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(12) **United States Patent**
Rufitskiy et al.

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(45) **Date of Patent: Aug. 19, 2025**

(54) **METHOD AND APPARATUS FOR AFFINE BASED INTER PREDICTION OF CHROMA SUBBLOCKS**

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(73) Assignee: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

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(22) Filed: **Jan. 31, 2024**

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(63) Continuation of application No. 17/407,548, filed on Aug. 20, 2021, now Pat. No. 11,924,457, which is a (Continued)

(51) **Int. Cl.**
H04N 19/513 (2014.01)
H04N 19/159 (2014.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04N 19/513*** (2014.11); ***H04N 19/159*** (2014.11); ***H04N 19/176*** (2014.11); ***H04N 19/186*** (2014.11); ***H04N 19/30*** (2014.11)

(58) **Field of Classification Search**
CPC H04N 19/176; H04N 19/70; H04N 19/105; H04N 19/52; H04N 19/159;
(Continued)

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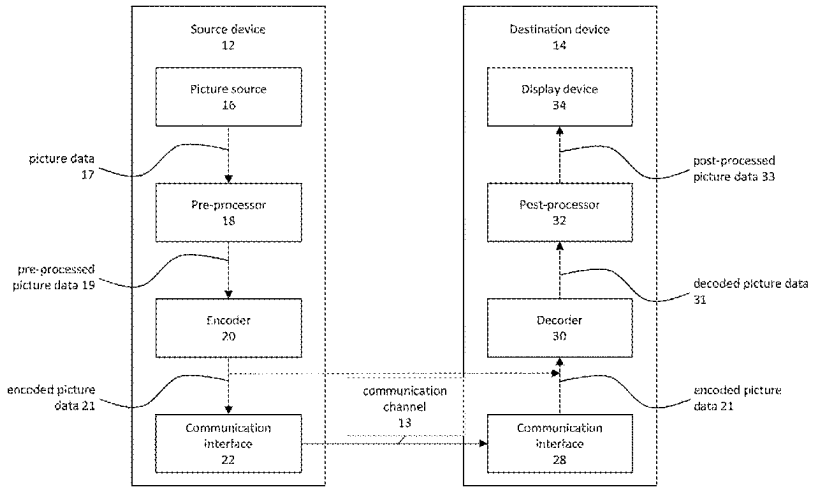
Primary Examiner — Nathnael Aynalem

(57) **ABSTRACT**

The present invention relates to method and apparatus for motion vector derivation for affine based inter prediction of chroma subblocks based on chroma format. The method includes: determining chroma scaling factors in horizontal and vertical directions based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the current image block belongs to; determining a set (S) of luma subblocks of the luma block based on values of the chroma scaling factors; determining a motion vector for a chroma subblock of the chroma block based on motion vectors of one or more luma subblocks in the set (S) of luma subblocks.

22 Claims, 32 Drawing Sheets



Related U.S. Application Data

continuation of application No. PCT/CN2020/076493, filed on Feb. 24, 2020.

(60) Provisional application No. 62/824,302, filed on Mar. 26, 2019, provisional application No. 62/823,653, filed on Mar. 25, 2019, provisional application No. 62/809,551, filed on Feb. 22, 2019.

(51) **Int. Cl.**
H04N 19/176 (2014.01)
H04N 19/186 (2014.01)
H04N 19/30 (2014.01)

(58) **Field of Classification Search**
CPC .. H04N 19/186; H04N 19/593; H04N 19/137; H04N 19/17; H04N 19/96; H04N 19/577; H04N 19/11; H04N 19/50; H04N 19/543; H04N 19/573; H04N 19/103; H04N 19/172; H04N 19/513; H04N 19/61; H04N 19/55; H04N 19/517; H04N 19/05; H04N 19/51
USPC 375/240–240.29
See application file for complete search history.

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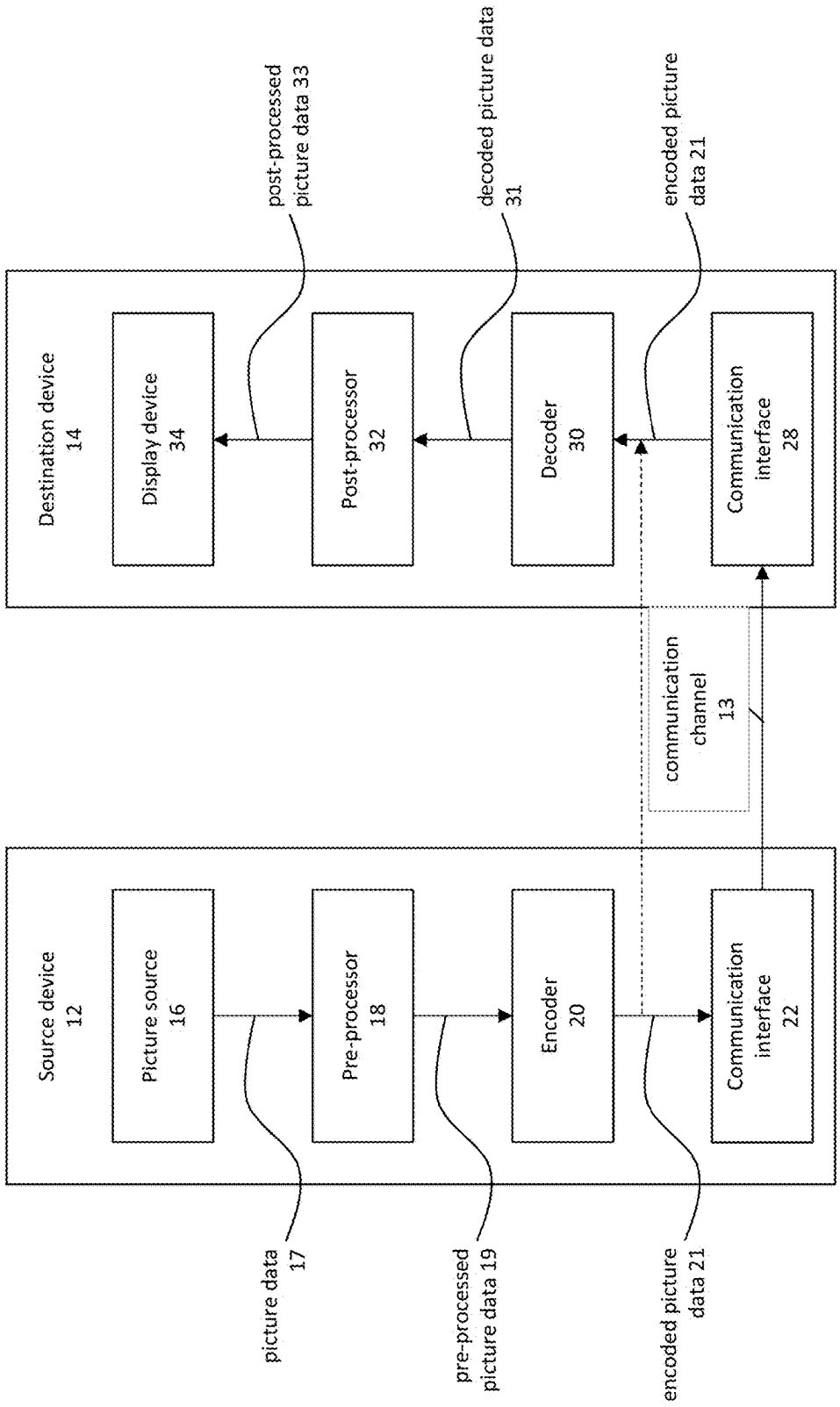

Destination device
14
Display device
34
post-processed
picture data 33
Post-processor
32
decoded picture data
31
Decoder
30
encoded picture
data 21
Communication
interface
28
communication
channel
13
Source device
12
Picture source
16
picture data
17
Pre-processor
18
pre-processed
picture data 19
Encoder
20
encoded picture
data 21
Communication
interface
22
10

FIG. 1A

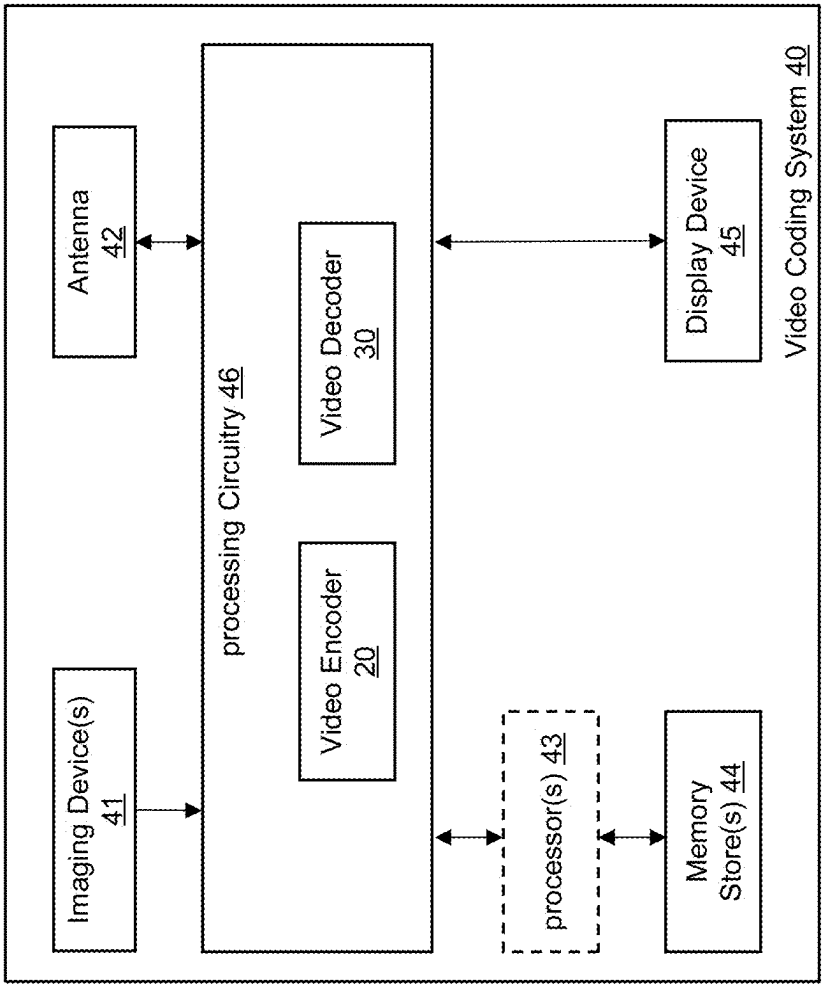

Imaging Device(s) 41
Antenna 42
processing Circuitry 46
Video Encoder 20
Video Decoder 30
processor(s) 43
Memory Store(s) 44
Display Device 45
Video Coding System 40

FIG. 1B

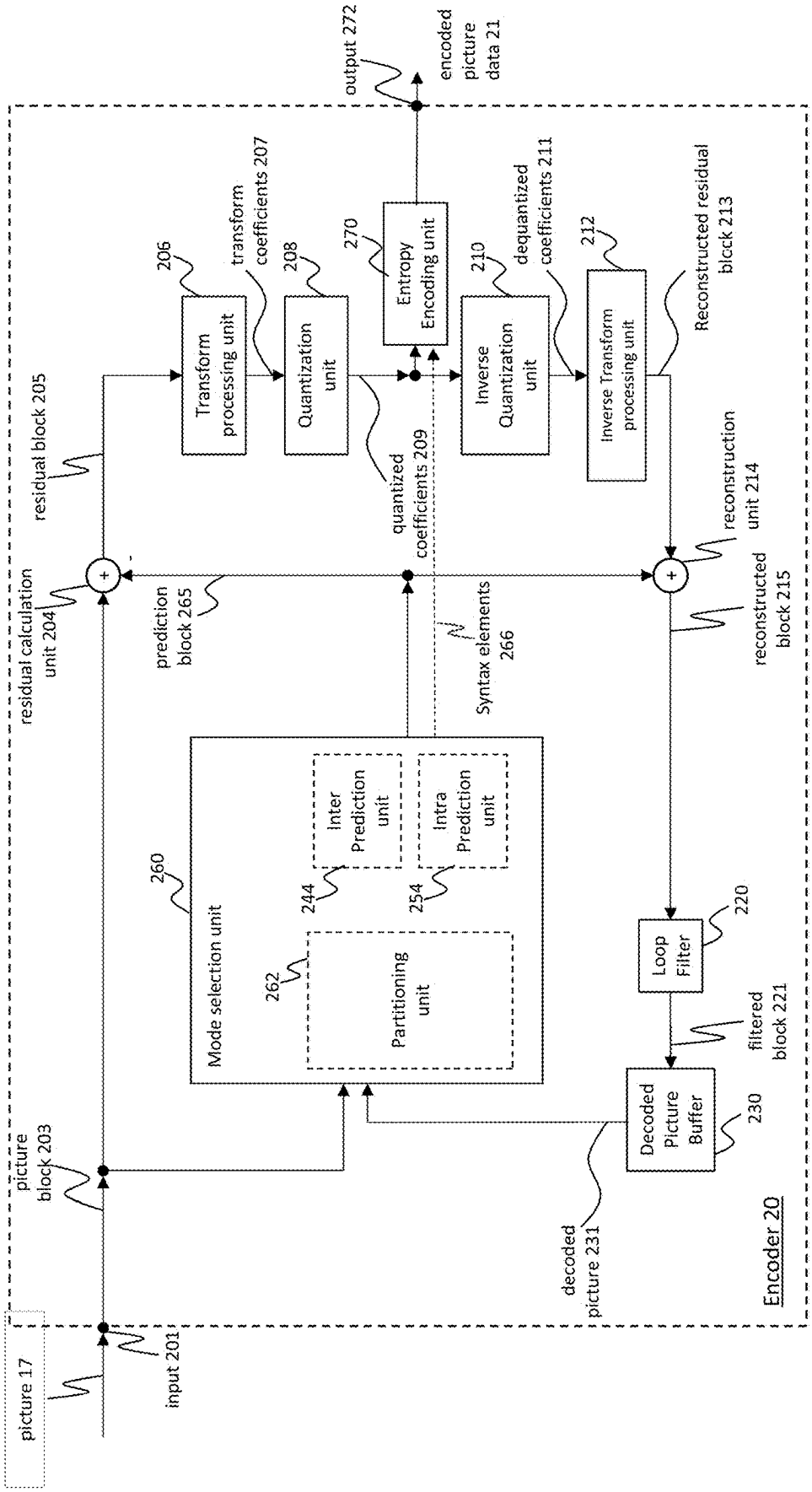

output 272
encoded picture data 21
206
Transform processing unit
transform coefficients 207
208
Quantization unit
270
Entropy Encoding unit
210
Inverse Quantization unit
dequantized coefficients 211
212
Inverse Transform processing unit
Reconstructed residual block 213
residual block 205
quantized coefficients 209
reconstruction unit 214
residual calculation unit 204
prediction block 265
Syntax elements 266
reconstructed block 215
260
Mode selection unit
244
Inter Prediction unit
254
Intra Prediction unit
262
Partitioning unit
220
Loop Filter
filtered block 221
230
Decoded Picture Buffer
picture block 203
decoded picture 231
Encoder 20
picture 17
input 201

FIG. 2

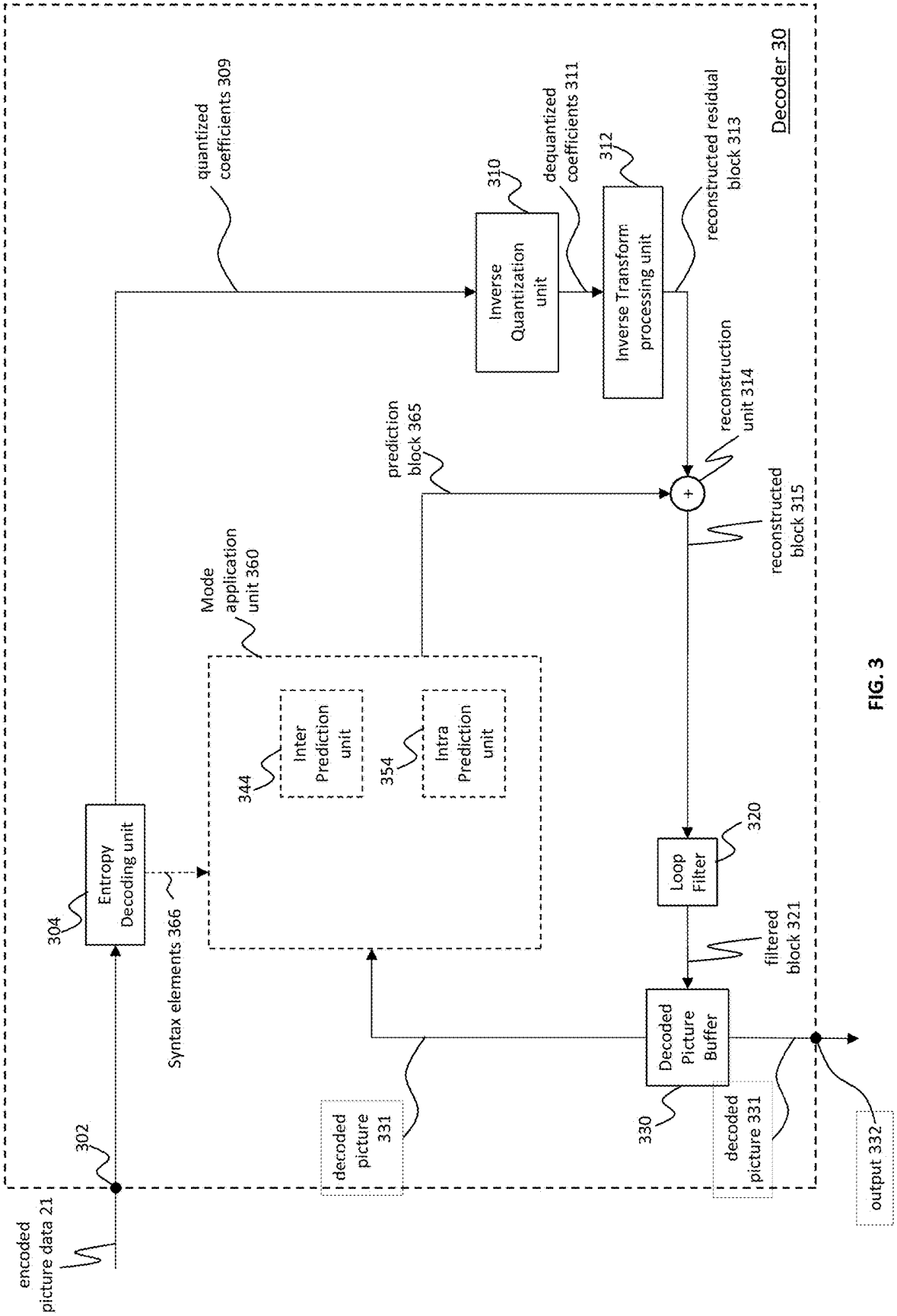

Decoder 30
quantized coefficients 309
310
Inverse Quantization unit
dequantized coefficients 311
312
Inverse Transform processing unit
reconstructed residual block 313
reconstruction unit 314
prediction block 365
reconstructed block 315
Mode application unit 360
344
Inter Prediction unit
354
Intra Prediction unit
304
Entropy Decoding unit
Syntax elements 366
320
Loop Filter
filtered block 321
Decoded Picture Buffer
330
decoded picture 331
decoded picture 331
302
encoded picture data 21
output 332

FIG. 3

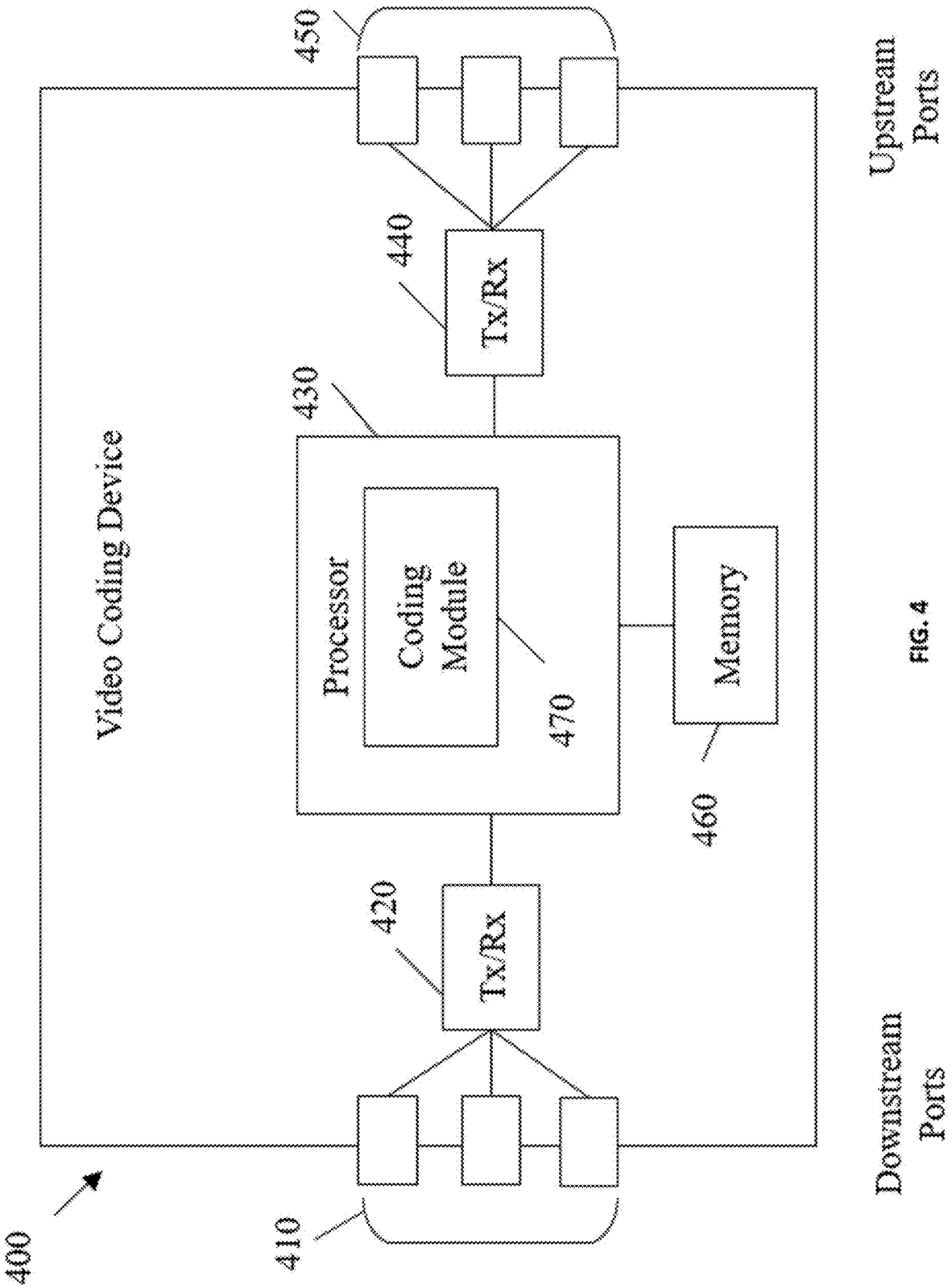

400
Video Coding Device
410
Downstream Ports
420
Tx/Rx
430
Processor
Coding Module
470
460
Memory
440
Tx/Rx
450
Upstream Ports

