherein a difference between the first value and the second value is different from a difference between the second value and the third value.

10. The method of any one of claims 7-9, wherein the first value is indexed by a first set of bits, and the second value is indexed by a second set of bits;

when a value of the first set of bits is greater than a value of the second set of bits, the first value is smaller than the second value; or

when a value of the first set of bits is smaller than a value of the second set of bits, the first value is greater than the second value.

11. The method of any one of claims 1-10, wherein the LUT comprises subranges of values, and a step of any two neighboring values is constant within one subrange.

12. An apparatus for intra predicting a chroma sample of a block by applying a cross-component linear model, wherein the apparatus is an encoder or a decoder, and the apparatus comprises:

an obtaining unit, configured to obtain reconstructed luma samples;

a determining unit, configured to determine maximum and minimum luma sample values based on the reconstructed luma samples;

the obtaining unit, further configured to obtain a difference of the maximum and minimum luma sample values;

the determining unit, further configured to determine a position of a most-significant bit of the difference of the maximum and minimum luma sample values; and

a calculating unit, configured to fetch a value out of a lookup table (LUT) by using a set of bits as an index, the set of bits following the position of the most-significant bit of the difference of the maximum and minimum luma sample values, obtain linear model parameters α and β based on the fetched value; and calculate a predicted chroma sample value by using the obtained linear model parameters α and β .

13. The apparatus of claim 12, wherein the position of the most-significant bit of the difference of the maximum and minimum luma sample values is a logarithm of two of the difference.

14. The apparatus of claim 12 or 13, wherein the set of bits comprises four bits.

15. The apparatus of any one of claims 12-14, wherein the most-significant bit is a first non-zero bit.

16. The apparatus of any one of claims 12-15, wherein the calculating unit is configured to: obtain the linear model parameters α and β , based on the fetched value and a difference of maximum and minimum values of reconstructed chroma samples.

17. The apparatus of claim 16, wherein the calculating unit is configured to: obtain the linear model parameters α and β by multiplying the fetched value by the difference of the maximum and minimum values of the reconstructed chroma samples.

18. The apparatus of any one of claims 12-17, wherein the LUT comprises subranges of values, and a step of any two neighboring values is constant within one subrange.

19. An encoder comprising processing circuitry for carrying out the method according to any one of claims 1 to 11.

20. A decoder comprising processing circuitry for carrying out the method according to any one of claims 1 to 11.

21. A program which causes a processor to carry out the method according to any one of claims 1 to 11.

22. A decoder, comprising:

one or more processors; and

a non-transitory computer-readable storage medium coupled to the one or more processors and storing programming for execution by the one or more processors, wherein the programming, when executed by the one or more processors, configures the decoder to carry out the method according to any one of claims 1 to 11.

23. An encoder, comprising:

one or more processors; and

a non-transitory computer-readable storage medium coupled to the one or more processors and storing programming for execution by the one or more processors, wherein the programming, when executed by the one or more processors, configures the encoder to carry out the method according to any one of claims 1 to 11.