FIG. 4

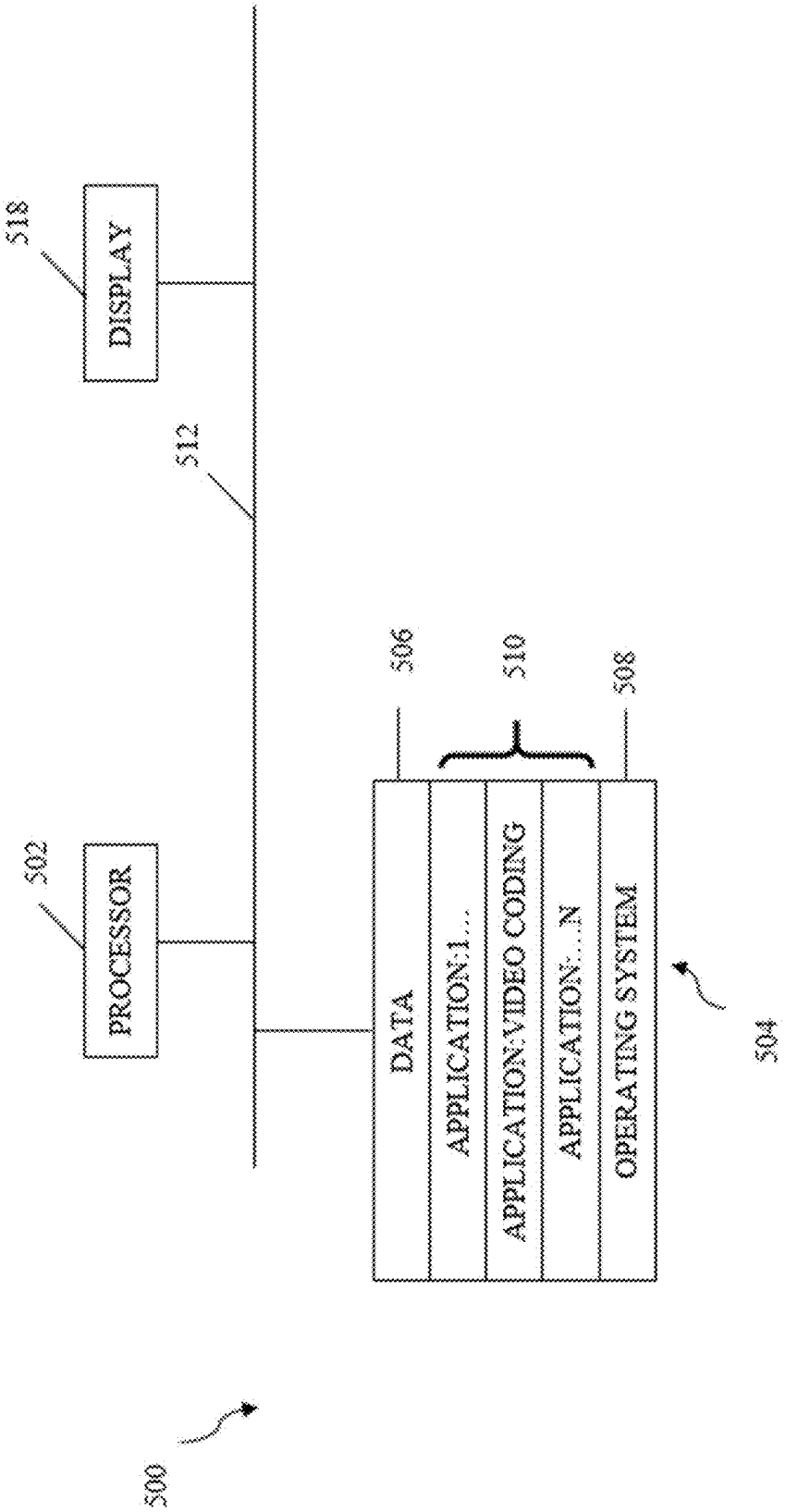

500
502
PROCESSOR
518
DISPLAY
512
506
DATA
510
APPLICATION:1...
APPLICATION:VIDEO CODING
APPLICATION:...N
508
OPERATING SYSTEM
504

FIG. 5

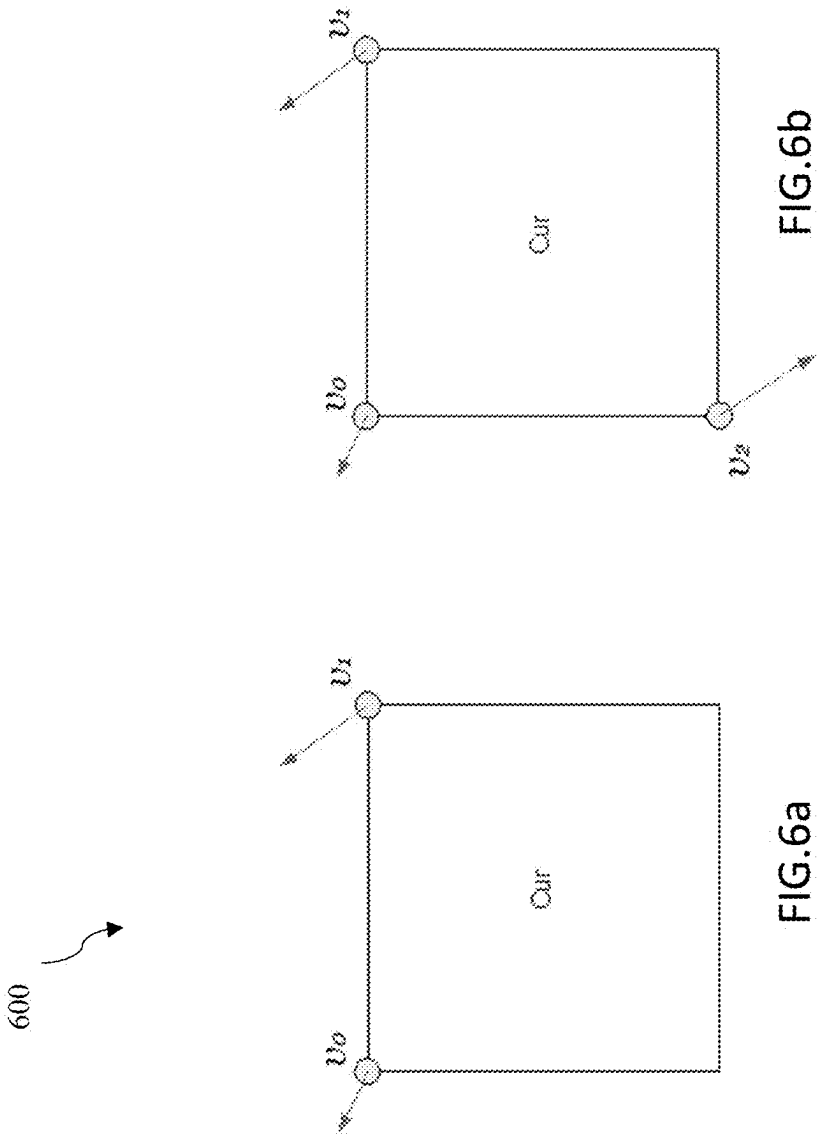


FIG.6a

FIG.6b

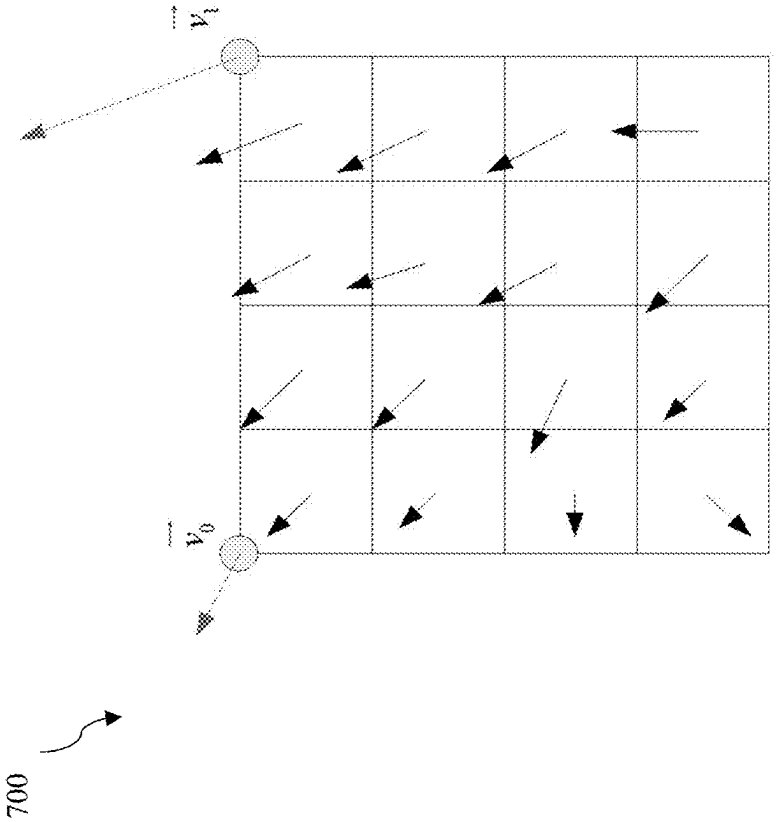


FIG. 7

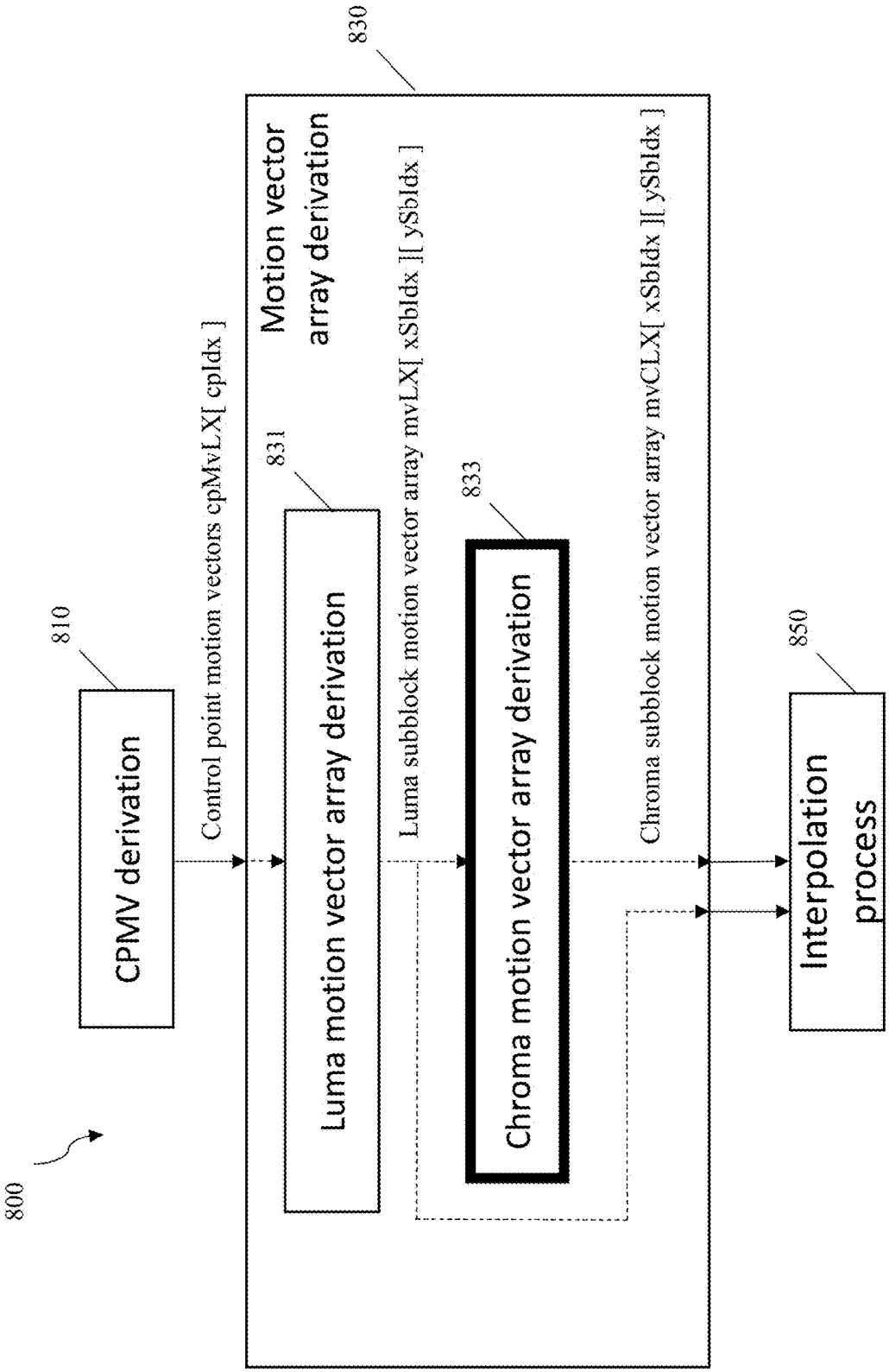

800
810
CPMV derivation
Control point motion vectors cpMvLX[cpIdx]
830
Motion vector array derivation
831
Luma motion vector array derivation
Luma subblock motion vector array mvLX[xSbIdx][ySbIdx]
833
Chroma motion vector array derivation
Chroma subblock motion vector array mvCLX[xSbIdx][ySbIdx]
850
Interpolation process

FIG. 8

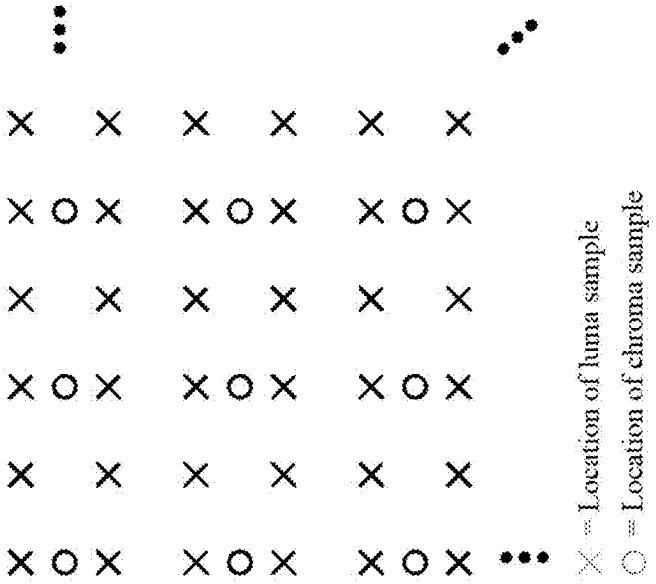


FIG. 9A

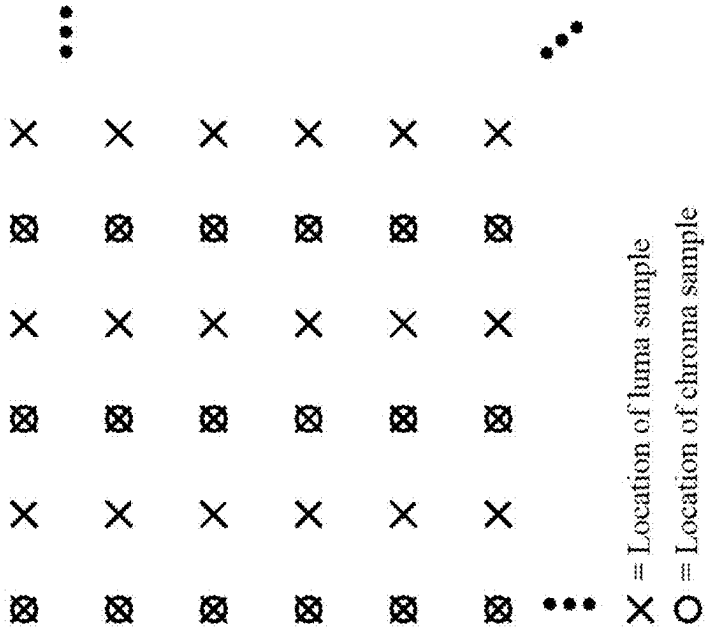


FIG. 9B

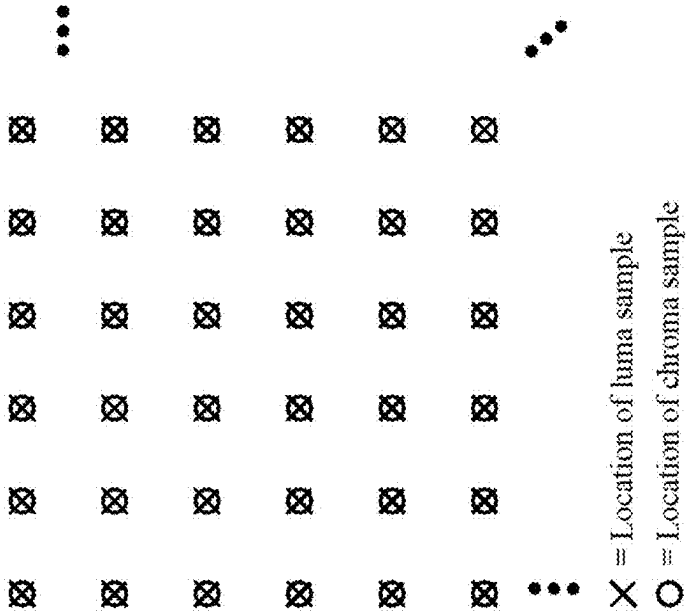
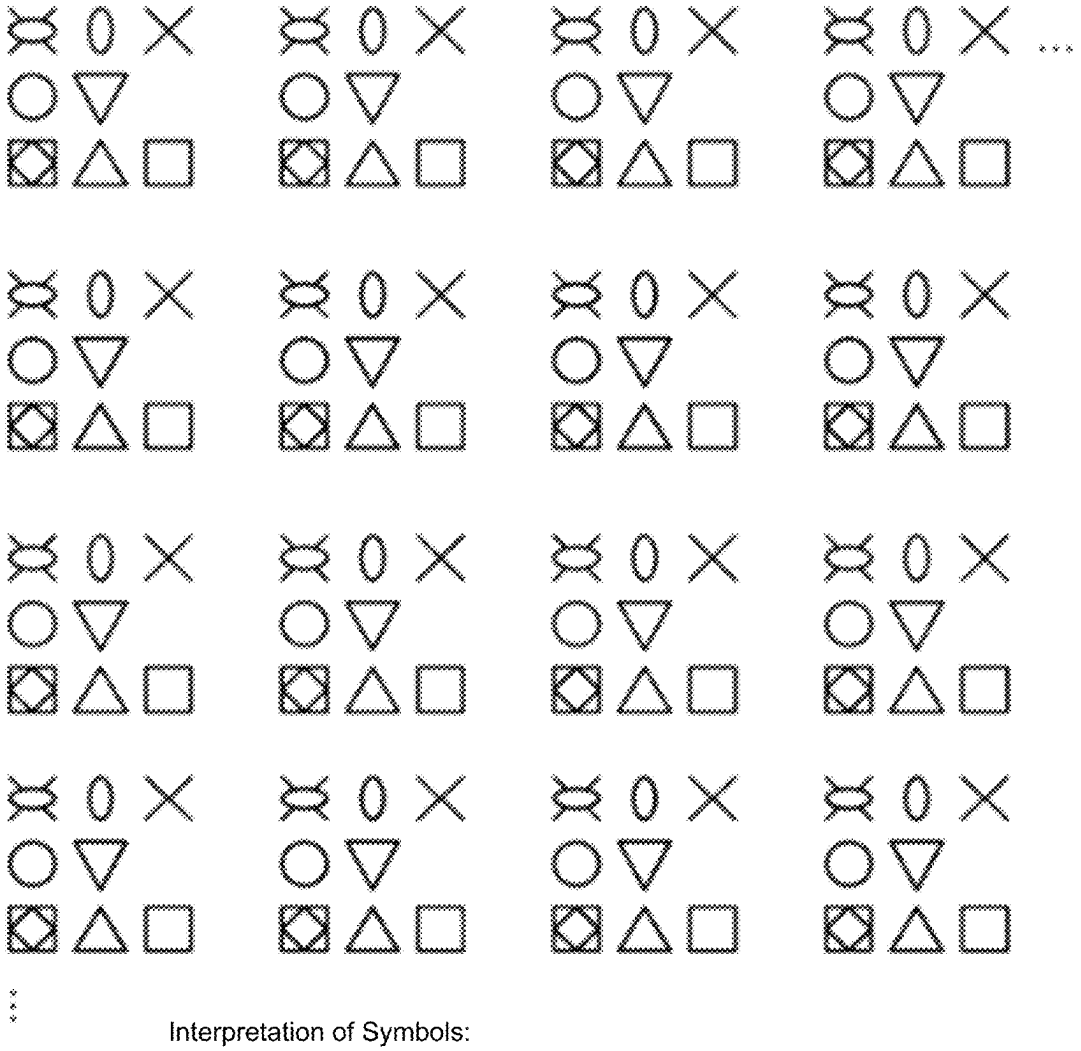
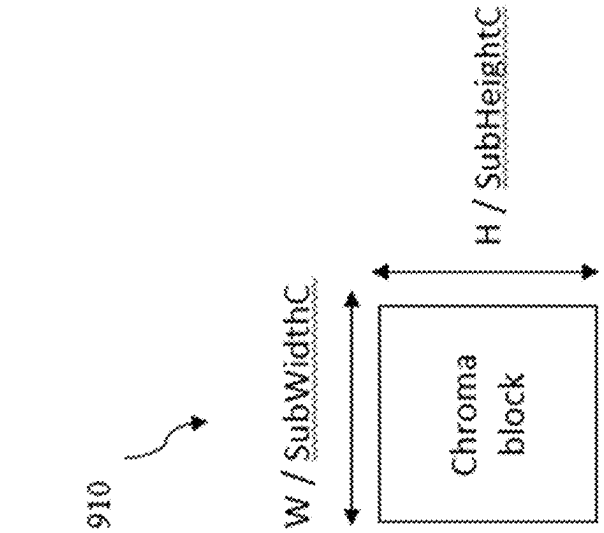


FIG. 9C



Interpretation of Symbols:
Luma sample position indications
=Luma Sample top field = Luma sample bottom field
Chroma sample position indications.
Where gray fill indicates a bottom field sample type
and no fill indicates a top filed sample type
=Chroma sample type 2 =Chroma sample type 3
=Chroma sample type 0 =Chroma sample type 1
=Chroma sample type 4 =Chroma sample type 5

FIG. 9D


910
W / SubWidthC
H / SubHeightC
Chroma block

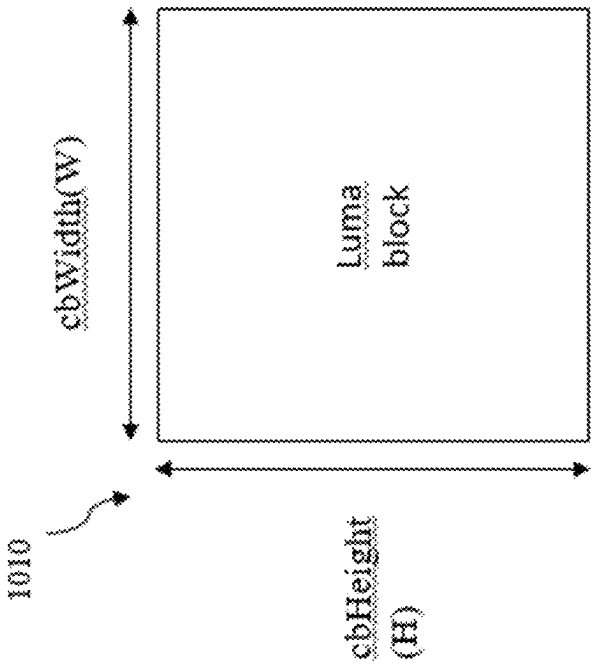

1010
cbWidth(W)
cbHeight (H)
Luma block

FIG. 10A

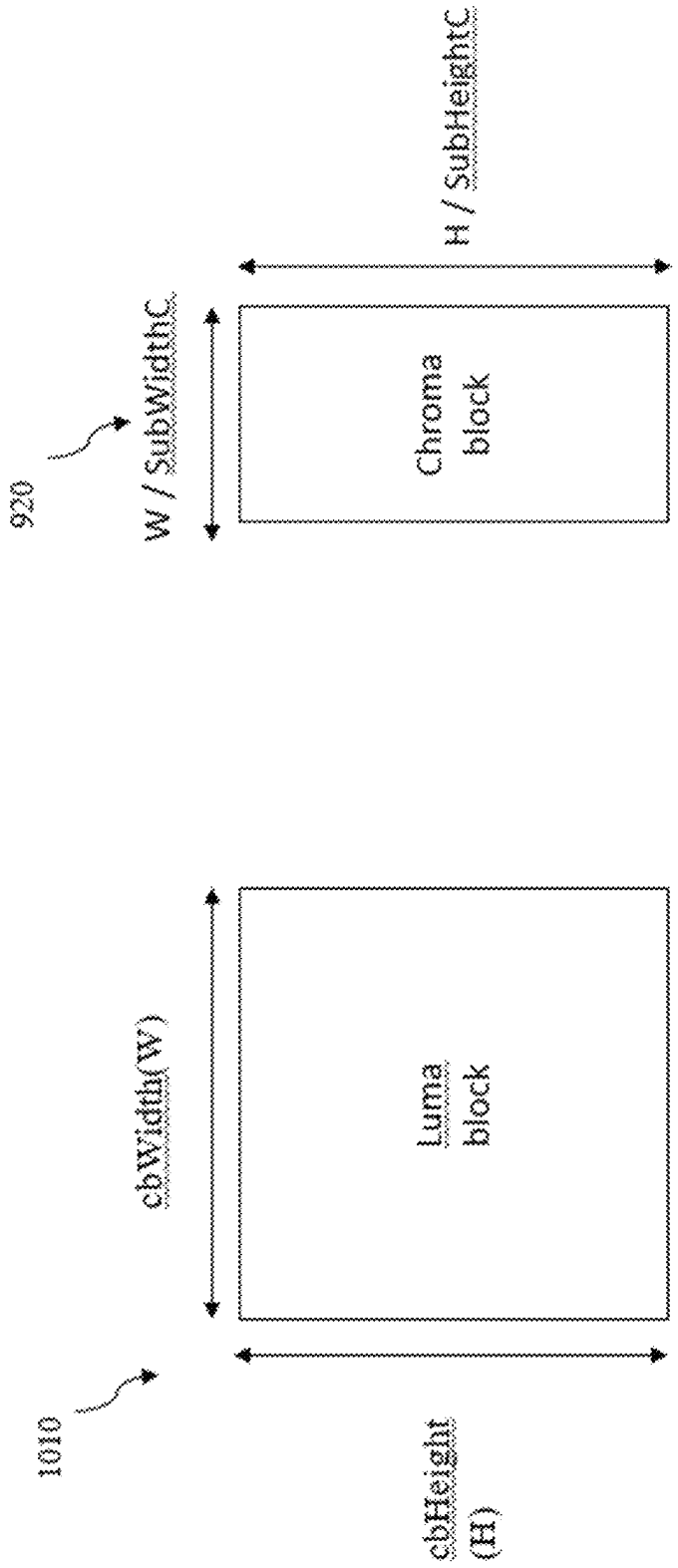

920
W / SubWidthC
H / SubHeightC
Chroma block
1010
cbWidth(W)
cbHeight (H)
Luma block

FIG. 10B

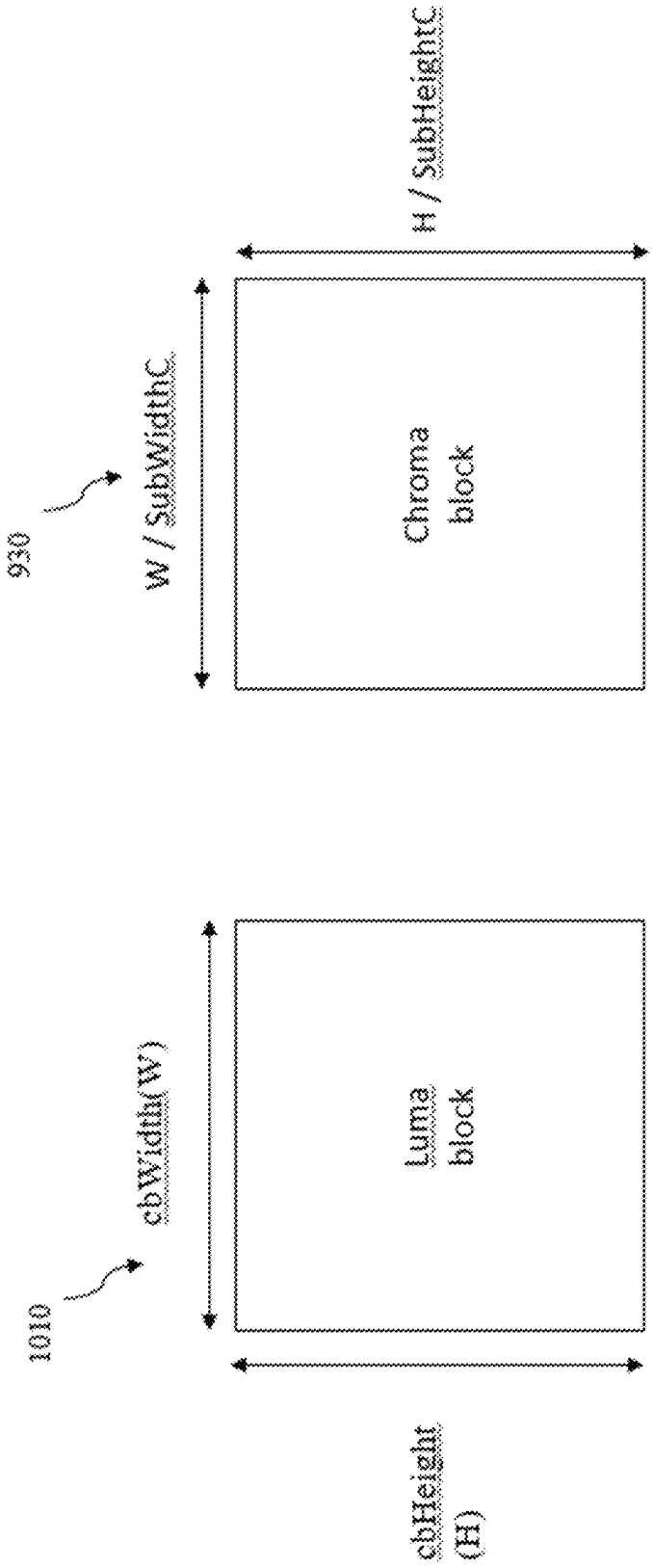

930
W / SubWidthC
Chroma block
H / SubHeightC
1010
cbWidth(W)
Luma block
cbHeight (H)

FIG. 10C

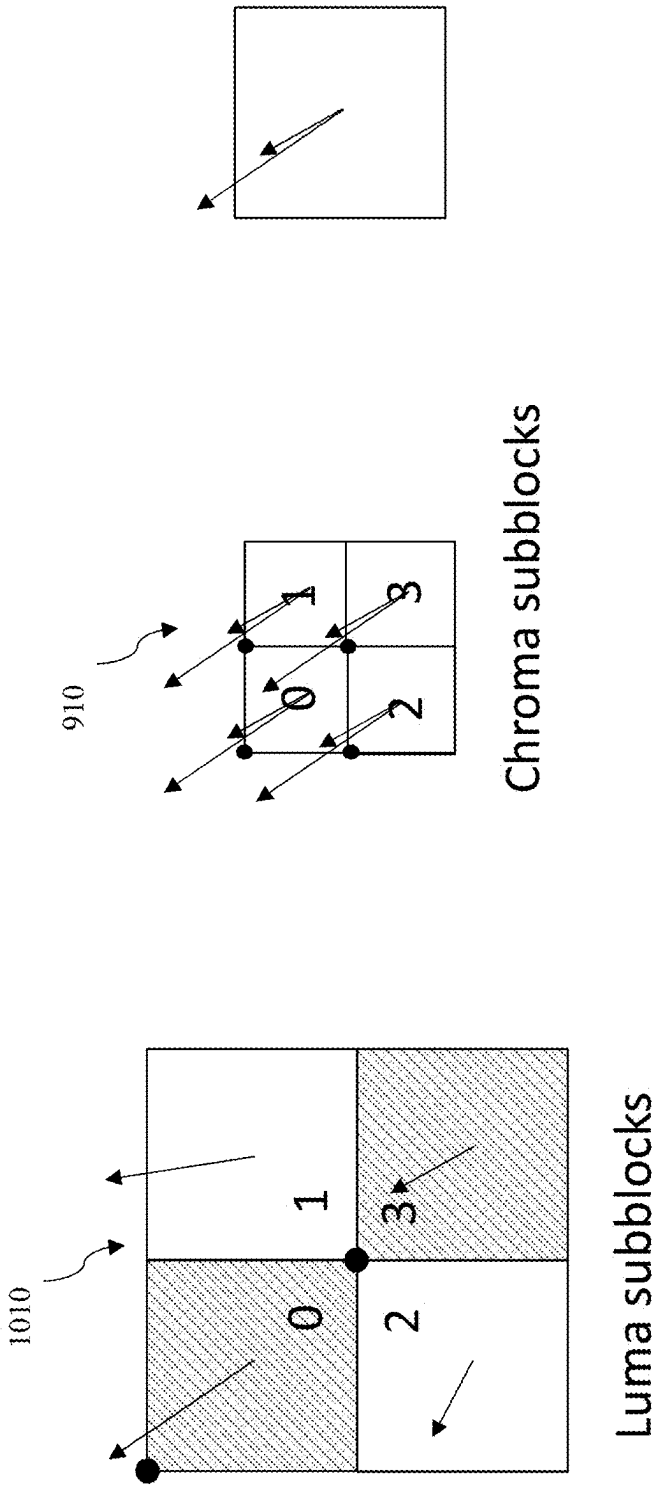


FIG. 11A

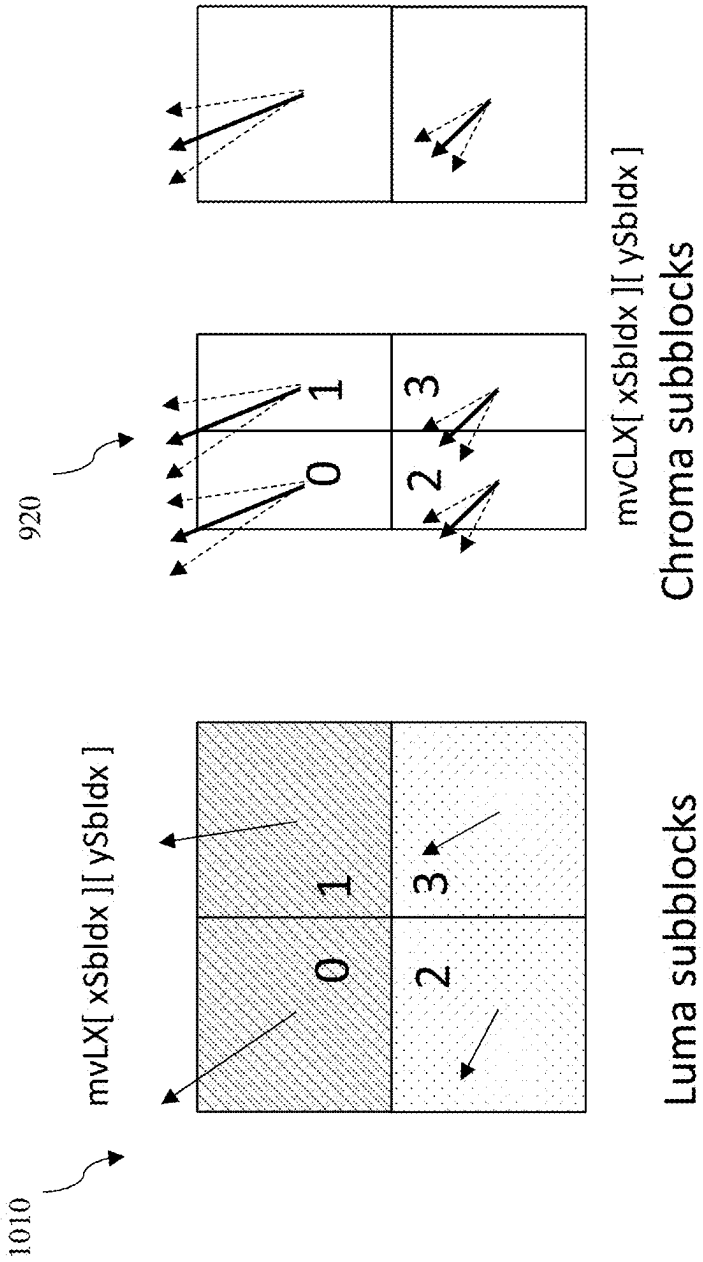

1010
mvLX[xSbIdx][ySbIdx]
0
1
2
3
Luma subblocks
920
0
1
2
3
mvCLX[xSbIdx][ySbIdx]
Chroma subblocks

FIG. 11B

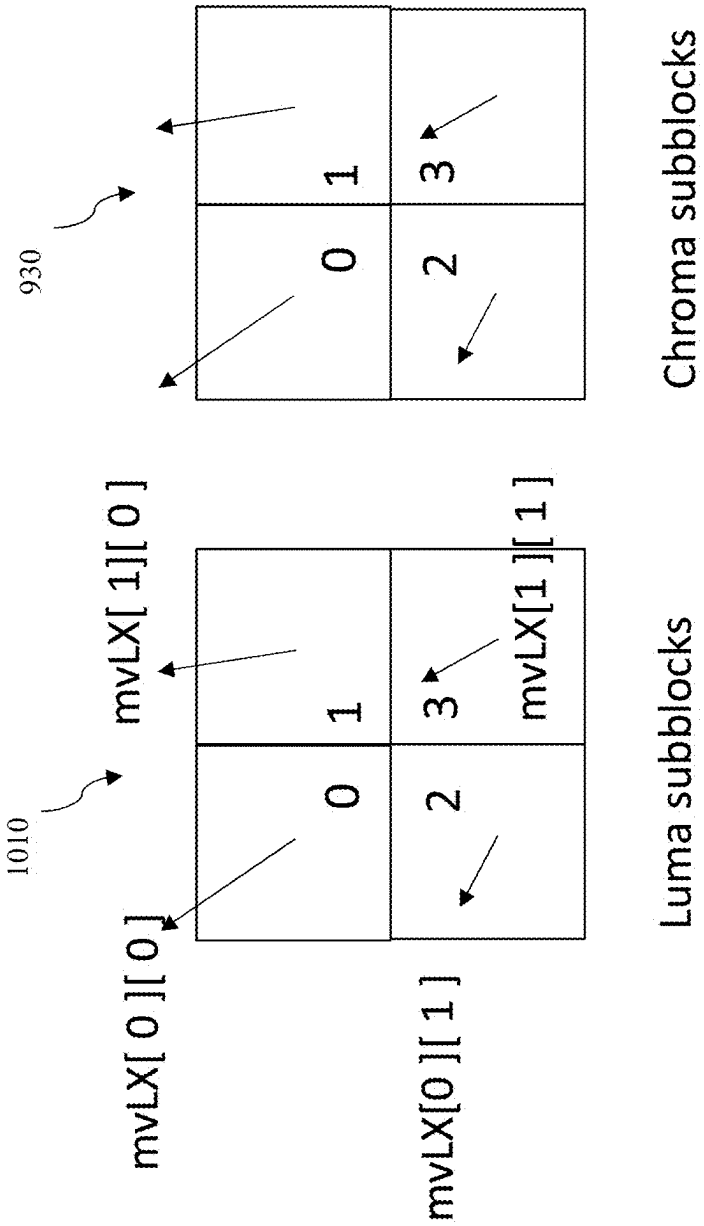

930
0
1
2
3
Chroma subblocks
1010
mvLX[0][0]
mvLX[1][0]
mvLX[0][1]
mvLX[1][1]
0
1
2
3
Luma subblocks

FIG. 11C

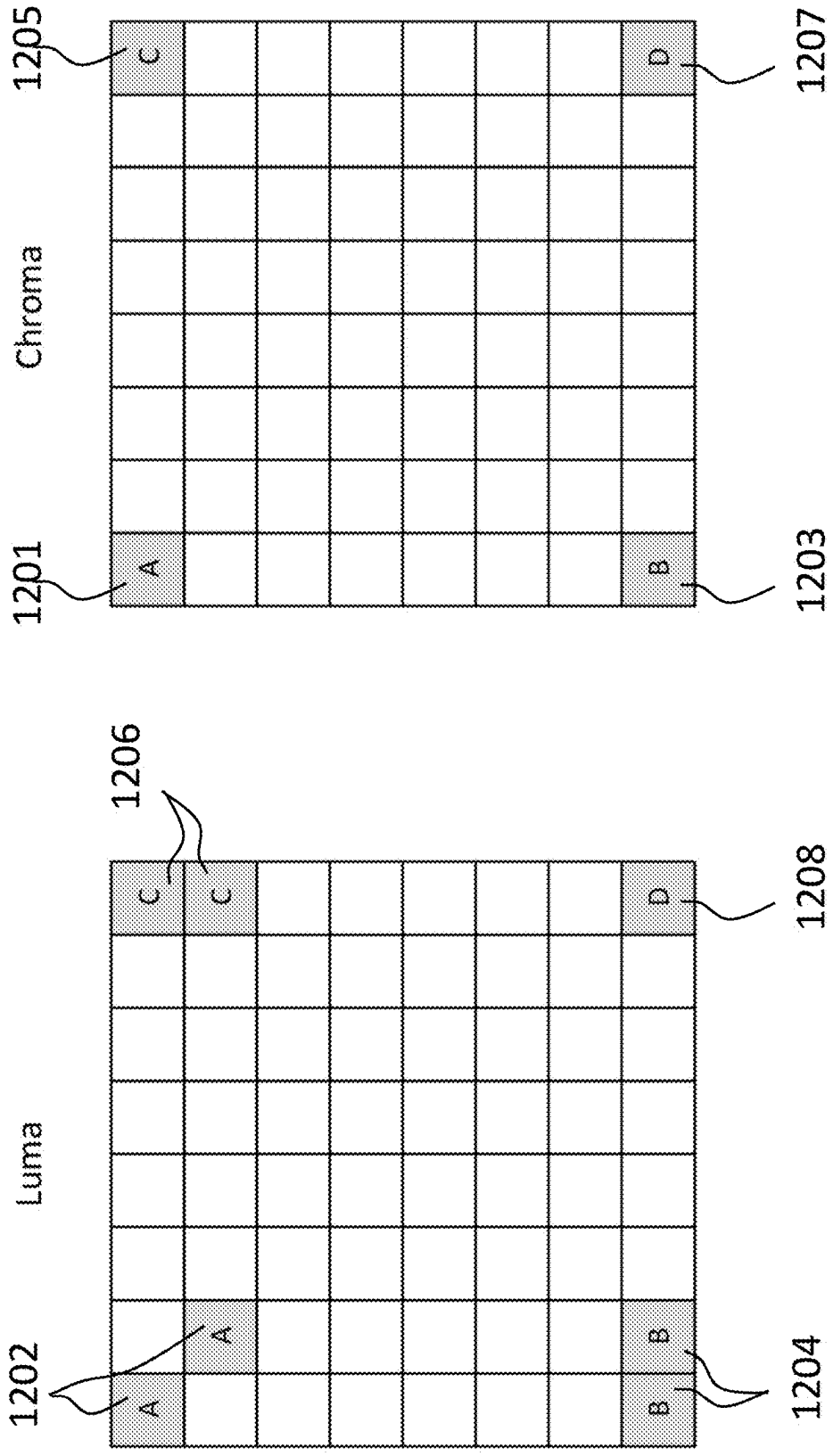


FIG. 12A

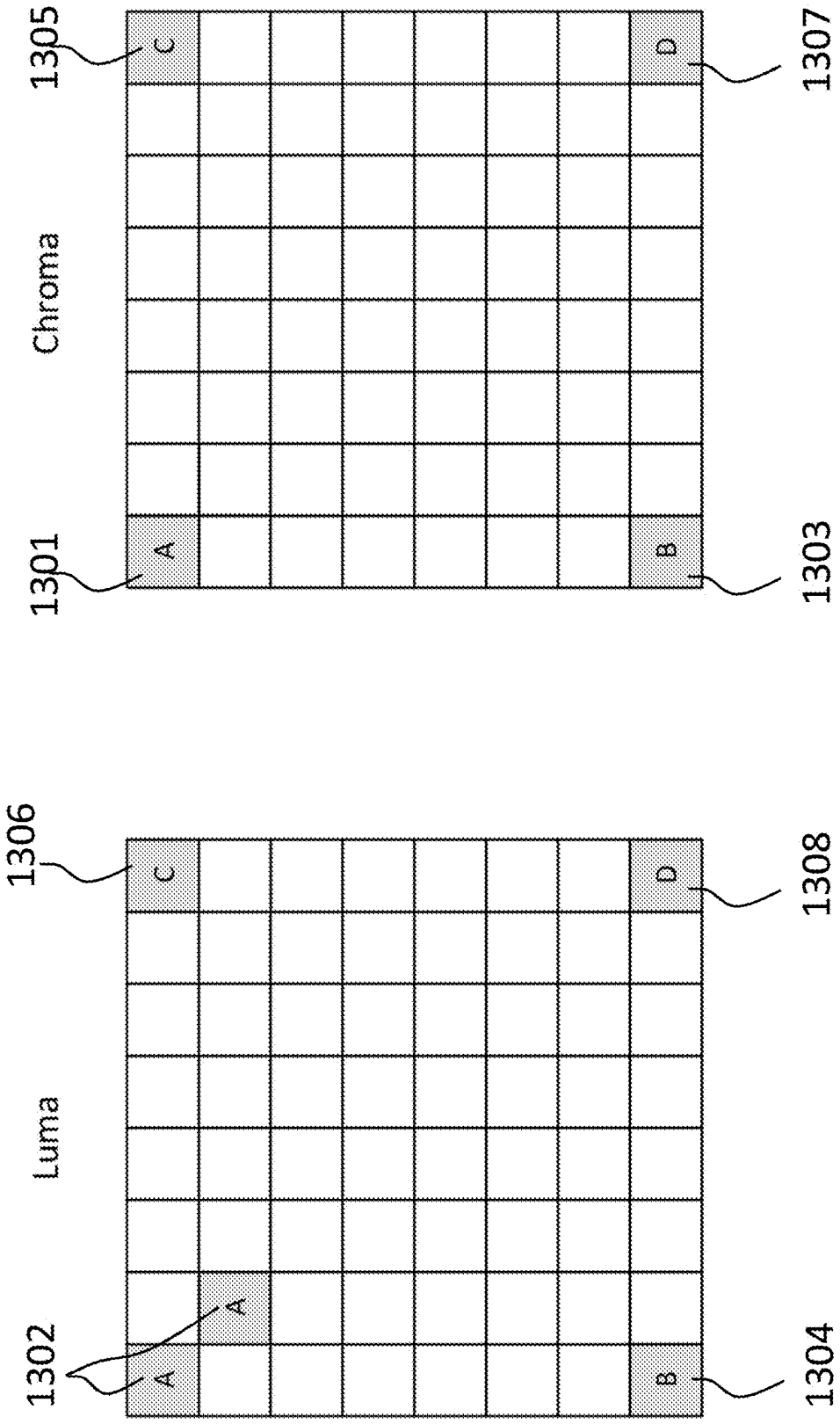

Chroma
1305
C
1307
D
1301
A
1303
B
Luma
1306
C
1308
D
1302
A
A
1304
B

FIG. 12B

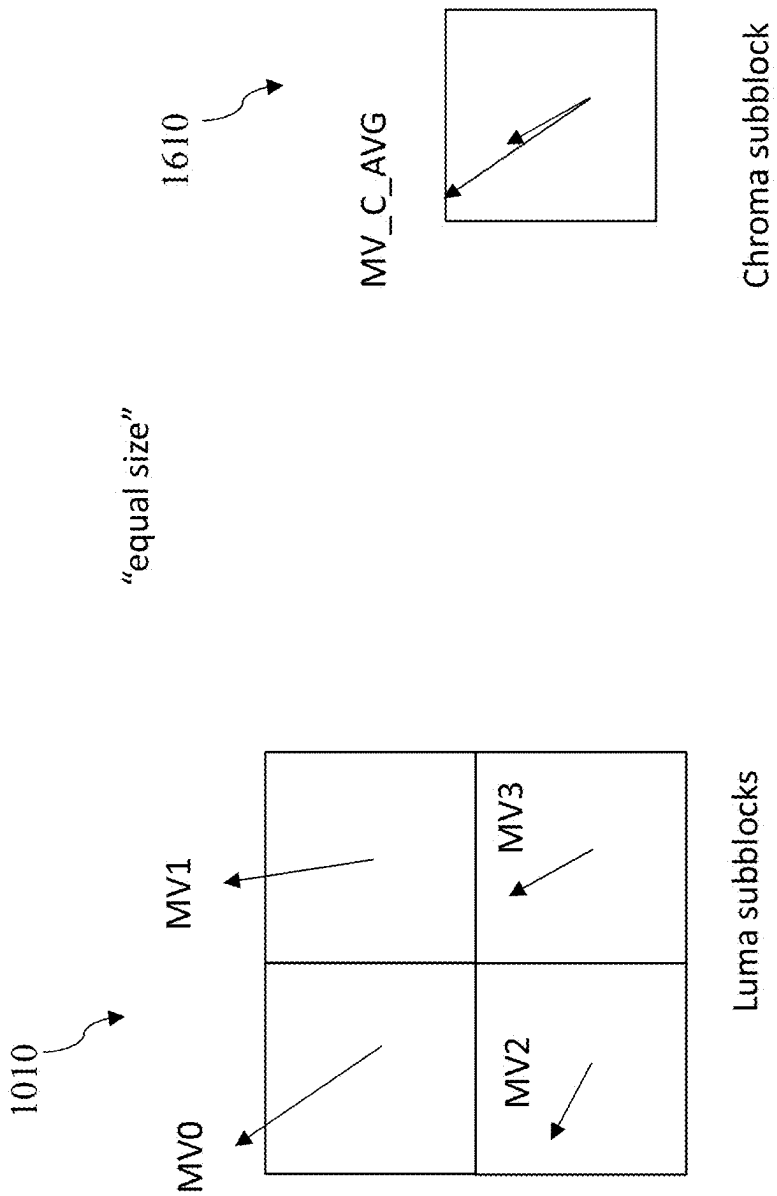

1010
MV0
MV1
MV2
MV3
Luma subblocks
"equal size"
1610
MV_C_AVG
Chroma subblock

FIG. 13A

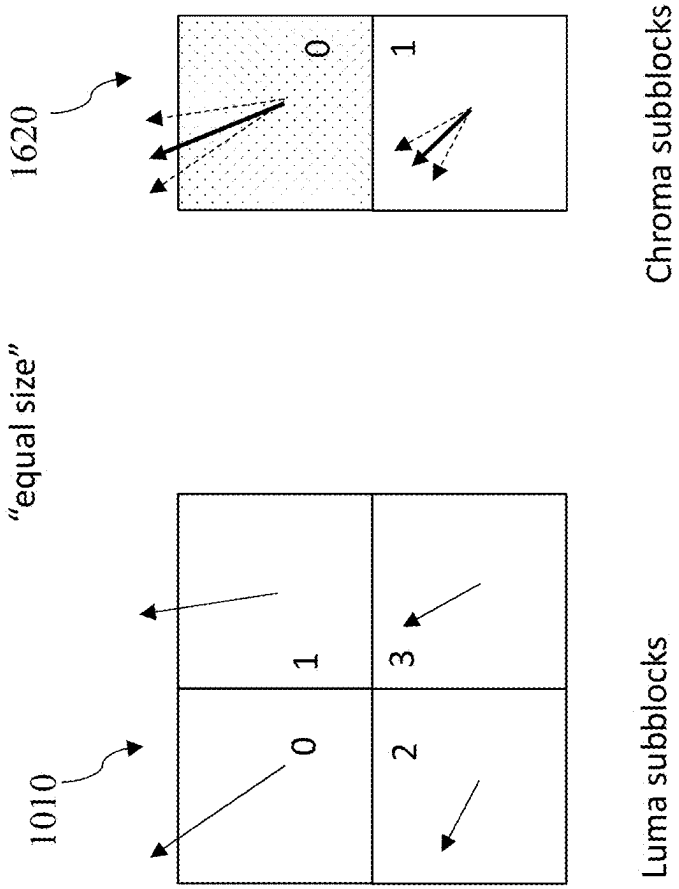

1010
"equal size"
0
1
2
3
Luma subblocks
1620
0
1
Chroma subblocks

FIG. 13B

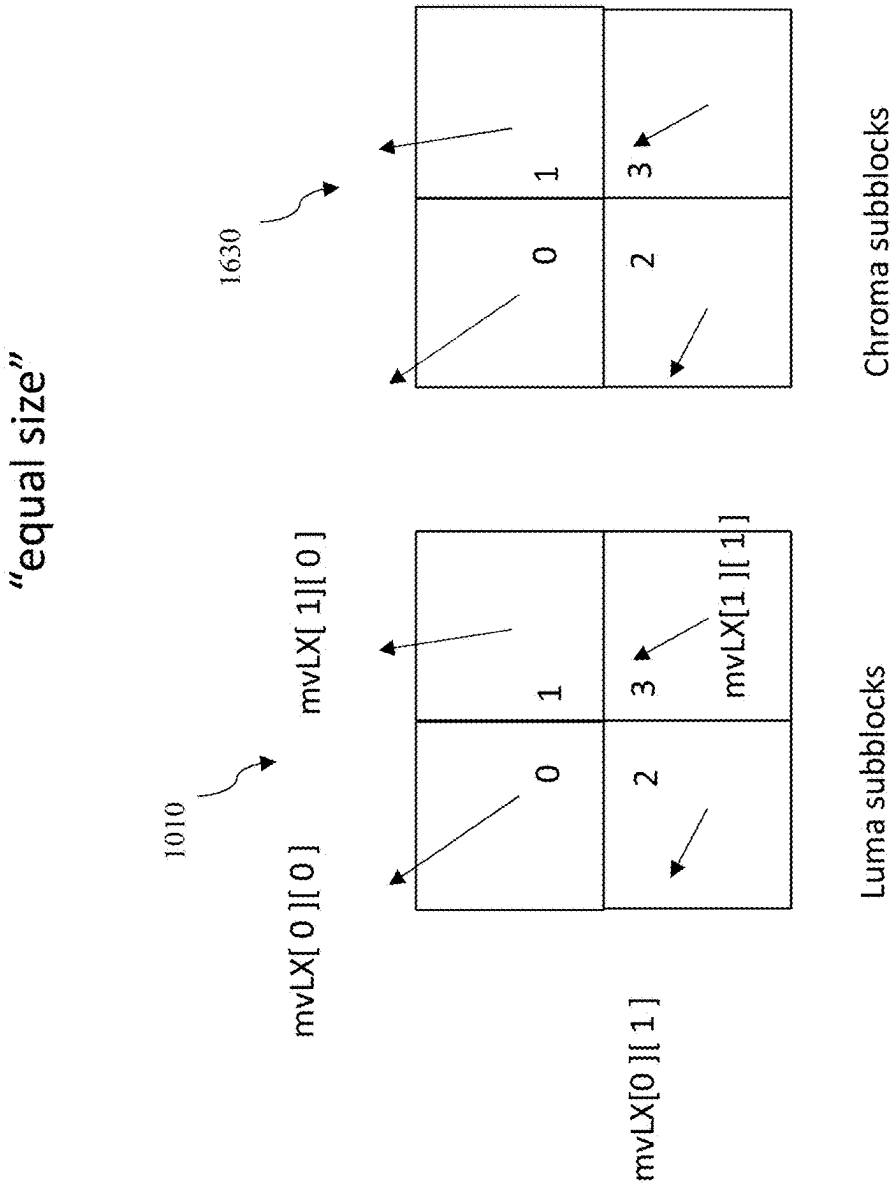
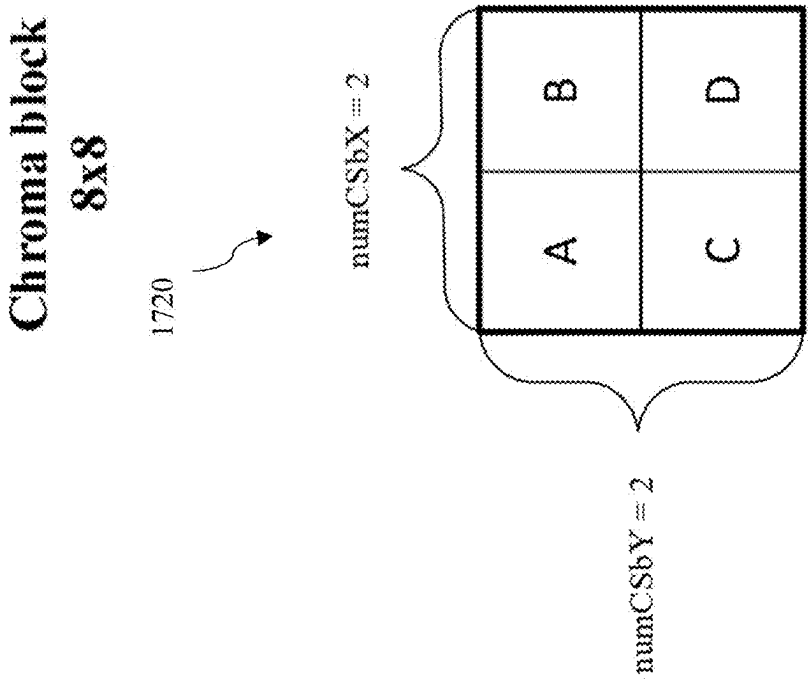

"equal size"
1010
mvLX[0][0]
mvLX[1][0]
mvLX[0][1]
mvLX[1][1]
0
1
2
3
Luma subblocks
1630
0
1
2
3
Chroma subblocks

FIG. 13C


Chroma block
8x8
1720
numCSbX = 2
numCSbY = 2
A
B
C
D

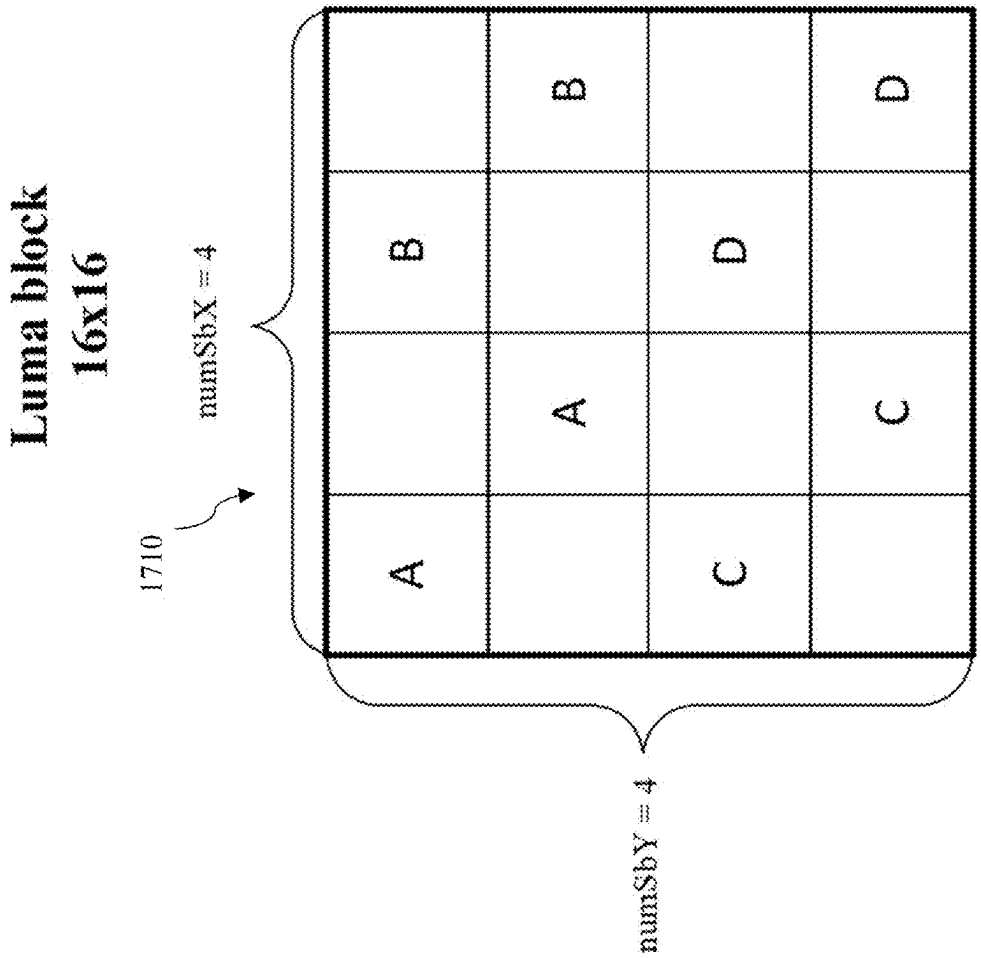
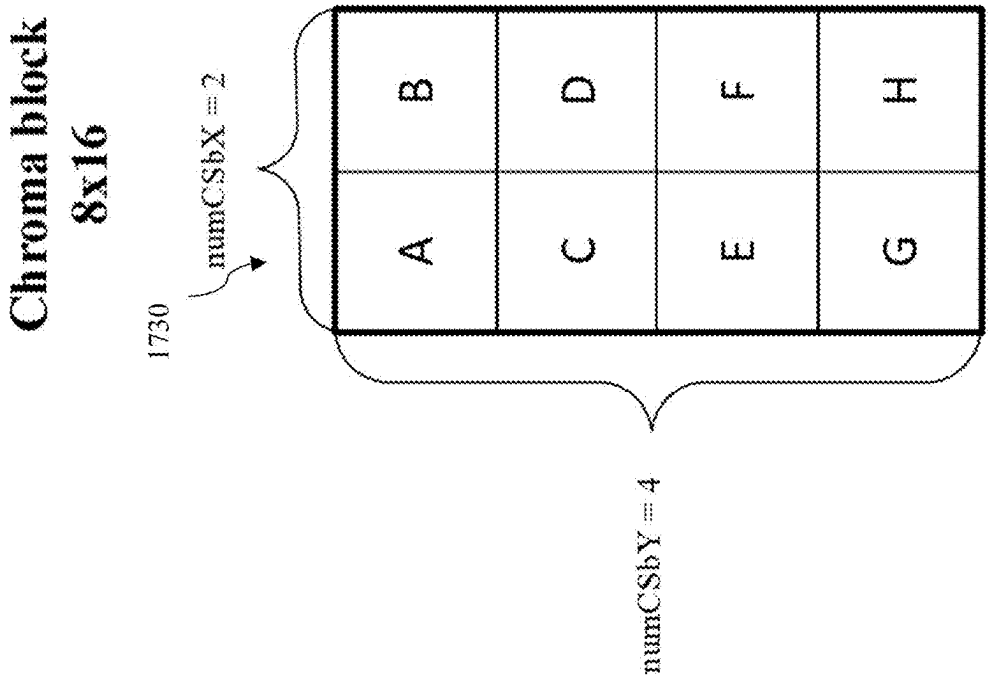

Luma block
16x16
1710
numSbX = 4
numSbY = 4
A
B
A
B
C
D
C
D

FIG. 14A


Chroma block
8x16
1730
numCSbX = 2
numCSbY = 4
A
B
C
D
E
F
G
H

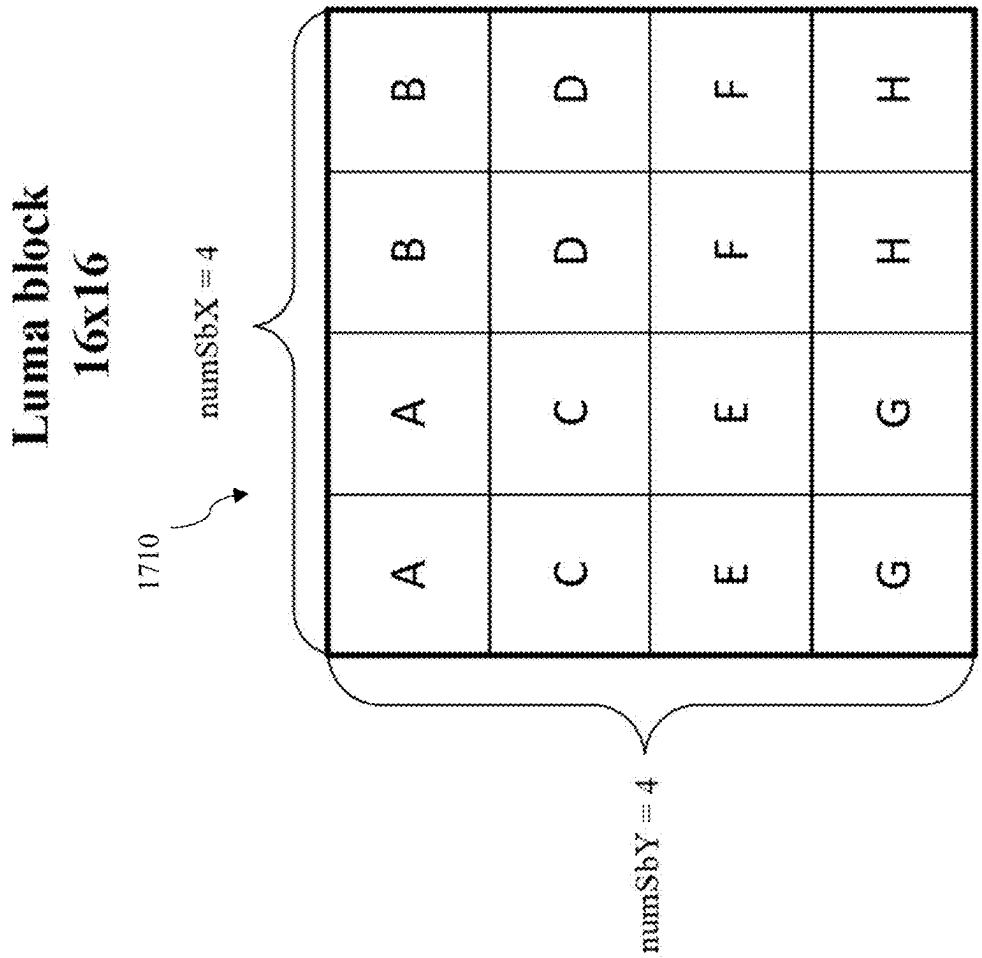
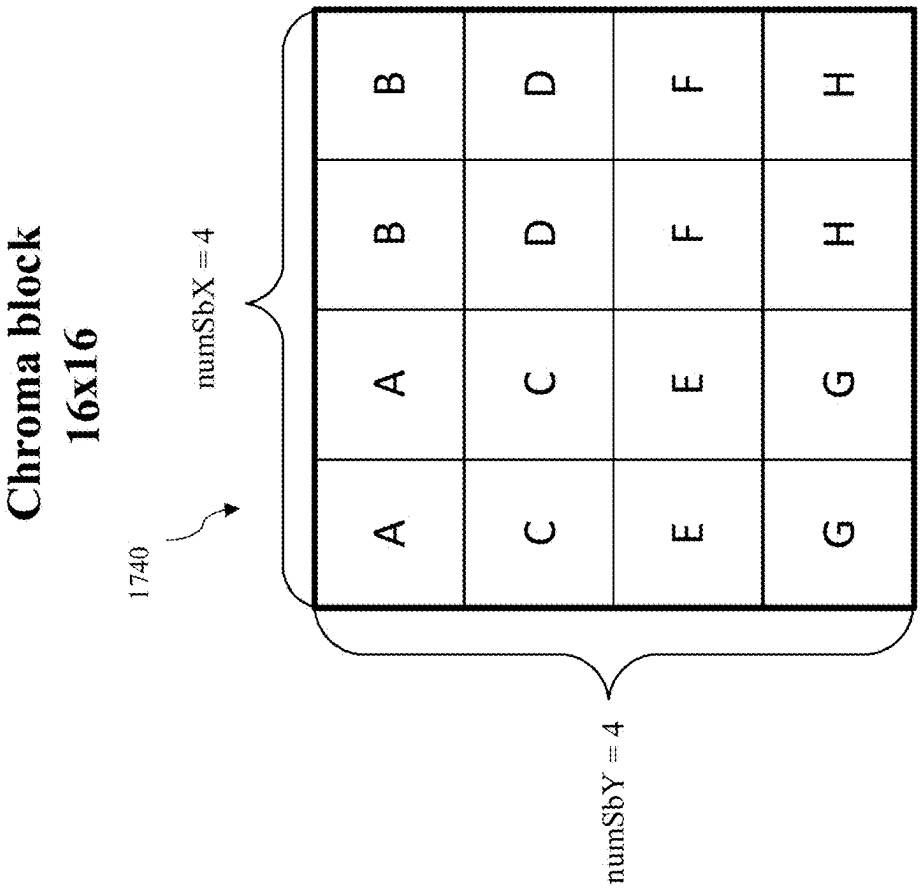

Luma block
16x16
1710
numSbX = 4
numSbY = 4
A
A
B
B
C
C
D
D
E
E
F
F
G
G
H
H

FIG. 14B


Chroma block
16x16
1740
numSbX = 4
numSbY = 4
A A B B
C C D D
E E F F
G G H H

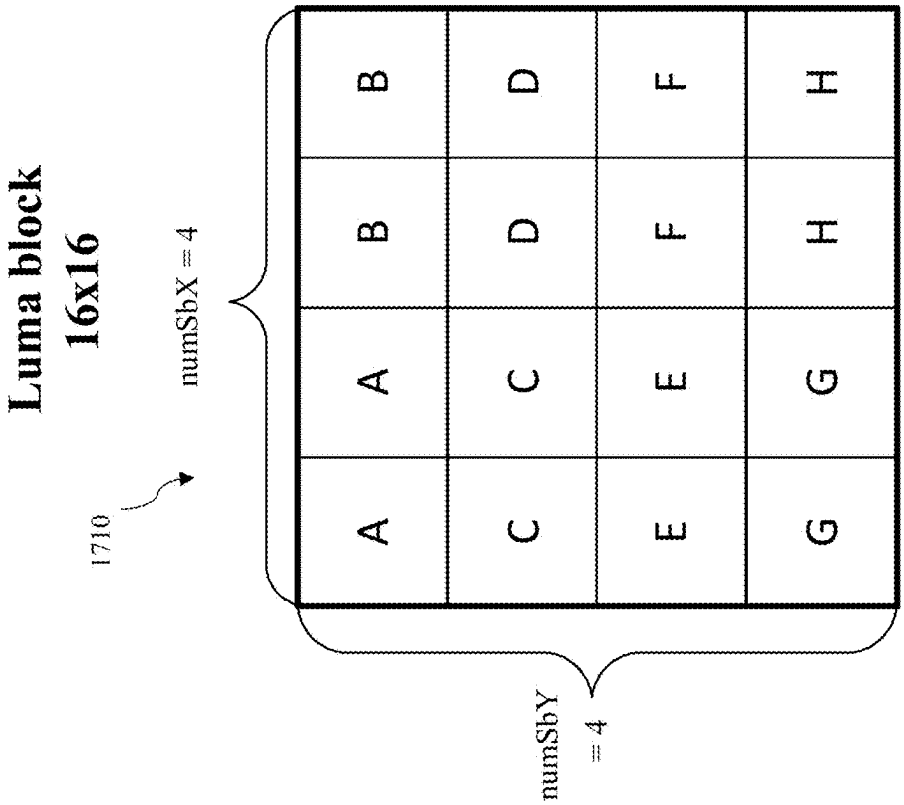

Luma block
16x16
1710
numSbX = 4
numSbY
= 4
A A B B
C C D D
E E F F
G G H H

FIG. 14C

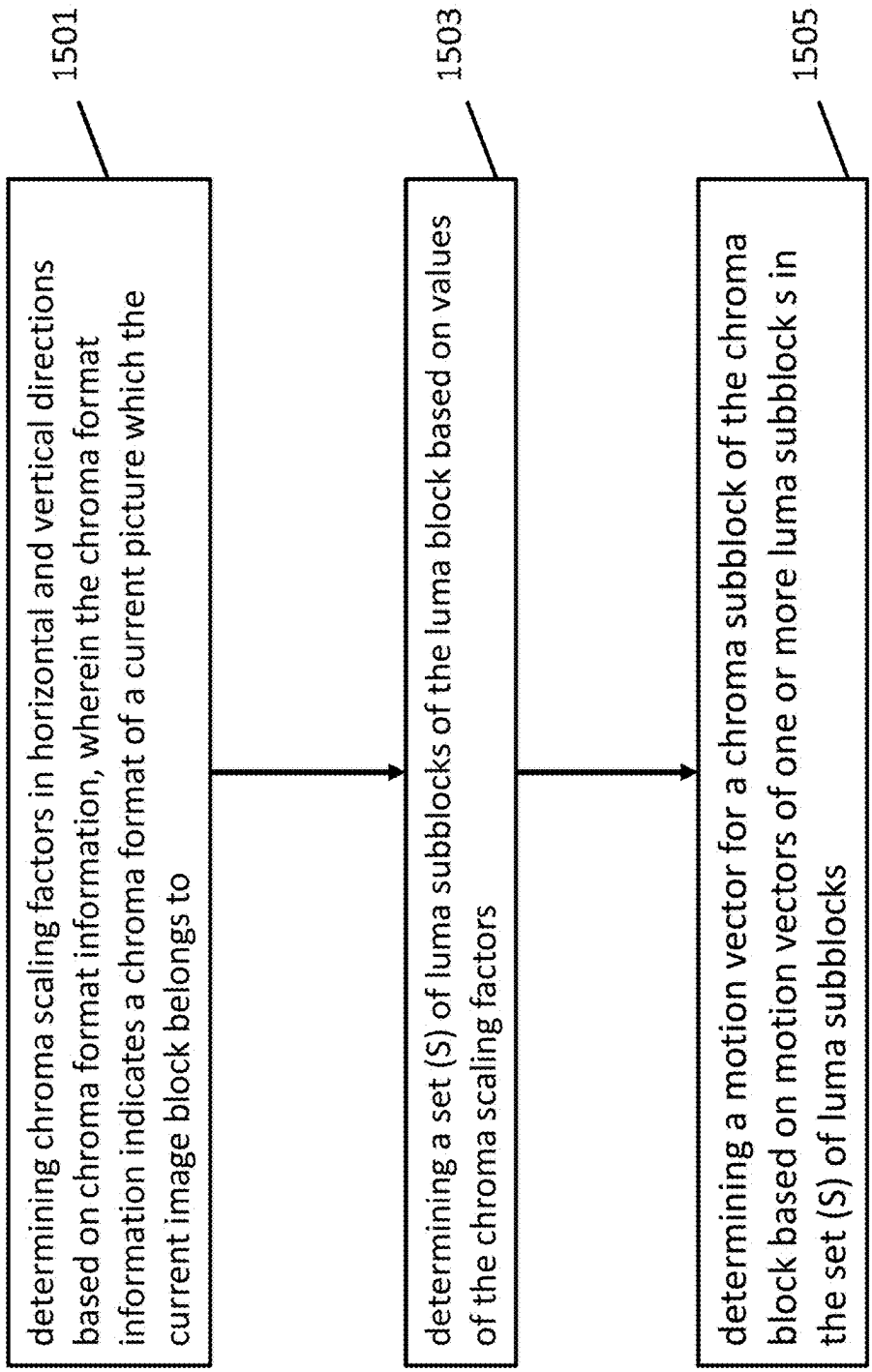

1501
determining chroma scaling factors in horizontal and vertical directions based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the current image block belongs to
1503
determining a set (S) of luma subblocks of the luma block based on values of the chroma scaling factors
1505
determining a motion vector for a chroma subblock of the chroma block based on motion vectors of one or more luma subblock s in the set (S) of luma subblocks

FIG. 15

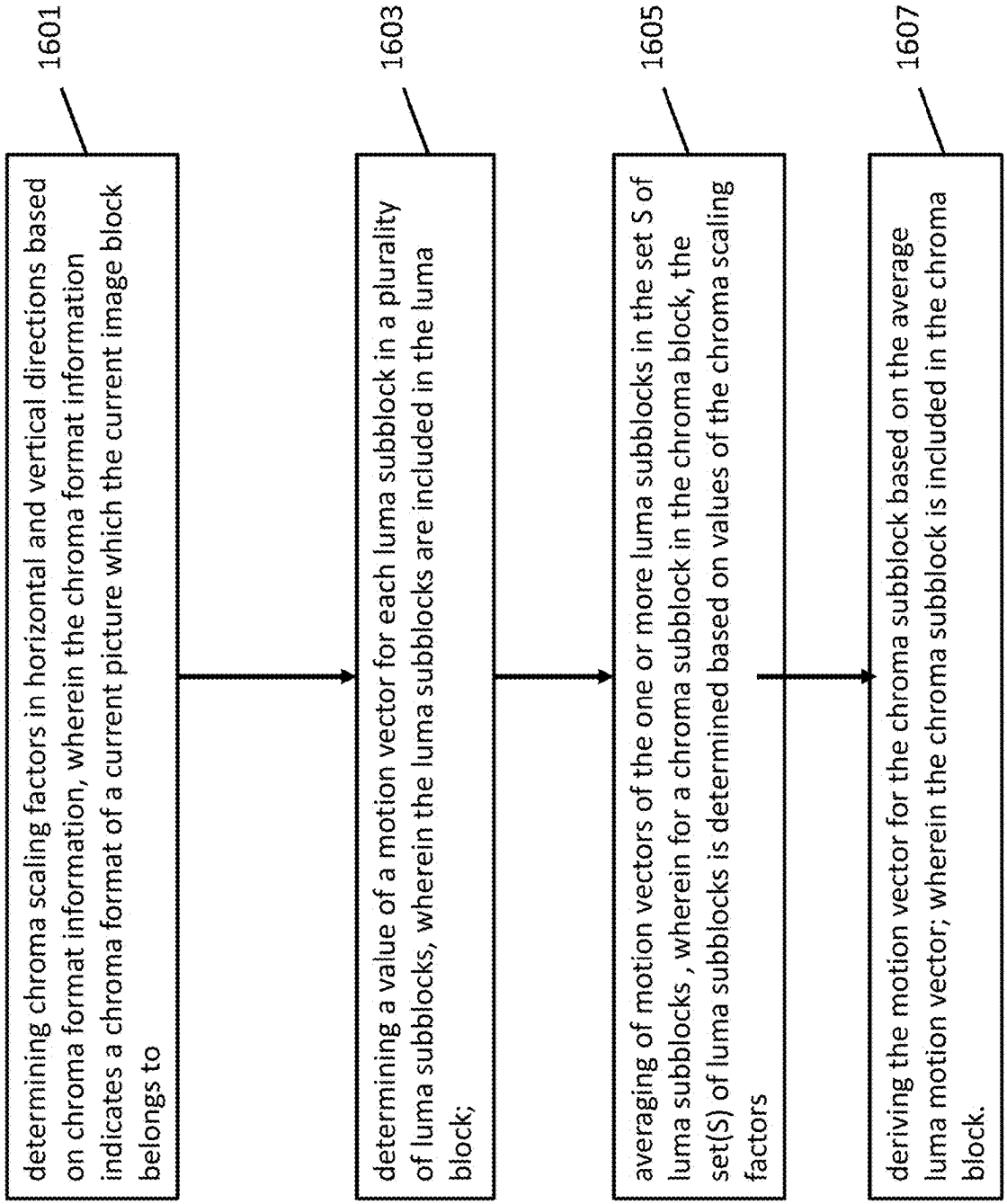

1601
determining chroma scaling factors in horizontal and vertical directions based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the current image block belongs to
1603
determining a value of a motion vector for each luma subblock in a plurality of luma subblocks, wherein the luma subblocks are included in the luma block;
1605
averaging of motion vectors of the one or more luma subblocks in the set S of luma subblocks , wherein for a chroma subblock in the chroma block, the set(S) of luma subblocks is determined based on values of the chroma scaling factors
1607
deriving the motion vector for the chroma subblock based on the average luma motion vector; wherein the chroma subblock is included in the chroma block.

FIG. 16

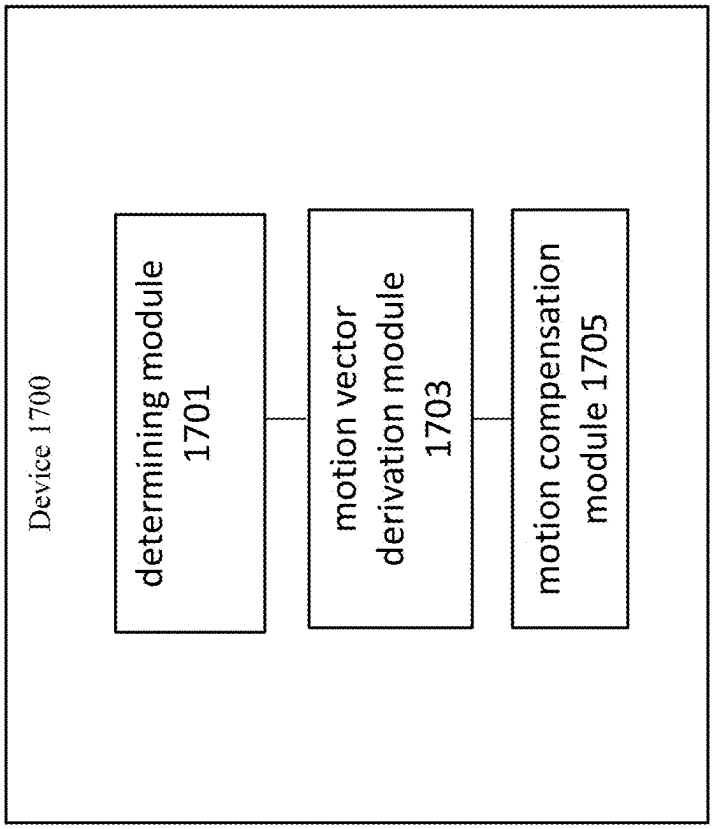

Device 1700
determining module 1701
motion vector derivation module 1703
motion compensation module 1705

FIG. 17

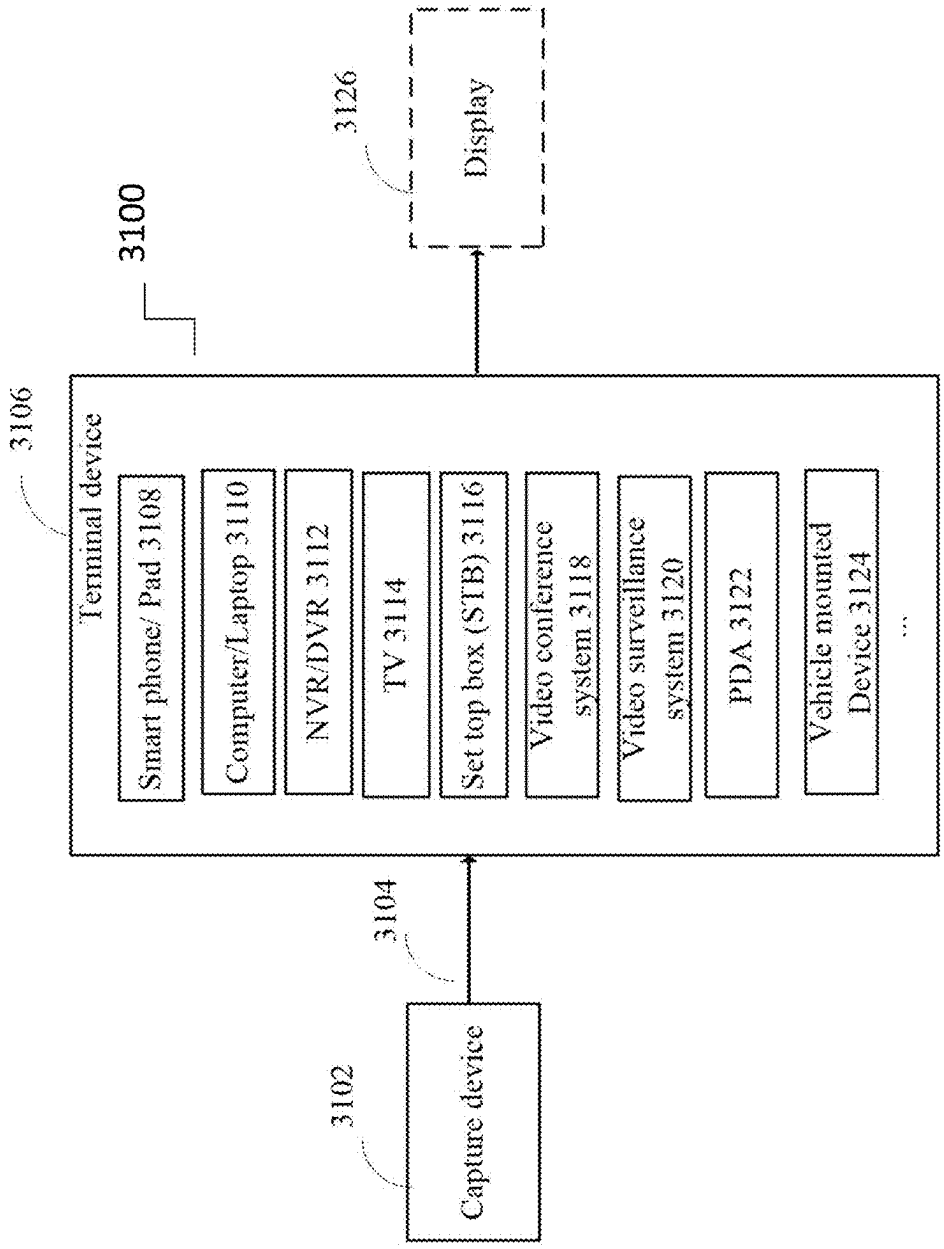

3100
3106
Terminal device
Smart phone/ Pad 3108
Computer/Laptop 3110
NVR/DVR 3112
TV 3114
Set top box (STB) 3116
Video conference system 3118
Video surveillance system 3120
PDA 3122
Vehicle mounted Device 3124
...
3126
Display
3104
3102
Capture device

FIG. 18

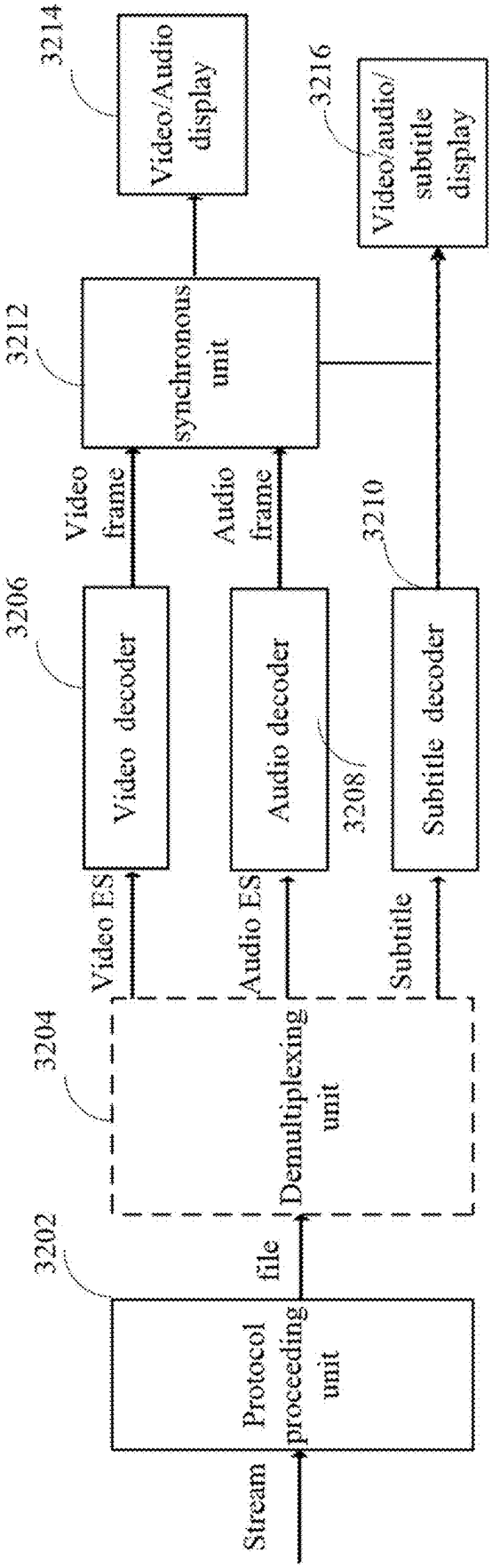

Stream
3202
Protocol proceeding unit
file
3204
Demultiplexing unit
Video ES
Audio ES
Subtitle
3206
Video decoder
Audio decoder
3208
Subtitle decoder
3210
Video frame
Audio frame
3212
synchronous unit
3214
Video/Audio display
3216
Video/audio/ subtitle display

FIG. 19

METHOD AND APPARATUS FOR AFFINE BASED INTER PREDICTION OF CHROMA SUBBLOCKS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 17/407,548, filed on Aug. 20, 2021, which is a continuation of International Application No. PCT/CN2020/076493, filed on Feb. 24, 2020, which claims the priority to U.S. Provisional Patent Application No. 62/809,551, filed Feb. 22, 2019 and Patent Application No. 62/823,653, filed Mar. 25, 2019 and Patent Application No. 62/824,302, filed Mar. 26, 2019. All of the aforementioned patent applications are hereby incorporated by reference in their entireties.

TECHNICAL FIELD

Embodiments of the present disclosure generally relate to the field of picture processing and more particularly to affine based inter prediction (affine motion compensation), in particular, method and apparatus for motion vector derivation for affine based inter prediction of chroma subblocks based on chroma format, and method and apparatus for affine based inter prediction of chroma subblocks.

BACKGROUND

Video coding (video encoding and/or decoding) is used in a wide range of digital video applications, for example broadcast digital TV, video transmission over internet and mobile networks, real-time conversational applications such as video chat, video conferencing, DVD and Blu-ray discs, video content acquisition and editing systems, and camcorders of security applications.

The amount of video data needed to depict even a relatively short video can be substantial, which may result in difficulties when the data is to be streamed or otherwise communicated across a communications network with limited bandwidth capacity. Thus, video data is generally compressed before being communicated across modern day telecommunications networks. The size of a video could also be an issue when the video is stored on a storage device because memory resources may be limited. Video compression devices often use software and/or hardware at the source to code the video data prior to transmission or storage, thereby decreasing the quantity of data needed to represent digital video images. The compressed data is then received at the destination by a video decompression device that decodes the video data. With limited network resources and ever increasing demands for higher video quality, improved compression and decompression techniques with a higher compression ratio and little to no sacrifice in picture quality are desirable.

Particularly, the current Versatile Video Coding and Test Model (VTM) coder mainly supports chroma format 4:2:0 as the input picture format. The VTM coder crash may happen when the input chroma format becomes 4:4:4. To avoid such an issue, a coder that supports other chroma formats (such as, 4:4:4 or 4:2:2) is highly desirable and even mandatory for a wide variety of applications.

SUMMARY

In view of the above-mentioned challenges, a modification to video coding process to support multiple chroma

formats is proposed in the present disclosure. In particular, embodiments of the present application aim to provide an apparatus, an encoder, a decoder and corresponding methods for motion vector derivation for affine based inter prediction of chroma subblocks based on a chroma format, that may be one of multiple supported chroma formats, so as to improve coding performance.

Embodiments of the invention are defined by the features of the independent claims, and further advantageous implementations of the embodiments by the features of the dependent claims.

Particular embodiments are outlined in the attached independent claims, with other embodiments in the dependent claims.

The foregoing and other objects are achieved by the subject matter of the independent claims. Further implementation forms are apparent from the dependent claims, the description and the figures.

According to a first aspect of the present disclosure, it is provided a method of chroma motion vector derivation used in affine based inter prediction of a current image block comprises a luma block and a co-located chroma block, the method comprising determining chroma scaling factors (i.e. the value of the chroma scaling factors) in horizontal and vertical directions based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the current image block belongs to; determining a set (S) of luma subblocks of the luma block based on values of the chroma scaling factors; and determining a motion vector for a chroma subblock of the chroma block based on motion vectors of one or more luma subblocks (e.g. one or two luma subblocks) in the set (S) of luma subblocks.

In the presented disclosure, because a (luma or chroma) block or subblock can be represented by its location, position or index, selecting/determining a block or subblock implies that the position or location or the index of the block or subblock is selected or determined.

It is noted that the term "block", "coding block" or "image block" used in the present disclosure can represent a transform units (TU), a prediction unit (PU), a coding unit (CU) etc. In Versatile Video Coding (VVC), transform units and coding units are generally aligned with each other except when TU tiling or sub block transform (SBT) is used. As such, the terms "block," "image block," "coding block," and "transform block" may be used interchangeably in the present disclosure; and the terms "block size," and "transform block size" may be used interchangeably in the present disclosure. The terms "sample" and "pixel" may also be used interchangeably in the present disclosure.

The present disclosure is directed to a method to consider the chroma format of the picture when obtaining chroma motion vectors from luma motion vectors. By taking an average of luma motion vectors, linear subsampling of luma motion field is performed. When chroma color planes have the same height as the luma plane, it is found more appropriate to select motion vectors from luma blocks that are horizontally adjacent, so that they have the same vertical position. Selecting luma motion vectors depending on the picture chroma format leads to a more accurate chroma motion field due to a more accurate luma motion vector field subsampling. This dependency on chroma format enables the selection of the most appropriate luma blocks when averaging luma motion vectors to generate the chroma motion vector. As a consequence of a more accurate motion field interpolation, prediction error is reduced, which leads

to a technical result of a compression performance improvement, thus coding performance is improved.

In a possible implementation form of the method according to the first aspect, the set (S) of luma subblocks is determined based on values of the chroma scaling factors in horizontal and vertical directions; That is, the one or more luma subblocks (such as, one or two luma subblocks) are determined based on values of the chroma scaling factors in horizontal and vertical directions.

In a possible implementation form of the method according to the first aspect, the chroma scaling factors in horizontal and vertical directions are represented by the variables SubWidthC and SubHeightC.

In a possible implementation form of the method according to the first aspect, a position of each of the luma subblocks is represented by a subblock index in a horizontal direction and a subblock index in a vertical direction, and a position of each of the chroma subblocks is represented by a subblock index in the horizontal direction and a subblock index in the vertical direction.

In a possible implementation form of the method according to the first aspect, the positions of each of the one or more luma subblocks (such as one or two luma subblocks) in the set(S) is represented by a subblock index in a horizontal direction and a subblock index in a vertical direction.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, if both the variables SubWidthC and SubHeightC are equal to 1, the set of luma subblocks (S) comprises:

a luma subblock indexed by S_0=(xSbIdx, ySbIdx);

if at least one of SubWidthC and SubHeightC is not equal to 1, the set of luma subblocks (S) comprises:

a first luma subblock indexed by S_0=

$$((xSbIdx>>(SubWidthC-1)<<(SubWidthC-1)),$$

$$(ySbIdx>>(SubHeightC-1)<<(SubHeightC-1))), \text{ and}$$

a second luma subblock indexed by S_1=

$$((xSbIdx>>(SubWidthC-1)<<(SubWidthC-1))+(SubWidthC-1),$$

$$(ySbIdx>>(SubHeightC-1)<<(SubHeightC-1))+(SubHeightC-1))$$

wherein SubWidthC and SubHeightC represent the respectively chroma scaling factors in horizontal and vertical directions;

xSbIdx and ySbIdx represent a subblock index in the horizontal direction and a subblock index in the vertical direction for a luma subblock in the set (S), respectively; "<<" represents a left arithmetic shift and ">>" represents a right arithmetic shift; and xSbIdx=0 . . . numSbX−1 and ySbIdx=0 . . . numSbY−1, and numSbX indicates the number of the luma subblocks in the luma block along the horizontal direction and numSbY indicates the number of the luma subblocks in the luma block along the vertical direction.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, the numbers of the chroma subblocks in horizontal and vertical directions are the same as the numbers of the luma subblocks in horizontal and vertical directions, respectively.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein if both SubWidthC and SubHeightC are equal to 1, the set of luma subblocks (S) comprises:

a luma subblock indexed by S_0=(xCSbIdx, yCSbIdx);

if at least one of SubWidthC and SubHeightC is not equal to 1, the set of luma subblocks (S) comprises:

a first luma subblock indexed by S_0=

$$((xCSbIdx>>(SubWidthC-1)<<(SubWidthC-1)),$$

$$(yCSbIdx>>(SubHeightC-1)<<(SubHeightC-1))), \text{ and}$$

a second luma subblock indexed by S_1=

$$(xCSbIdx>>(SubWidthC-1)<<(SubWidthC-1))+(SubWidthC-1),$$

$$(yCSbIdx>>(SubHeightC-1)<<(SubHeightC-1))+(SubHeightC-1))$$

wherein the variables SubWidthC and SubHeightC represent respectively the chroma scaling factors in horizontal and vertical directions; xCSbIdx and yCSbIdx represent a subblock index in horizontal direction and a subblock index in vertical direction, respectively, for a luma subblock in the set (S); and xCSbIdx=0 . . . numCSbX−1 and yCSbIdx=0 . . . numCSbY−1, and numCSbX indicates the number of the chroma subblocks in the chroma block along the horizontal direction and numCSbY indicates the number of the chroma subblocks in the chroma block along the vertical direction.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein a size of each of the chroma subblocks is the same as a size of each of the luma subblocks. It is allowed that when a number of chroma subblocks is defined to be equal to the number of luma subblocks, and when a chroma color plane size is equal to luma plane size (such as the chroma format of the input picture being 4:4:4), motion vectors of adjacent chroma subblocks may assume the same value. When implementing this processing step, an optimization could be performed by skipping the repeated values calculation step.

The proposed invention discloses a method to define a size of chroma subblock equal to a size of luma subblock. In this case, implementation could be simplified by unifying luma and chroma processing, and redundant motion vector calculations are naturally avoided.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, in the case that a size of each of the chroma subblocks is the same as a size of each of the luma subblocks, the number of chroma subblocks in the horizontal direction depends on the number of the luma subblocks in the horizontal direction and the value of the chroma scaling factor in the horizontal direction;

the number of chroma subblocks in vertical direction depends on the number of the luma subblocks in the vertical direction and the value of the chroma scaling factor in the vertical direction.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, xCSbIdx is obtained based on xSbIdx and a step value of SubWidth; and yCSbIdx is obtained based on ySbIdx and a step value of SubHeightC.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such,

$$numCSbX=numSbX>>(SubWidthC-1)$$

$$numCSbY=numSbY>>(SubHeightC-1);$$

numCSbX and numCSbY represent the number of chroma subblocks in horizontal and vertical directions, respectively; and

numSbX and numSbY represent the number of the luma subblocks in the luma block in horizontal and vertical directions, respectively.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, for the chroma block, the set of luma subblocks (S) comprises one or more of subblocks indexed by:

$$S_0=(xSbIdxL,ySbIdxL),$$

$$S_1=(xSbIdxL,ySbIdxL+(SubHeightC-1)),$$

$$S_2=(xSbIdxL+(SubWidthC-1),ySbIdxL), \text{ or}$$

$$S_3=(xSbIdxL+(SubWidthC-1),ySbIdxL+(SubHeightC-1)).$$

wherein the luma block position or index S_0 is represented by a subblock index xSbIdxL in the horizontal direction and a subblock index ySbIdxL in the vertical direction;

for the chroma block position (such as [xSbIdxL][ySbIdxL] in mvCLX[xSbIdxL][ySbIdxL],

the luma block position or index S_1 is represented by a subblock index in the horizontal direction, xSbIdxL, and a subblock index in the vertical direction, ySbIdxL+(SubHeightC−1);

the luma block position or index S_2 is represented by a subblock index in the horizontal direction, xSbIdxL+(SubWidthC−1), and a subblock index in the vertical direction, ySbIdxL;

the luma block position or index S_3 is represented by a subblock index in the horizontal direction, xSbIdxL+(SubWidthC−1), and a subblock index in vertical direction, ySbIdxL+(SubHeightC−1).

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein the set of luma subblocks (S) comprises two luma subblocks indexed by:

$$S_0=(xSbIdxL,ySbIdxL), \text{ and}$$

$$S_1=(xSbIdxL+(SubWidthC-1),ySbIdxL+(SubHeightC-1)).$$

wherein the luma block position or index S_0 is represented by a subblock index xSbIdxL in the horizontal direction and a subblock index ySbIdxL in the vertical direction;

the luma block position or index S_1 is represented by a subblock index in the horizontal direction, xSbIdxL+(SubWidthC−1), and a subblock index in the vertical direction, ySbIdxL+(SubHeightC−1).

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein

in the case that the chroma format is 4:4:4, the set (S) comprise (consist of) one luma subblock which is co-located with the chroma subblock;

wherein in the case that the chroma format is 4:2:2, the set (S) comprise two luma subblocks which are horizontally adjacent;

wherein in the case that the chroma format is 4:2:0, the set (S) comprise two luma subblocks which are diagonal.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein if there are more than one luma subblock in the set (S), the determining a motion vector for the chroma subblock based on the motion vector of at least one luma subblock in a set (S) of luma subblocks, comprises:

averaging of motion vectors of the luma subblocks in the set S; and

deriving the motion vector for the chroma subblock based on the average luma motion vector.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, averaging of motion vectors of the luma subblocks in the set S comprise:

averaging of horizontal components of the motion vectors of the luma subblocks in the set S; and/or,

averaging of vertical components of the motion vectors of the luma subblocks in the set S.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein the averaging of motion vectors of the luma subblocks in the set S comprise checking whether a sum of motion vectors of the luma subblocks in the set S is greater than or equal to 0.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein the averaging of motion vectors of the luma subblocks in the set S comprises:

$$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX=$$

$$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y \text{ if } mvAvgLX[0] \text{ is greater than or equal to 0 then}$$

$$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0]=(mvAvgLX[0]+(N>>1)-1)>>\log 2(N), \text{otherwise,}$$

$$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0]=-((-mvAvgLX[0]+(N>>1)-1)>>\log 2(N))$$

$$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y \text{ if } mvAvgLX[1] \text{ is greater than or equal to 0 then}$$

$$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1]=(mvAvgLX[1]+(N>>1)-1)>>\log 2(N), \text{otherwise,}$$

$$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1]=-((-mvAvgLX[1]+(N>>1)-1)>>\log 2(N)),$$

$\Sigma_i mvLX[S_i^x][S_i^y]\ S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ where mvAvgLX is a result of averaging, mvAvgLX[0] is a horizontal component of motion vector mvAvgLX, mvAvgLX[1] is a vertical component of motion vector mvAvgLX, and are horizontal and vertical indices of subblock Si in the set of luma subblocks (S) in a motion vector array, is a motion vector of luma subblock with indices and, N is a number of elements (e.g. luma subblocks) in the set of luma subblocks (S), log 2(N) represents the logarithm of N to the base 2 and is the power to which the number 2 is raised to obtain the value N and ">>" is a right arithmetic shift.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, N is equal to 2.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, the averaging of motion vectors of the luma subblocks in the set S comprises:

```
mvAvgLX=mvLX[(xSbIdx>>(SubWidthC−1)<<
    (SubWidthC−1))]

[(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))]+

mvLX[(xSbIdx>>(SubWidthC−1)<<(SubWidthC−
    1))+(SubWidthC−1)]

[(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))+
    (SubHeightC−1)]

if mvAvgLX[0]>=0 then

mvAvgLX[0]=(mvAvgLX[0]+1−(mvAvgLX[0]>=0))
    >>1

if mvAvgLX[1]>=0 then

mvAvgLX[1]=(mvAvgLX[1]+1−(mvAvgLX[1]>=0))
    >>1
```

wherein mvAvgLX[0] is a horizontal component of the averaged motion vector mvAvgLX, mvAvgLX[1] is a vertical component of the averaged motion vector mvAvgLX; wherein SubWidthC and SubHeightC represent the chroma scaling factors in horizontal and vertical directions respectively; xSbIdx and ySbIdx represent a subblock index in horizontal direction and vertical direction, respectively, for a luma subblock in the set (S), "<<" is a left arithmetic shift and ">>" is a right arithmetic shift.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, if Case 1: mvAvgLX[0]>=0, then the value for "(mvAvgLX[0]>=0)"=1; if case2: mvAvgLX[0]<0, then the value for "(mvAvgLX[0]>=0)"=0;

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, the averaging of motion vectors of the luma subblocks in the set S comprises

when the sum of motion vectors of the luma subblocks in the set S is greater than or equal to 0, the sum of motion vectors of the luma subblocks in the set S is divided by right shifting operation depending on the number of elements (e.g. luma subblocks) in the set of luma subblocks (S).

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, the determining chroma scaling factors in horizontal and vertical directions based on chroma format information, comprises: determining the chroma scaling factors in horizontal and vertical directions based on a mapping between the chroma format information and the chroma scaling factors in horizontal and vertical directions.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, further comprising generating a prediction of the chroma subblock based on the determined motion vector.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, the chroma format comprises one of a YUV 4:2:2 format, a YUV 4:2:0 format or a YUV 4:4:4 format.

The method according to any preceding implementation of the first aspect or the first aspect as such implemented by an encoding device.

The method according to any preceding implementation of the first aspect or the first aspect as such implemented by a decoding device.

According to a second aspect of the invention, an apparatus for affine based inter prediction of a current image block comprises co-located luma and chroma blocks, is provided, wherein the apparatus comprising

a determining module configured to determine chroma scaling factors in horizontal and vertical directions based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the current image block belongs to; and determine a set (S) of luma subblocks of the luma block based on values of the chroma scaling factors; and

a motion vector derivation module configured to determine a motion vector for a chroma subblock of the chroma block based on motion vectors of one or more luma subblocks in the set (S) of luma subblocks.

The method according to the first aspect of the invention can be performed by the apparatus according to the second aspect of the invention. Further features and implementation forms of the apparatus according to the second aspect of the invention correspond to the features and implementation forms of the method according to the first aspect of the invention.

According to a third aspect the invention relates to an apparatus for decoding a video stream includes a processor and a memory. The memory is storing instructions that cause the processor to perform the method according to the first aspect.

According to a fourth aspect the invention relates to an apparatus for encoding a video stream includes a processor and a memory. The memory is storing instructions that cause the processor to perform the method according to the first aspect.

According to a fifth aspect, a computer-readable storage medium having stored thereon instructions that, when executed, cause one or more processors configured to code video data is proposed. The instructions cause the one or more processors to perform a method according to the first aspect or any possible embodiment of the first aspect.

According to a sixth aspect, the invention relates to a computer program comprising program code for performing the method according to the first or second aspect or any possible embodiment of the first aspect when executed on a computer.

Details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description, drawings, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following embodiments of the invention are described in more detail with reference to the attached figures and drawings, in which:

FIG. 1A is a block diagram showing an example of a video coding system configured to implement embodiments presented herein;

FIG. 1B is a block diagram showing another example of a video coding system configured to implement embodiments presented herein;

FIG. **2** is a block diagram showing an example of a video encoder configured to implement embodiments presented herein;

FIG. **3** is a block diagram showing an example structure of a video decoder configured to implement embodiments presented herein;

FIG. **4** is a block diagram illustrating an example of an encoding apparatus or a decoding apparatus;

FIG. **5** is a block diagram illustrating another example of an encoding apparatus or a decoding apparatus;

FIG. **6***a* shows an example about a control point motion vector positions for 4-parameter affine motion model;

FIG. **6***b* shows an example about a control point motion vector positions for 6-parameter affine motion model;

FIG. **7** shows an example of a subblock motion vector field for affine motion model;

FIG. **8** is a block diagram illustrating motion compensation using affine motion model;

FIG. **9**A shows an example about a nominal vertical and horizontal locations of 4:2:0 luma and chroma samples in a picture;

FIG. **9**B shows an example about a nominal vertical and horizontal locations of 4:2:2 luma and chroma samples in a picture;

FIG. **9**C shows an example about a nominal vertical and horizontal locations of 4:4:4 luma and chroma samples in a picture;

FIG. **9**D illustrates various sampling patterns;

FIG. **10**A shows an example illustrating co-located luma and chroma blocks which are included in a current image block of a current picture, where the chroma format of the current picture is 4:2:0.

FIG. **10**B shows an example illustrating co-located luma and chroma blocks which are included in a current image block of a current picture, where the chroma format of the current picture is 4:2:2;

FIG. **10**C shows an example illustrating co-located luma and chroma blocks which are included in a current image block of a current picture, where the chroma format of the current picture is 4:4:4;

FIG. **11**A is an example illustrating positions of two luma subblocks for a given position of a chroma subblock during chroma motion vectors derivation from luma motion vectors when the chroma format of the current picture is 4:2:0 as shown in FIG. **10**A;

FIG. **11**B is an example illustrating positions of two luma subblocks for a given position of a chroma subblock during chroma motion vectors derivation from luma motion vectors when the chroma format of the current picture is 4:2:2 as shown in FIG. **10**B;

FIG. **11**C is an example illustrating a position of a luma subblock for a given position of a chroma subblock during chroma motion vectors derivation from luma motion vectors when the chroma format of the current picture is 4:4:4 as shown in FIG. **10**C;

FIG. **12**A shows various examples of a subset S that comprises positions of luma subblocks for a given position of chroma subblock when the chroma format is set to 4:4:4;

FIG. **12**B shows various examples of a subset S, in which chroma subblocks located on the boundary of a chroma block have corresponding positions in the luma block as in the fourth case "D" shown in FIG. **12**A;

FIG. **13**A shows an example illustrating the selection of two luma subblocks to derive the motion vector for a given chroma subblock during chroma motion vectors derivation from luma motion vectors when the chroma format of the current picture is 4:2:0;

FIG. **13**B shows an example illustrating the selection of two luma subblocks for a given chroma subblock during chroma motion vectors derivation from luma motion vectors when the chroma format of the current picture is 4:2:2;

FIG. **13**C shows an example illustrating the selection of a luma subblock for a given chroma subblock during chroma motion vectors derivation from luma motion vectors when the chroma format of the current picture is 4:4:4;

FIG. **14**A shows an example of subdivision of a 16×16 luma block into subblocks and the subdivision of a chroma block co-located with the luma block when the chroma format is YUV 4:2:0;

FIG. **14**B shows an example of subdivision of a 16×16 luma block into subblocks and the subdivision of a chroma block co-located with the luma block when the chroma format is YUV 4:2:2;

FIG. **14**C shows an example of subdivision of a 16×16 luma block into subblocks and the subdivision of a chroma block co-located with the luma block when the chroma format is YUV 4:4:4;

FIG. **15** shows a flow diagram depicting an exemplary process for motion vector derivation for affine based inter prediction of chroma subblocks based on a chroma format according to some aspects of the present disclosure;

FIG. **16** shows a flow diagram depicting another exemplary process for motion vector derivation for affine based inter prediction of chroma subblocks based on a chroma format according to some aspects of the present disclosure;

FIG. **17** shows a schematic diagram of a device for affine based inter prediction according to some aspects of the present disclosure;

FIG. **18** is a block diagram showing an example structure of a content supply system which realizes a content delivery service; and

FIG. **19** is a block diagram showing a structure of an example of a terminal device.

In the following identical reference signs refer to identical or at least functionally equivalent features if not explicitly specified otherwise.

DETAILED DESCRIPTION OF THE EMBODIMENTS

In the following description, reference is made to the accompanying figures, which form part of the disclosure, and which show, by way of illustration, specific aspects of embodiments of the invention or specific aspects in which embodiments of the present invention may be used. It is understood that embodiments of the invention may be used in other aspects and comprise structural or logical changes not depicted in the figures. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

For instance, it is understood that a disclosure in connection with a described method may also hold true for a corresponding device or system configured to perform the method and vice versa. For example, if one or a plurality of specific method steps are described, a corresponding device may include one or a plurality of units, e.g. functional units, to perform the described one or plurality of method steps (e.g. one unit performing the one or plurality of steps, or a plurality of units each performing one or more of the plurality of steps), even if such one or more units are not explicitly described or illustrated in the figures. On the other hand, for example, if a specific apparatus is described based on one or a plurality of units, e.g. functional units, a

corresponding method may include one step to perform the functionality of the one or plurality of units (e.g. one step performing the functionality of the one or plurality of units, or a plurality of steps each performing the functionality of one or more of the plurality of units), even if such one or plurality of steps are not explicitly described or illustrated in the figures. Further, it is understood that the features of the various exemplary embodiments and/or aspects described herein may be combined with each other, unless specifically noted otherwise.

Video coding typically refers to the processing of a sequence of pictures, which form the video or video sequence. Instead of using the term "picture", the term "frame" or "image" may be used as synonyms in the field of video coding. Video coding (or coding in general) comprises two parts: video encoding and video decoding. Video encoding is performed at the source side, typically comprising processing (e.g. by compression) the original video pictures to reduce the amount of data required for representing the video pictures (for more efficient storage and/or transmission). Video decoding is performed at the destination side and typically comprises the inverse processing compared to the encoder to reconstruct the video pictures. Embodiments referring to "coding" of video pictures (or pictures in general) shall be understood to relate to "encoding" or "decoding" of video pictures or respective video sequences. The combination of the encoding part and the decoding part is also referred to as CODEC (Coding and Decoding).

In case of lossless video coding, the original video pictures can be reconstructed, i.e. the reconstructed video pictures have the same quality as the original video pictures (assuming no transmission loss or other data loss during storage or transmission). In case of lossy video coding, further compression, e.g. by quantization, is performed, to reduce the amount of data representing the video pictures, which cannot be completely reconstructed at the decoder, i.e. the quality of the reconstructed video pictures is lower or worse compared to the quality of the original video pictures.

Several video coding standards belong to the group of "lossy hybrid video codecs" (i.e. combine spatial and temporal prediction in the sample domain and 2D transform coding for applying quantization in the transform domain). Each picture of a video sequence is typically partitioned into a set of non-overlapping blocks and the coding is typically performed on a block level. In other words, at the encoder the video is typically processed, i.e. encoded, on a block (video block) level, e.g. by using spatial (intra picture) prediction and/or temporal (inter picture) prediction to generate a prediction block, subtracting the prediction block from the current block (block currently processed/to be processed) to obtain a residual block, transforming the residual block and quantizing the residual block in the transform domain to reduce the amount of data to be transmitted (compression), whereas at the decoder the inverse processing compared to the encoder is applied to the encoded or compressed block to reconstruct the current block for representation. Furthermore, the encoder duplicates the 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.

The present disclosure relates to improvements in the process of inter-prediction. In particular, the present disclosure relates to improvements in the derivation process for chroma motion vectors. Particularly, the present disclosure relates to improvements in the process of motion vector derivation of affine chroma blocks (such as, chroma subblocks). More particularly, the present disclosure relates to improvements in the process of motion vector derivation for affine based inter prediction of chroma subblocks based on chroma format.

Disclosed herein are improved mechanisms to support multiple chroma formats for derivation process for chroma motion vectors.

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. **1**A is a schematic block diagram illustrating an example coding system **10**, e.g. a video coding system **10** (or coding system **10** for short) that may utilize techniques of this present application. Video encoder **20** (or encoder **20** for short) and video decoder **30** (or decoder **30** for short) 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. **1**A, 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 picture data **19**. Pre-processing performed by the pre-processor **18** may, e.g., comprise trimming, color format conversion (e.g. from RGB to YCbCr), color correction, or de-noising. It can be understood that the pre-processing unit **18** may be an optional component.

The video encoder **20** is configured to receive the pre-processed picture data **19** and provide encoded picture data **21** (further details will be described below, e.g., based on FIG. **2**).

Communication interface **22** of the source device **12** may be configured to receive the encoded picture data **21** and to transmit the encoded picture data **21** (or any further processed version thereof) over communication channel **13** to another device, e.g. the destination device **14** or any other device, for storage or direct reconstruction.

The destination device **14** comprises a decoder **30** (e.g. a video decoder **30**), and may additionally, i.e. optionally, comprise a communication interface or communication unit **28**, a post-processor **32** (or post-processing unit **32**) and a display device **34**.

The communication interface **28** of the destination device **14** is configured receive the encoded picture data **21** (or any

further processed version thereof), e.g. directly from the source device **12** or from any other source, e.g. a storage device, e.g. an encoded picture data storage device, and provide the encoded picture data **21** to the decoder **30**.

The communication interface **22** and the communication interface **28** may be configured to transmit or receive the encoded picture data **21** or encoded data **21** via a direct communication link between the source device **12** and the destination device **14**, e.g. a direct wired or wireless connection, or via any kind of network, e.g. a wired or wireless network or any combination thereof, or any kind of private and public network, or any kind of combination thereof.

The communication interface **22** may be, e.g., configured to package the encoded picture data **21** into an appropriate format, e.g. packets, and/or process the encoded picture data using any kind of transmission encoding or processing for transmission over a communication link or communication network.

The communication interface **28**, forming the counterpart of the communication interface **22**, may be, e.g., configured to receive the transmitted data and process the transmission data using any kind of corresponding transmission decoding or processing and/or de-packaging to obtain the encoded picture data **21**.

Both, communication interface **22** and communication interface **28** may be configured as unidirectional communication interfaces as indicated by the arrow for the communication channel **13** in FIG. **1**A pointing from the source device **12** to the destination device **14**, or bi-directional communication interfaces, and may be configured, e.g. to send and receive messages, e.g. to set up a connection, to acknowledge and exchange any other information related to the communication link and/or data transmission, e.g. encoded picture data transmission.

The decoder **30** is configured to receive the encoded picture data **21** and provide decoded picture data **31** or a decoded picture **31** (further details will be described below, e.g., based on FIG. **3** or FIG. **5**).

The post-processor **32** of destination device **14** is configured to post-process the decoded picture data **31** (also called reconstructed picture data), e.g. the decoded picture **31**, to obtain post-processed picture data **33**, e.g. a post-processed picture **33**. The post-processing performed by the post-processing unit **32** may comprise, e.g. color format conversion (e.g. from YCbCr to RGB), color correction, trimming, or re-sampling, or any other processing, e.g. for preparing the decoded picture data **31** for display, e.g. by display device **34**.

The display device **34** of the destination device **14** is configured to receive the post-processed picture data **33** for displaying the picture, e.g. to a user or viewer. The display device **34** may be or comprise any kind of display for representing the reconstructed picture, e.g. an integrated or external display or monitor. The displays may comprise, for example, liquid crystal displays (LCD), organic light emitting diodes (OLED) displays, plasma displays, projectors, micro LED displays, liquid crystal on silicon (LCoS), digital light processor (DLP) or any kind of other display(s).

Although FIG. **1**A depicts the source device **12** and the destination device **14** as separate devices, embodiments of devices may also comprise both or both functionalities, the source device **12** or corresponding functionality and the destination device **14** or corresponding functionality. In such embodiments the source device **12** or corresponding functionality and the destination device **14** or corresponding functionality may be implemented using the same hardware and/or software or by separate hardware and/or software or any combination thereof.

As will be apparent for the skilled person based on the description, the existence and (exact) split of functionalities of the different units or functionalities within the source device **12** and/or destination device **14** as shown in FIG. **1**A may vary depending on the actual device and application.

The encoder **20** (e.g. a video encoder **20**) or the decoder **30** (e.g. a video decoder **30**) or both the encoder **20** and decoder **30** may be implemented via processing circuitry as shown in FIG. **1**B, such as one or more microprocessors, digital signal processors (DSPs), application-specific integrated circuits (ASICs), field-programmable gate arrays (FPGAs), discrete logic, hardware, video coding dedicated or any combinations thereof. The encoder **20** may be implemented via processing circuitry **46** to embody the various modules as discussed with respect to encoder **20** of FIG. **2** and/or any other encoder system or subsystem described herein. The decoder **30** may be implemented via processing circuitry **46** to embody the various modules as discussed with respect to decoder **30** of FIG. **3** and/or any other decoder system or subsystem described herein. The processing circuitry may be configured to perform the various operations as discussed later. As shown in FIG. **5**, if the techniques are implemented partially in software, a device may store instructions for the software in a suitable, non-transitory computer-readable storage medium and may execute the instructions in hardware using one or more processors to perform the techniques of this disclosure. Either of video encoder **20** and video decoder **30** may be integrated as part of a combined encoder/decoder (CODEC) in a single device, for example, as shown in FIG. **1**B.

Source device **12** and destination device **14** may comprise any of a wide range of devices, including any kind of handheld or stationary devices, e.g. notebook or laptop computers, mobile phones, smart phones, tablets or tablet computers, cameras, desktop computers, set-top boxes, televisions, display devices, digital media players, video gaming consoles, video streaming devices (such as content services servers or content delivery servers), broadcast receiver device, broadcast transmitter device, or the like and may use no or any kind of operating system. In some cases, the source device **12** and the destination device **14** may be equipped for wireless communication. Thus, the source device **12** and the destination device **14** may be wireless communication devices.

In some cases, video coding system **10** illustrated in FIG. **1**A is merely an example and the techniques of the present application may apply to video coding settings (e.g., video encoding or video decoding) that do not necessarily include any data communication between the encoding and decoding devices. In other examples, data is retrieved from a local memory, streamed over a network, or the like. A video encoding device may encode and store data to memory, and/or a video decoding device may retrieve and decode data from memory. In some examples, the encoding and decoding is performed by devices that do not communicate with one another, but simply encode data to memory and/or retrieve and decode data from memory.

For convenience of description, embodiments of the invention are described herein, for example, by reference to High-Efficiency Video Coding (HEVC) or to the reference software of Versatile Video coding (VVC), the next generation video coding standard developed by the Joint Collaboration Team on Video Coding (JCT-VC) of ITU-T Video Coding Experts Group (VCEG) and ISO/IEC Motion Pic-

ture Experts Group (MPEG). One of ordinary skill in the art will understand that embodiments of the invention are not limited to HEVC or VVC.

Encoder and Encoding Method

FIG. **2** shows a schematic block diagram of an example video encoder **20** that is configured to implement the techniques of the present application. In the example of FIG. **2**, the video encoder **20** comprises an input **201** (or input interface **201**), a residual calculation unit **204**, a transform processing unit **206**, a quantization unit **208**, an inverse quantization unit **210**, and inverse transform processing unit **212**, a reconstruction unit **214**, a loop filter unit **220**, a decoded picture buffer (DPB) **230**, a mode selection unit **260**, an entropy encoding unit **270** and an output **272** (or output interface **272**). The mode selection unit **260** may include an inter prediction unit **244**, an intra prediction unit **254** and a partitioning unit **262**. Inter prediction unit **244** may include a motion estimation unit and a motion compensation unit (not shown). A video encoder **20** as shown in FIG. **2** may also be referred to as hybrid video encoder or a video encoder according to a hybrid video codec.

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 a pixel (a short form of a picture element) or a pel. The number of samples in the 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 an RGB format or a 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 luma for short) component Y represents the brightness or grey level intensity (e.g. like in a grey-scale picture), while the two chrominance (or chroma for short) components Cb and Cr represent the chromaticity or color information components. Accordingly, a picture in YCbCr format comprises a luminance sample array of luminance sample values (Y), and two chrominance sample arrays of chrominance values (Cb and Cr). Pictures in RGB format may be converted or transformed into YCbCr format and vice versa, the process is also known as color transformation or conversion. If a picture is monochrome, the picture may comprise only a luminance sample array. Accordingly, a picture may be, for example, an array of luma samples in monochrome format or an array of luma samples and two corresponding arrays of chroma samples in 4:2:0, 4:2:2, and 4:4:4 colour format.

Embodiments of the video encoder **20** may comprise a picture partitioning unit (not depicted in FIG. **2**) configured to partition the picture **17** into a plurality of (typically non-overlapping) picture blocks **203**. These blocks may also be referred to as root blocks, macro blocks (H.264/AVC) or coding tree blocks (CTB) or coding tree units (CTU) (H.265/HEVC and VVC). The picture partitioning unit may be configured to use the same block size for all pictures of a video sequence and the corresponding grid defining the block size, or to change the block size between pictures or subsets or groups of pictures, and partition each picture into the corresponding blocks.

In further embodiments, the video encoder **20** may be configured to receive directly a block **203** of the picture **17**, e.g. one, several or all blocks forming the picture **17**. The picture block **203** may also be referred to as a current picture block or a picture block to be coded.

Like the picture **17**, the picture block **203** again is or can be regarded as a two-dimensional array or a matrix of samples with intensity values (sample values), although of smaller dimension than the picture **17**. In other words, the block **203** may comprise, e.g., one sample array (e.g. a luma array in case of a monochrome picture **17**, or a luma or chroma array in case of a color picture) or three sample arrays (e.g. a luma and two chroma arrays in case of a color picture **17**) or any other number and/or kind of arrays depending on the color format applied. The number of samples in horizontal and vertical direction (or axis) of the block **203** define the size of block **203**. Accordingly, a block may, for example, an MxN (M-column by N-row) array of samples, or an M×N array of transform coefficients.

Embodiments of the video encoder **20** as shown in FIG. **2** may be configured to encode the picture **17** block by block, e.g. the encoding and prediction is performed per block **203**.

Embodiments of the video encoder **20** as shown in FIG. **2** may be further configured to partition and/or encode the picture by using slices (also referred to as video slices), wherein a picture may be partitioned into or encoded using one or more slices (typically non-overlapping), and each slice may comprise one or more blocks (e.g. CTUs).

Embodiments of the video encoder **20** as shown in FIG. **2** may be further configured to partition and/or encode the picture by using tile groups (also referred to as video tile groups) and/or tiles (also referred to as video tiles), wherein a picture may be partitioned into or encoded using one or more tile groups (typically non-overlapping), and each tile group may comprise, e.g. one or more blocks (e.g. CTUs) or one or more tiles, wherein each tile, e.g. may be of rectangular shape and may comprise one or more blocks (e.g. CTUs), e.g. complete or fractional blocks.

Residual Calculation

The residual calculation unit **204** may be configured to calculate a residual block **205** (also referred to as a residual **205**) based on the picture block **203** and a prediction block **265** (further details about the prediction block **265** are provided later), e.g. by subtracting sample values of the prediction block **265** from sample values of the picture block **203**, sample by sample (pixel by pixel) to obtain the residual block **205** in the sample domain.

Transform

The transform processing unit **206** may be configured to apply a transform, e.g. a discrete cosine transform (DCT) or discrete sine transform (DST), on the sample values of the residual block **205** to obtain transform coefficients **207** in a transform domain. The transform coefficients **207** may also be referred to as transform residual coefficients and represent the residual block **205** in the transform domain.

The transform processing unit **206** may be configured to apply integer approximations of DCT/DST, such as the transforms specified for H.265/HEVC. Compared to an orthogonal DCT transform, such integer approximations are typically scaled by a certain factor. In order to preserve the norm of the residual block which is processed by forward and inverse transforms, additional scaling factors are applied as part of the transform process. The scaling factors are typically chosen based on certain constraints like scaling factors being a power of two for shift operations, a bit depth of the transform coefficients, a tradeoff between accuracy and implementation costs, etc. Specific scaling factors are, for example, specified for the inverse transform, e.g. by inverse transform processing unit **212** (and the corresponding inverse transform, e.g. by inverse transform processing unit **312** at video decoder **30**) and corresponding scaling factors for the forward transform, e.g. by transform processing unit **206**, at an encoder **20** may be specified accordingly.

Embodiments of the video encoder **20** (comprising the transform processing unit **206**) may be configured to output transform parameters, e.g. a type of transform or transforms, e.g. directly or encoded or compressed via the entropy encoding unit **270**, so that, e.g., the video decoder **30** may receive and use the transform parameters for decoding.

Quantization

The quantization unit **208** may be configured to quantize the transform coefficients **207** to obtain quantized coefficients **209**, e.g. by applying scalar quantization or vector quantization. The quantized coefficients **209** may also be referred to as quantized transform coefficients **209** or quantized residual coefficients **209**.

The quantization process may reduce the bit depth associated with some or all of the transform coefficients **207**. For example, an n-bit transform coefficient may be rounded down to an m-bit Transform coefficient during quantization, where n is greater than m. The degree of quantization may be modified by adjusting a quantization parameter (QP). For example for scalar quantization, different scaling may be applied to achieve finer or coarser quantization. Smaller quantization step sizes correspond to finer quantization, whereas larger quantization step sizes correspond to coarser quantization. The applicable quantization step size may be indicated by a quantization parameter (QP). The quantization parameter may for example be an index to a predefined set of applicable quantization step sizes. For example, small quantization parameters may correspond to fine quantization (small quantization step sizes) and large quantization parameters may correspond to coarse quantization (large quantization step sizes) or vice versa. The quantization may include division by a quantization step size and a corresponding dequantization and/or the inverse quantization, e.g. by inverse quantization unit **210**, may include multiplication by the quantization step size. Embodiments according to some standards, e.g. HEVC, may be configured to use a quantization parameter to determine the quantization step size. Generally, the quantization step size may be calculated based on a quantization parameter using a fixed point approximation of an equation including division. Additional scaling factors may be introduced for quantization and dequantization to restore the norm of the residual block, which might get modified because of the scaling used in the fixed point approximation of the equation for the quantization step size and quantization parameter. In one example implementation, the scaling of the inverse transform and dequantization might be combined. Alternatively, customized quantization tables may be used and signaled from an encoder to a decoder, e.g. in a bitstream. The quantization is a lossy operation, wherein the loss increases with increasing quantization step sizes.

Embodiments of the video encoder **20** (comprising the quantization unit **208**) may be configured to output quantization parameters (QP), e.g. directly or encoded via the entropy encoding unit **270**, so that, e.g., the video decoder **30** may receive and apply the quantization parameters for decoding.

Inverse Quantization

The inverse quantization unit **210** is configured to apply the inverse quantization of the quantization unit **208** on the quantized coefficients to obtain dequantized coefficients **211**, e.g. by applying the inverse of the quantization scheme applied by the quantization unit **208** based on or using the same quantization step size as the quantization unit **208**. The dequantized coefficients **211** may also be referred to as dequantized residual coefficients **211** and correspond to the transform coefficients **207**, although typically not identical to the transform coefficients due to the loss by quantization.

Inverse Transform

The inverse transform processing unit **212** is configured to apply the inverse transform of the transform applied by the transform processing unit **206**, e.g. an inverse discrete cosine transform (DCT) or inverse discrete sine transform (DST) or other inverse transforms, to obtain a reconstructed residual block **213** (or corresponding dequantized coefficients **211**) in the sample domain. The reconstructed residual block **213** may also be referred to as a transform block **213**.

Reconstruction

The reconstruction unit **214** (e.g. an adder or a summer **214**) is configured to add the transform block **213** (i.e. a reconstructed residual block **213**) to the prediction block **265** to obtain a reconstructed block **215** in the sample domain, e.g. by adding—sample by sample—the sample values of the reconstructed residual block **213** and the sample values of the prediction block **265**.

Filtering

The loop filter unit **220** (or a "loop filter" **220** for short), is configured to filter the reconstructed block **215** to obtain a filtered block **221**, or in general, to filter reconstructed samples to obtain filtered samples. The loop filter unit is, e.g., configured to smooth pixel transitions, or otherwise improve the video quality. The loop filter unit **220** may comprise one or more loop filters such as a de-blocking filter, a sample-adaptive offset (SAO) filter or one or more other filters, e.g. a bilateral filter, an adaptive loop filter (ALF), a sharpening, a smoothing filters or a collaborative filters, or any combination thereof. Although the loop filter unit **220** is shown in FIG. **2** as being an in loop filter, in other configurations, the loop filter unit **220** may be implemented

as a post loop filter. The filtered block **221** may also be referred to as filtered reconstructed block **221**.

Embodiments of the video encoder **20** (comprising loop filter unit **220**) may be configured to output loop filter parameters (such as sample adaptive offset information), e.g. directly or encoded via the entropy encoding unit **270**, so that, e.g., a decoder **30** may receive and apply the same loop filter parameters or respective loop filters for decoding.

Decoded Picture Buffer

The decoded picture buffer (DPB) **230** may be a memory that stores reference pictures, or in general reference picture data, for encoding video data by video encoder **20**. The DPB **230** may be formed by any of a variety of memory devices, such as dynamic random access memory (DRAM), including synchronous DRAM (SDRAM), magnetoresistive RAM (MRAM), resistive RAM (RRAM), or other types of memory devices. The decoded picture buffer (DPB) **230** may be configured to store one or more filtered blocks **221**. The decoded picture buffer **230** may be further configured to store other previously filtered blocks, e.g. previously reconstructed and filtered blocks **221**, of the same current picture or of different pictures, e.g. previously reconstructed pictures, and may provide complete previously reconstructed, i.e. decoded, pictures (and corresponding reference blocks and samples) and/or a partially reconstructed current picture (and corresponding reference blocks and samples), for example for inter prediction. The decoded picture buffer (DPB) **230** may be also configured to store one or more unfiltered reconstructed blocks **215**, or in general unfiltered reconstructed samples, e.g. if the reconstructed block **215** is not filtered by loop filter unit **220**, or any other further processed version of the reconstructed blocks or samples.

Mode Selection (Partitioning & Prediction)

The mode selection unit **260** comprises a partitioning unit **262**, an inter-prediction unit **244** and an intra-prediction unit **254**, and is configured to receive or obtain original picture data, e.g. an original block **203** (current block **203** of the current picture **17**), and reconstructed picture data, e.g. filtered and/or unfiltered reconstructed samples or blocks of the same (current) picture and/or from one or a plurality of previously decoded pictures, e.g. from decoded picture buffer **230** or other buffers (e.g. line buffer, not shown). The reconstructed picture data is used as reference picture data for prediction, e.g. inter-prediction or intra-prediction, to obtain a prediction block **265** or predictor **265**. As will be discussed in detail below, the embodiments presented herein provide an improvement to the inter-prediction unit **244** by providing more accurate motion vector prediction used by the inter-prediction unit when performing the inter prediction, for example, the affine based inter prediction or sub-block based inter prediction.

Mode selection unit **260** may be configured to determine or select a partitioning for a current block prediction mode (including no partitioning) and a prediction mode (e.g. an intra or inter prediction mode) and generate a corresponding prediction block **265**, which is used for the calculation of the residual block **205** and for the reconstruction of the reconstructed block **215**.

Embodiments of the mode selection unit **260** may be configured to select the partitioning and the prediction mode (e.g. from those supported by or available for mode selection unit **260**), which provide the best match or in other words the minimum residual (minimum residual means better compression for transmission or storage), or a minimum signaling overhead (minimum signaling overhead means better compression for transmission or storage), or which considers or balances both. The mode selection unit **260** may be configured to determine the partitioning and prediction mode based on rate distortion optimization (RDO), i.e. select the prediction mode which provides a minimum rate distortion. Terms like "best", "minimum", "optimum" etc. in this context do not necessarily refer to an overall "best", "minimum", "optimum", etc. but may also refer to the fulfillment of a termination or selection criterion like a value exceeding or falling below a threshold or other constraints leading potentially to a "sub-optimum selection" but reducing complexity and processing time.

In other words, the partitioning unit **262** may be configured to partition the block **203** into smaller block partitions or sub-blocks (which form again blocks), e.g. iteratively using quad-tree-partitioning (QT), binary partitioning (BT) or triple-tree-partitioning (TT) or any combination thereof, and to perform, e.g., the prediction for each of the block partitions or sub-blocks, wherein the mode selection comprises the selection of the tree-structure of the partitioned block **203** and the prediction modes are applied to each of the block partitions or sub-blocks.

In the following the partitioning (e.g. by partitioning unit **262**) and prediction processing (by inter-prediction unit **244** and intra-prediction unit **254**) performed by an example video encoder **20** will be explained in more detail.

Partitioning

The partitioning unit **262** may partition (or split) a current block **203** into smaller partitions, e.g. smaller blocks of square or rectangular size. These smaller blocks (which may also be referred to as sub-blocks) may be further partitioned into even smaller partitions. This is also referred to tree-partitioning or hierarchical tree-partitioning, wherein a root block, e.g. at root tree-level 0 (hierarchy-level 0, depth 0), may be recursively partitioned, e.g. partitioned into two or more blocks of a next lower tree-level, e.g. nodes at tree-level 1 (hierarchy-level 1, depth 1), wherein these blocks may be again partitioned into two or more blocks of a next lower level, e.g. tree-level 2 (hierarchy-level 2, depth 2), etc. until the partitioning is terminated, e.g. because a termination criterion is fulfilled, e.g. a maximum tree depth or minimum block size is reached. Blocks which are not further partitioned are also referred to as leaf-blocks or leaf nodes of the tree. A tree using partitioning into two partitions is referred to as binary-tree (BT), a tree using partitioning into three partitions is referred to as ternary-tree (TT), and a tree using partitioning into four partitions is referred to as quad-tree (QT).

As mentioned before, the term "block" as used herein may be a portion, in particular a square or rectangular portion, of a picture. With reference, for example, to HEVC and VVC, the block may be or correspond to a coding tree unit (CTU), a coding unit (CU), prediction unit (PU), and transform unit (TU) and/or to the corresponding blocks, e.g. a coding tree block (CTB), a coding block (CB), a transform block (TB) or prediction block (PB).

For example, a coding tree unit (CTU) may be or comprise a CTB of luma samples, two corresponding CTBs of chroma samples of a picture that has three sample arrays, or a CTB of samples of a monochrome picture or a picture that is coded using three separate colour planes and syntax structures used to code the samples. Correspondingly, a coding tree block (CTB) may be an N×N block of samples for some value of N such that the division of a component into CTBs is a partitioning. A coding unit (CU) may be or comprise a coding block of luma samples, two corresponding coding blocks of chroma samples of a picture that has three sample arrays, or a coding block of samples of a monochrome picture or a picture that is coded using three

separate colour planes and syntax structures used to code the samples. Correspondingly a coding block (CB) may be an M×N block of samples for some values of M and N such that the division of a CTB into coding blocks is a partitioning.

In embodiments, e.g., according to HEVC, a coding tree unit (CTU) may be split into CUs by using a quad-tree structure denoted as a coding tree. The decision whether to code a picture area using inter-picture (temporal) or intra-picture (spatial) prediction is made at the CU level. Each CU can be further split into one, two or four PUs according to the PU splitting type. Inside one PU, the same prediction process is applied and the relevant information is transmitted to the decoder on a PU basis. After obtaining the residual block by applying the prediction process based on the PU splitting type, a CU can be partitioned into transform units (TUs) according to another quadtree structure similar to the coding tree for the CU.

In embodiments, e.g., according to the latest video coding standard currently in development, which is referred to as Versatile Video Coding (VVC), a combined Quad-tree and binary tree (QTBT) partitioning is for example used to partition a coding block. In the QTBT block structure, a CU can have either a square or rectangular shape. For example, a coding tree unit (CTU) is first partitioned by a quadtree structure. The quadtree leaf nodes are further partitioned by a binary tree or ternary (or triple) tree structure. The partitioning tree leaf nodes are called coding units (CUs), and that segmentation is used for prediction and transform processing without any further partitioning. This means that the CU, PU and TU have the same block size in the QTBT coding block structure. In parallel, multiple partition, for example, triple tree partition may be used together with the QTBT block structure.

In one example, the mode selection unit **260** of the video encoder **20** may be configured to perform any combination of the partitioning techniques described herein.

As described above, the video encoder **20** is configured to determine or select the best or an optimum prediction mode from a set of (e.g. pre-determined) prediction modes. The set of prediction modes may comprise, e.g., intra-prediction modes and/or inter-prediction modes.

Intra-Prediction

The set of intra-prediction modes may comprise 35 different intra-prediction modes, e.g. non-directional modes like DC (or mean) mode and planar mode, or directional modes, e.g. as defined in HEVC, or may comprise 67 different intra-prediction modes, e.g. non-directional modes like DC (or mean) mode and planar mode, or directional modes, e.g. as defined for VVC.

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.

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.

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 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, a skip mode and/or a direct mode may be applied.

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 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.

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 block as inter prediction parameters to the motion estimation unit. This offset is also called motion vector (MV).

The motion compensation unit is configured to obtain, e.g. receive, an inter prediction parameter and to perform inter prediction based on or using the inter prediction parameter to obtain an inter prediction block **265**. Motion compensation, performed by the motion compensation unit, may involve fetching or generating the prediction block based on the motion/block vector determined by motion estimation, possibly performing interpolations to sub-pixel precision. Interpolation filtering may generate additional pixel samples from known pixel samples, thus potentially increasing the number of candidate prediction blocks that may be used to code a picture block. Upon receiving the motion vector for the PU of the current picture block, the motion compensation unit may locate the prediction block to which the motion vector points in one of the reference picture lists. In the present disclosure, improvements to the inter prediction (especially, affine based inter prediction or sub-block based inter prediction) are made by supporting multiple chroma formats and by refining affine sub-block motion vector derivation process. In particular, an improved method and apparatus for motion vector derivation for affine based inter prediction of chroma subblocks based on a chroma format will be introduced as below.

The motion compensation unit may also generate syntax elements associated with the blocks and video slices for use by video decoder **30** in decoding the picture blocks of the video slice. In addition or as an alternative to slices and respective syntax elements, tile groups and/or tiles and respective syntax elements may be generated or used.

Entropy Coding

The entropy encoding unit **270** is configured to apply, for example, an entropy encoding algorithm or scheme (e.g. a variable length coding (VLC) scheme, an context adaptive VLC scheme (CAVLC), an arithmetic coding scheme, a binarization, a context adaptive binary arithmetic coding (CABAC), syntax-based context-adaptive binary arithmetic coding (SBAC), probability interval partitioning entropy (PIPE) coding or another entropy encoding methodology or

technique) or bypass (no compression) on the quantized coefficients **209**, inter prediction parameters, intra prediction parameters, loop filter parameters and/or other syntax elements to obtain encoded picture data **21** which can be output via the output **272**, e.g. in the form of an encoded bitstream **21**, so that, e.g., the video decoder **30** may receive and use the parameters for decoding. The encoded bitstream **21** may be transmitted to the video decoder **30**, or stored in a memory for later transmission or retrieval by the video decoder **30**.

Other structural variations of the video encoder **20** can be used to encode the video stream. For example, a non-transform based encoder **20** can quantize the residual signal directly without the transform processing unit **206** for certain blocks or frames. In another implementation, an encoder **20** can have the quantization unit **208** and the inverse quantization unit **210** combined into a single unit.

Decoder and Decoding Method

FIG. **3** shows an example 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 the 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/or tile groups or tiles) and associated syntax elements.

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**, a mode application unit **360**, 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 decoding pass generally reciprocal to the encoding pass described with respect to the video encoder **20** 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 also referred to as forming the "built-in decoder" of the 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 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**.

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 obtain, e.g., quantized coefficients **309** and/or decoded coding parameters (not shown in FIG. **3**), e.g. any or all of inter prediction parameters (e.g. reference picture index and motion vector), an intra prediction parameter (e.g., an intra prediction mode or index), transform parameters, quantization parameters, loop filter parameters, and/or other syntax elements. Entropy decoding unit **304** maybe configured to apply the decoding algorithms or schemes corresponding to the encoding schemes as described with regard to the entropy encoding unit **270** of the encoder **20**. Entropy decoding unit **304** may be further configured to provide inter prediction parameters, intra prediction parameter and/or other syntax elements to the mode application unit **360** and other parameters to other units of the decoder **30**. Video decoder **30** may receive the syntax elements at the video slice level and/or the video block level. In addition or as an alternative to slices and respective syntax elements, tile groups and/or tiles and respective syntax elements may be received and/or used.

Inverse Quantization

The inverse quantization unit **310** may be configured to receive quantization parameters (QP) (or in general information related to the inverse quantization) and quantized coefficients from the encoded picture data **21** (e.g. by parsing and/or decoding, e.g. by entropy decoding unit **304**) and to apply based on the quantization parameters an inverse quantization on the decoded quantized coefficients **309** to obtain dequantized coefficients **311**, which may also be referred to as transform coefficients **311**. The inverse quantization process may include use of a quantization parameter determined by the video encoder **20** for each video block in the video slice (or tile or tile group) to determine a degree of quantization and, likewise, a degree of inverse quantization that should be applied.

Inverse Transform

Inverse transform processing unit **312** may be configured to receive dequantized coefficients **311**, also referred to as transform coefficients **311**, and to apply a transform to the dequantized coefficients **311** in order to obtain reconstructed residual blocks **213** in the sample domain. The reconstructed residual blocks **213** may also be referred to as transform blocks **313**. The transform may be an inverse transform, e.g., an inverse DCT, an inverse DST, an inverse integer transform, or a conceptually similar inverse transform process. The inverse transform processing unit **312** may be further configured to receive transform parameters or corresponding information from the encoded picture data **21** (e.g. by parsing and/or decoding, e.g. by entropy decoding unit **304**) to determine the transform to be applied to the dequantized coefficients **311**.

Reconstruction

The reconstruction unit **314** (e.g. adder or summer **314**) may be configured to add the reconstructed residual block **313**, to the prediction block **365** to obtain a reconstructed block **315** in the sample domain, e.g. by adding the sample values of the reconstructed residual block **313** and the sample values of the prediction block **365**.

Filtering

The loop filter unit **320** (either in the coding loop or after the coding loop) is configured to filter the reconstructed block **315** to obtain a filtered block **321**, e.g. to smooth pixel transitions, or otherwise improve the video quality. The loop filter unit **320** may comprise one or more loop filters such as a de-blocking filter, a sample-adaptive offset (SAO) filter or one or more other filters, e.g. a bilateral filter, an adaptive loop filter (ALF), a sharpening filter, a smoothing filter or a collaborative filter, or any combination thereof. Although the loop filter unit **320** is shown in FIG. **3** as being an in loop filter, in other configurations, the loop filter unit **320** may be implemented as a post loop filter.

Decoded Picture Buffer

The decoded video blocks **321** of a picture are then stored in the decoded picture buffer **330**, which stores the decoded

pictures **331** as reference pictures for subsequent motion compensation for other pictures and/or for output respectively display.

The decoder **30** is configured to output the decoded picture **331**, e.g. via output **272**, for presentation or viewing to a user.

Prediction

The inter prediction unit **344** may be identical to the inter prediction unit **244** (in particular to the motion compensation unit) and the intra prediction unit **354** may be identical to the intra prediction unit **254** in function, and performs split or partitioning decisions and prediction based on the partitioning and/or prediction parameters or respective information received from the encoded picture data **21** (e.g. by parsing and/or decoding, e.g. by entropy decoding unit **304**). Mode application unit **360** may be configured to perform the prediction (intra or inter prediction) per block based on reconstructed pictures, blocks or respective samples (filtered or unfiltered) to obtain the prediction block **365**.

When the video slice is coded as an intra coded (I) slice, intra prediction unit **354** of mode application unit **360** is configured to generate prediction block **365** for a picture block of the current video slice based on a signaled intra prediction mode and data from previously decoded blocks of the current picture. When the video picture is coded as an inter coded (i.e., B, or P) slice, inter prediction unit **344** (e.g. motion compensation unit) of mode application unit **360** is configured to produce prediction blocks **365** for a video block of the current video slice based on the motion vectors and other syntax elements received from entropy decoding unit **304**. For inter prediction, the prediction blocks may be produced from one of the reference pictures within one of the reference picture lists. Video decoder **30** may construct the reference frame lists, List 0 and List 1, using default construction techniques based on reference pictures stored in DPB **330**. The same or similar may be applied for or by embodiments using tile groups (e.g. video tile groups) and/or tiles (e.g. video tiles) in addition or alternatively to slices (e.g. video slices), e.g. a video may be coded using I, P or B tile groups and/or tiles.

Mode application unit **360** is configured to determine the prediction information for a video block of the current video slice by parsing the motion vectors or related information and other syntax elements, and uses the prediction information to produce the prediction blocks for the current video block being decoded. For example, the mode application unit **360** uses some of the received syntax elements to determine a prediction mode (e.g., intra or inter prediction) used to code the video blocks of the video slice, an inter prediction slice type (e.g., B slice, P slice, or GPB slice), construction information for one or more of the reference picture lists for the slice, motion vectors for each inter encoded video block of the slice, inter prediction status for each inter coded video block of the slice, and other information to decode the video blocks in the current video slice. The same or similar may be applied for or by embodiments using tile groups (e.g. video tile groups) and/or tiles (e.g. video tiles) in addition or alternatively to slices (e.g. video slices), e.g. a video may be coded using I, P or B tile groups and/or tiles.

Embodiments of the video decoder **30** as shown in FIG. **3** may be configured to partition and/or decode the picture by using slices (also referred to as video slices), wherein a picture may be partitioned into or decoded using one or more slices (typically non-overlapping), and each slice may comprise one or more blocks (e.g. CTUs).

Embodiments of the video decoder **30** as shown in FIG. **3** may be configured to partition and/or decode the picture by using tile groups (also referred to as video tile groups) and/or tiles (also referred to as video tiles), wherein a picture may be partitioned into or decoded using one or more tile groups (typically non-overlapping), and each tile group may comprise, e.g. one or more blocks (e.g. CTUs) or one or more tiles, wherein each tile, e.g. may be of rectangular shape and may comprise one or more blocks (e.g. CTUs), e.g. complete or fractional blocks.

Other variations of the video decoder **30** can be used to decode the encoded picture data **21**. For example, the decoder **30** can produce the output video stream without the loop filtering unit **320**. For example, a non-transform based decoder **30** can inverse-quantize the residual signal directly without the inverse-transform processing unit **312** for certain blocks or frames. In another implementation, the video decoder **30** can have the inverse-quantization unit **310** and the inverse-transform processing unit **312** combined into a single unit.

It should be understood that, in the encoder **20** and the decoder **30**, a processing result of a current step may be further processed and then output to the next step. For example, after interpolation filtering, motion vector derivation or loop filtering, a further operation, such as Clip or shift, may be performed on the processing result of the interpolation filtering, motion vector derivation or loop filtering.

It should be noted that further operations may be applied to the derived motion vectors of current block (including but not limit to control point motion vectors of affine mode, sub-block motion vectors in affine, planar, ATMVP modes, temporal motion vectors, and so on). For example, the value of motion vector is constrained to a predefined range according to its representing bit. If the representing bit of a motion vector is bitDepth, then the range is −2^(bitDepth−1)~2^(bitDepth−1)−1, where "^" means exponentiation. For example, if bitDepth is set equal to 16, the range is −32768~0 32767; if bitDepth is set equal to 18, the range is −131072~131071. For example, the value of the derived motion vector (e.g. the MVs of four 4×4 sub-blocks within one 8×8 block) is constrained such that the max difference between integer parts of the four 4×4 sub-block MVs is no more than N pixels, such as no more than 1 pixel. Here provides two methods for constraining the motion vector according to the bitDepth.

Method 1: remove the overflow MSB (most significant bit) by flowing operations

$$ux=(mvx+2^{bitDepth})\%\ 2^{bitDepth} \quad (1)$$

$$mvx=(ux>=2^{bitDepth-1})?(ux-2^{bitDepth}):ux \quad (2)$$

$$uy=(mvy+2^{bitDepth})\%\ 2^{bitDepth} \quad (3)$$

$$mvy=(uy>=2^{bitDepth-1})?(uy-2^{bitDepth}):uy \quad (4)$$

where mvx is a horizontal component of a motion vector of an image block or a sub-block, mvy is a vertical component of a motion vector of an image block or a sub-block, and ux and uy indicates an intermediate value;

For example, if the value of mvx is −32769, after applying formula (1) and (2), the resulting value is 32767. In computer system, decimal numbers are stored as two's complement. The two's complement of −32769 is 1,0111,1111, 1111,1111 (17 bits), then the MSB is discarded, so the resulting two's complement is 0111,1111,1111,1111 (deci-

mal number is 32767), which is same as the output by applying formula (1) and (2).

$$ux=(mvpx+mvdx+2^{bitDepth})\%\ 2^{bitDepth} \quad (5)$$

$$mvx=(ux>=2^{bitDepth-1})?(ux-2^{bitDepth}):ux \quad (6)$$

$$uy=(mvpy+mvdy+2^{bitDepth})\%\ 2^{bitDepth} \quad (7)$$

$$mvy=(uy>=2^{bitDepth-1})?(uy-2^{bitDepth}):\ uy \quad (8)$$

The operations may be applied during the sum of mvp and mvd, as shown in formula (5) to (8).

Method 2: remove the overflow MSB by clipping the value

$$vx=\text{Clip3}(-2^{bitDepth-1},2^{bitDepth-1}-1,vx)$$

$$vy=\text{Clip3}(-2^{bitDepth-1},2^{bitDepth-1}-1,vy)$$

where vx is a horizontal component of a motion vector of an image block or a sub-block, vy is a vertical component of a motion vector of an image block or a sub-block; x, y and z respectively correspond to three input value of the MV clipping process, and the definition of function Clip3 is as follow:

$$\text{Clip3}(x, y, z) = \begin{cases} x; & z < x \\ y; & z > y \\ z; & \text{otherwise} \end{cases}$$

FIG. **4** is a schematic diagram of a video coding device **400** according to an embodiment of the disclosure. The video coding device **400** is suitable for implementing the disclosed embodiments as described herein. In an embodiment, the video coding device **400** may be a decoder such as video decoder **30** of FIG. **1**A or an encoder such as video encoder **20** of FIG. **1**A.

The video coding device **400** comprises ingress ports **410** (or input ports **410**) and receiver units (Rx) **420** for receiving data; a processor, logic unit, or central processing unit (CPU) **430** to process the data; transmitter units (Tx) **440** and egress ports **450** (or output ports **450**) for transmitting the data; and a memory **460** for storing the data. The video coding device **400** may also comprise optical-to-electrical (OE) components and electrical-to-optical (EO) components coupled to the ingress ports **410**, the receiver units **420**, the transmitter units **440**, and the egress ports **450** for egress or ingress of optical or electrical signals.

The processor **430** is implemented by hardware and software. The processor **430** may be implemented as one or more CPU chips, cores (e.g., as a multi-core processor), FPGAs, ASICs, and DSPs. The processor **430** is in communication with the ingress ports **410**, receiver units **420**, transmitter units **440**, egress ports **450**, and memory **460**. The processor **430** comprises a coding module **470**. The coding module **470** implements the disclosed embodiments described above. For instance, the coding module **470** implements, processes, prepares, or provides the various coding operations. The inclusion of the coding module **470** therefore provides a substantial improvement to the functionality of the video coding device **400** and effects a transformation of the video coding device **400** to a different state. 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 overflow 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. **1** 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**.

Although depicted here as a single bus, the bus **512** of the apparatus **500** can be composed of multiple buses. Further, the secondary storage **514** can be directly coupled to the other components of the apparatus **500** or can be accessed via a network and can comprise a single integrated unit such as a memory card or multiple units such as multiple memory cards. The apparatus **500** can thus be implemented in a wide variety of configurations.

The embodiments presented herein will be described in more detail as follows. A video source that is represented by a bitstream can include a sequence of pictures in decoding order. Each of the pictures (which can be a source picture or a decoded picture) includes one or more of the following sample arrays:

Luma (Y) only (monochrome).

Luma and two chroma (YCbCr or YCgCo).

Green, blue, and red (GBR, also known as RGB).

Arrays representing other unspecified monochrome or tri-stimulus colour samplings (for example, YZX, also known as XYZ).

For convenience of notation and terminology in the present disclosure, the variables and terms associated with these arrays are referred to as luma (or L or Y) and chroma, where the two chroma arrays are referred to as Cb and Cr.

FIG. **9**A illustrates chroma component location in case of 4:2:0 sampling scheme. Examples for other sampling schemes are shown in FIGS. **9**B and **9**C.

As shown in FIG. **9**A, in the 4:2:0 sampling scheme, there may be a shift between the Luma and Chroma component

grids. In a block of 2×2 pixels, the Chroma components are actually shifted by half a pixel vertically compared to the Luma component (see FIG. **9**A). Such shift may have an influence on the interpolation filters when down-sampling the picture, or when up-sampling the picture. In FIG. **9**D, various sampling patterns are represented, in case of interlaced image. This means that the parity, i.e. whether the pixels are on the top or bottom fields of an interlaced image, is also taken into account.

According to Versatile Video Coding (VVC) specification draft, a special flag "sps_cclm_colocated_chroma_flag" is signalled on the level of sequence parameters. The "sps_cclm_colocated_chroma_flag" flag equal to 1 specifies that the top-left downsampled luma sample in cross-component linear model intra prediction is co-located with the top-left luma sample. sps_cclm_colocated_chroma_flag equal to 0 specifies that the top-left downsampled luma sample in cross-component linear model intra prediction is horizontally co-sited with the top-left luma sample but vertically shifted by 0.5 units of luma samples relatively to the top-left luma sample.

Affine Motion Compensated Prediction

In the real world, there are many kinds of motion, e.g. zoom in/out, rotation, perspective motions, a translation motion, and the other irregular motions. In HEVC (ITU-T H.265), only a translation motion model is utilized for motion compensation prediction (MCP). In the VVC, affine transform motion compensation prediction is applied. The affine motion field of the block is described by two or three control point motion vectors (CPMV) which correspond to the four parameters affine motion model and the six parameters affine motion model respectively. CPMV positions for a 4-parameter affine motion model are depicted in FIG. **6***a* and CPMV positions for a 6-parameter affine motion model are depicted in FIG. **6***b*.

In the case of 4-parameter motion model, the motion vector field (MVF) of a block is described by the following equation:

$$\begin{cases} v_x = \frac{(v_{1x} - v_{0x})}{w}x - \frac{(v_{1y} - v_{0y})}{w}y + v_{0x} \\ v_y = \frac{(v_{1y} - v_{0y})}{w}x + \frac{(v_{1x} - v_{0x})}{w}y + v_{0y} \end{cases} \quad (1)$$

Where (v0x, v0y) is the motion vector of the top-left corner control point, and (v1x, v1y) is a motion vector of the top-right corner control point. (vx, vy) is the motion vector at a given location (x, y) in the block. A Rate distortion cost (RDC) check is used to determine which motion vector pair is selected as the control point motion vectors of the current CU.

CPMVs can be derived based on motion information of neighboring blocks (for example, in a process of subblock merge mode). Alternatively, or additionally, CPMVs can be derived by deriving CPMV predictors (CPMVP) and obtaining difference between CPMV and CPMVP from the bitstream.

In order to simplify the motion compensation prediction, block based affine transform prediction is applied. For example, to derive the motion vector of each 4×4 sub-block, a motion vector of the center sample of each sub-block, as shown in FIG. **7**, is calculated according to the above Equation (1), and rounded to 1/16 fraction accuracy. The motion compensation interpolation filters are applied to generate the prediction of each sub-block with the derived motion vector.

After motion compensation prediction (MCP), the higher accuracy motion vector of each sub-block is rounded and saved as the same accuracy as the normal motion vector with accuracy.

FIG. **8** shows an example of a flowchart depicting a process **800** for affine based inter prediction (i.e. motion compensation using an affine motion model). The process **800** may include following blocks:

At block **810**, control point motion vector derivation is performed to generate control point motion vectors cpMvLX[cpIdx];

At block **830**, motion vector array derivation is performed to generate a Luma subblock motion vector array mvLX[xSbIdx][ySbIdx] and a Chroma subblock motion vector array mvCLX[xSbIdx][ySbIdx]. Block **830** may include:

Block **831**, where luma motion vector array derivation is performed to generate the Luma subblock motion vector array mvLX[xSbIdx][ySbIdx];

Block **833**, where chroma motion vector array derivation is performed to generate the Chroma subblock motion vector array mvCLX[xSbIdx][ySbIdx];

At block **850**, an interpolation process is carried out to generate the prediction of each sub-block with the derived motion vector, i.e. an array predSamples of prediction samples.

The embodiments presented herein mainly focus on block **833** for chroma motion vector array derivation (this block is indicated in bold in FIG. **8**).

The details of derivation process for chroma motion vector in a previous design (in a conventional way) are described as follows:

Inputs for this process (Chroma motion vector array derivation) include:

the luma subblock motion vector array mvLX[xSbIdx][ySbIdx] with xSbIdx=0 . . . numSbX−1, ySbIdx=0 . . . numSbY−1 and X being 0 or 1

a chroma sampling ratio in horizontal direction, SubWidthC

a chroma sampling ratio in vertical direction, SubHeightC

Outputs:

the chroma subblock motion vector array mvCLX[xSbIdx][ySbIdx] with xSbIdx=0 . . . numSbX−1, ySbIdx=0 . . . numSbY−1 and X being 0 or 1.

This process is implemented as following:

The average luma motion vector mvAvgLX is derived as follows:

```
mvAvgLX=mvLX[(xSbIdx>>1<<1)][(ySbIdx>>1<<1)]+mvLX[(xSbIdx>>1<<1)+1][(ySbIdx<<1)+1]   (2)

mvAvgLX[0]=(mvAvgLX[0]>=0?(mvAvgLX[0]+1)>>1:−((−mvAvgLX[0]+1)>>1))   (3)

mvAvgLX[1]=(mvAvgLX[1]>=0?(mvAvgLX[1]+1)>>1:−((−mvAvgLX[1]+1)>>1))   (4)
```

Scale the mvAvgLX in accordance with the reference index value refIdxLX. Specifically,

If the reference picture corresponding to refIdxLX for the current coding unit is not the current picture, the following applies:

```
mvCLX[0]=mvLX[0]*2/SubWidthC

mvCLX[1]=mvLX[1]*2/SubHeightC
```

Otherwise (the reference picture corresponding to refIdxLX for the current coding unit is the current picture), the following applies:

mvCLX[0]=((mvLX[0]>>(3+SubWidthC))*32

mvCLX[1]=((mvLX[1]>>(3+SubHeightC))*32

In the above design, the calculation of mvAvgLX does not take into account the Chroma subsampling. This leads to inaccurate estimation of a motion field for cases where one of the variables SubWidthC and SubHeightC is equal to 1.

The embodiments of the present invention solve this problem by subsampling the luma motion field based on the chroma format of the picture thereby increasing the accuracy of the chroma motion field. More specifically, the embodiments of the present invention disclose a method to consider the chroma format of the picture when obtaining chroma motion vectors from luma motion vectors. By taking an average of luma motion vectors, linear subsampling of luma motion field is performed. Selecting luma motion vectors based on the picture chroma format leads to a more accurate chroma motion field due to a more accurate luma motion vector field subsampling. This dependency on chroma format enables the selection of the most appropriate luma blocks when averaging luma motion vectors. As a consequence of a more accurate motion field interpolation, prediction error is reduced, which has a technical result of compression performance improvement.

In one exemplary implementation, table 1-1 shows the chroma formats which can be supported in the present disclosure. Chroma format information, such as chroma_format_idc and/or separate_colour_plane_flag, which may be used to determine the values of the variables SubWidthC and SubHeightC.

TABLE 1-1

chroma_format_idc	separate_colour_plane_flag	Chroma format	SubWidthC	SubHeightC
0	0	Monochrome	1	1
1	0	4:2:0	2	2
2	0	4:2:2	2	1
3	0	4:4:4	1	1
3	1	4:4:4	1	1

chroma_format_idc specifies the chroma sampling relative to the luma sampling. The value of chroma_format_idc shall be in the range of 0 to 3, inclusive.

separate_colour_plane_flag equal to 1 specifies that the three colour components of the 4:4:4 chroma format are coded separately. separate_colour_plane_flag being equal to 0 specifies that the colour components are not coded separately. When separate_colour_plane_flag is not present, it is inferred to be equal to 0. When separate_colour_plane_flag is equal to 1, the coded picture consists of three separate components, each of which consists of coded samples of one colour plane (Y, Cb, or Cr) and uses the monochrome coding syntax.

Chroma format determines precedence and subsampling of chroma arrays;

In monochrome sampling there is only one sample array, which is nominally considered the luma array.

In 4:2:0 sampling, each of the two chroma arrays has half the height and half the width of the luma array, as shown in FIG. **9**A.

In 4:2:2 sampling, each of the two chroma arrays has the same height and half the width of the luma array, as shown in FIG. **9**B.

In 4:4:4 sampling, depending on the value of separate_colour_plane_flag, the following applies:

If separate_colour_plane_flag is equal to 0, each of the two chroma arrays has the same height and width as the luma array, as shown in FIG. **9**C.

Otherwise (separate_colour_plane_flag is equal to 1), the three colour planes are separately processed as monochrome sampled pictures.

In another exemplary implementation, Table 1-2 also shows the chroma formats which can be supported in the present disclosure. Chroma format information, such as chroma_format_idc and/or separate_colour_plane_flag, which may be used to determine the values of the variables SubWidthC and SubHeightC.

TABLE 1-2

chroma_format_idc	separate_colour_plane_flag	Chroma format	Sub Width C	SubHeight C
2(0)	0	4:2:2	2	1
3(1)	0	4:4:4	1	1
3(1)	1	4:4:4	1	1

The number of bits necessary for the representation of each of the samples in the luma and chroma arrays in a video sequence is in the range of 8 to 16, inclusive, and the number of bits used in the luma array may differ from the number of bits used in the chroma arrays.

When the value of chroma_format_idc is equal to 1, the nominal vertical and horizontal relative locations of luma and chroma samples in pictures are shown in FIG. **9**A. Alternative chroma sample relative locations may be indicated in video usability information.

When the value of chroma_format_idc is equal to 2, the chroma samples are co-sited with the corresponding luma samples and the nominal locations in a picture are as shown in FIG. **9**B.

When the value of chroma_format_idc is equal to 3, all array samples are co-sited for all cases of pictures and the nominal locations in a picture are as shown in FIG. **9**C.

In one exemplary implementation, the variables SubWidthC and SubHeightC are specified in Table 1-1 or 1-2, depending on the chroma format sampling structure, which is specified through chroma_format_idc and separate_colour_plane_flag. It can be understood that chroma format information, such as the chroma format sampling structure, is specified through chroma_format_idc and separate_colour_plane_flag.

Contrary to the previous design, in the present disclosure, derivation of positions within the luma subblock motion vector array may be applied for different chroma formats and depends on the value of the chroma scaling factor (e.g. SubWidthC and SubHeightC). It should be understood that the "chroma scaling factor in horizontal and vertical directions" can also be referred to as "chroma sampling ratio in horizontal and vertical directions".

Alternatively, in another exemplary implementation, SubWidthC and SubHeightC could be defined as SubWidthC=(1+log 2(wluma)−log 2(wchroma)) and SubHeightC=(1+log 2(hluma)−log 2(hchroma)), where wluma and hluma are the width and height of the luma array respectively, and wchroma and hchroma are the width and height of the chroma array respectively.

In possible implementations of some embodiments of the present disclosure, for a given chroma format, the process of determination of the positions or indexes within luma motion vector array for a given index of a co-located chroma subblock could be performed as follows:

At the outset, the values of SubWidthC and SubHeightC are determined based on the chroma format of the currently coding or decoding picture (or frame).

Then, for each of chroma spatial positions specified by indices xSbIdx=0 . . . numSbX−1, ySbIdx=0 . . . numSbY−1 and X being 0 or 1, the value of chroma motion vector is stored as a corresponding mvCLX element. The steps for determining chroma motion vector are as follows:

The first step is to perform rounding, to determine the x and y indices of the co-located luma subblock:

$$xSbIdxL=(xSbIdx>>(SubWidthC-1))<<(SubWidthC-1);$$

$$ySbIdxL=(ySbIdx>>(SubHeightC-1))<<(SubHeightC-1).$$

The second step is to determine the set of luma subblock positions that are further in determination of the chroma motion vector. A possible example for defining such a set S may be described below:

$$S_0=(xSbIdxL,ySbIdxL);$$

$$S_1=(xSbIdxL+(SubWidthC-1),ySbIdxL+(SubHeightC-1)).$$

The third step is to calculate the average vector mvAvgLX:

When a set S contains N elements, N is a power-of-two, in one exemplary implementation, a motion vector mvAvgLX is determined as follows:

$$mvAvgLX=\Sigma_i>mvLX[S_i^x][S_i^y]$$

$$mvAvgLX[0]=(mvAvgLX[0]+N>>1)>>\log 2(N)$$

$$mvAvgLX[1]=(mvAvgLX[1]+N>>1)>>\log 2(N)$$

where S_i^x and S_i^y are x and y coordinates of position Si.

To summarize, in one exemplary implementation, the determination of the average vector mvAvgLX for averaging can be formulated as follows:

$$mvAvgLX=mvLX[(xSbIdx>>(SubWidthC-1)<<(SubWidthC-1))][(ySbIdx>>(SubHeightC-1)<<(SubHeightC-1))]+mvLX[(xSbIdx>>(SubWidthC-1)<<(SubWidthC-1))+(SubWidthC-1)][(ySbIdx>>(SubHeightC-1)<<(SubHeightC-1))+(SubHeightC-1)] \quad \text{(Eqn.1)}$$

$$mvAvgLX[0](mvAvgLX[0]+N>>1)>>\log 2(N) \quad \text{(Eqn.2)}$$

$$mvAvgLX[1](mvAvgLX[1]+N>>1)>>\log 2(N) \quad \text{(Eqn.3)}$$

It is noted that the way for averaging luma motion vectors presented herein is not limited as above and that the average function in the present disclosure can be implemented in different implementations.

It should be understood that although the above describes the process as a 3-step process, the determination of the average vector mvAvgLX as formulated above in Eqn. 1-3 can be performed in any order.

In another exemplary implementation, the third step can be also implemented as follows:

$$mvAvgLX=\Sigma_i mvLX[S_i^x][S_i^y]$$

$$mvAvgLX[0]=(mvAvgLX[0]>=0?(mvAvgLX[0]+N>>1)>>\log 2(N): -((-mvAvgLX[0]+N>>1)>>\log 2(N)) \quad (5)$$

$$mvAvgLX[1]=(mvAvgLX[1]>=0?(mvAvgLX[1]+N>>1)>>\log 2(N):-((-mvAvgLX[1]+N>>1)>>\log 2(N))) \quad (6)$$

where S_i^x and S_i^y are x and y coordinates of position Si.

It should be noted that the way for averaging luma motion vectors presented herein is not limited as above and that the average function in the present disclosure can be implemented in different implementations.

The next step is to scale the mvAvgLX in accordance with the reference index value refIdxLX. In some examples, the scaling process is performed as follows by replacing mvLX with mvAvgLX (i.e., mvLX[0] will be replaced with mvAvgLX[0], and mvLX[1] will be replaced with mvAvgLX[1]):

If a reference picture corresponding to refIdxLX for the current coding unit is not the current picture, the following applies:

$$mvCLX[0]=mvLX[0]*2/SubWidthC$$

$$mvCLX[1]=mvLX[1]*2/SubHeightC$$

Otherwise (the reference picture corresponding to refIdxLX for the current coding unit is the current picture), the following applies:

$$mvCLX[0]=((mvLX[0]>>(3+SubWidthC))*32$$

$$mvCLX[1]=((mvLX[1]>>(3+SubHeightC))*32$$

Likewise, the derivation process for chroma motion vectors in clause 8.5.2.13 described below can be invoked with mvAvgLX and refIdxLX as inputs, and the chroma motion vector array mvCLXSub[xCSbIdx][yCSbIdx] as output. In the process described in clause 8.5.2.13, mvLX will be replaced with mvAvgLX, and in particular, mvLX[0] will be replaced with mvAvgLX[0], and mvLX[1] will be replaced with mvAvgLX[1].

The details of possible implementations of the average vector mvAvgLX calculation in a derivation process for chroma motion vector of the proposed method are described as follows in the format of the modification of the specification of the VVC draft. There are multiple variants of the process.

1. One of the variants of the average vector mvAvgLX calculation in derivation process for chroma motion vector of the proposed method could be described as follows in the format of the modification of the specification of the VVC draft:

. . .

The average luma motion vector mvAvgLX is derived as follows:

$$mvAvgLX=mvLX[(xSbIdx>>(SubWidthC-1)<<(SubWidthC-1))][(ySbIdx>>(SubHeightC-1)<<(SubHeightC-1))]+mvLX[(xSbIdx>>(SubWidthC-1)<<(SubWidthC-1))+(1>>(2-SubWidthC)]$$

$$[(ySbIdx>>(SubHeightC-1)<<(SubHeightC-1))+(1>>(2-SubHeightC))]$$

Explanatory notes: The above equation shows an example of selecting luma motion vectors for average motion vector calculation (e.g. selection of luma subblock positions for a given chroma subblock position). The selected luma subblocks (and thus their respective positions) are represented by their respective subblock indexes in the horizontal direction and in the vertical direction. For example, and as shown above, for a given chroma subblock (xSbIdx, ySbIdx) where xSbIdx and ySbIdx are the subblock indexes of the chroma subblock in the horizontal and vertical direction, respectively, two luman subblocks (and thus their respective positions, e.g. their respective subblock indices) can be selected. One of the two selected luma subblocks can be represented by a subblock index in the horizontal direction as [(xSbIdx>>(SubWidthC−1)<<(SubWidthC−1))] and a subblock

index in the vertical direction as [(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))]. Another selected luma subblock can be represented by a subblock index in the horizontal direction as [(xSbIdx>>(SubWidthC−1)<<(SubWidthC−1))+(1>>(2−SubWidthC))] and a subblock index in the vertical direction as [(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))+(1>>(2−SubHeightC))]). Accordingly, the selection of the luma blocks for averaging luma motion vectors is dependent on the picture chroma format. In particular, selection of the luma blocks for averaging luma motion vectors, is dependent on the chroma scaling factors SubWidthC and SubHeightC which are determined based on the picture chroma format.

The mvAvgLX obtained above can be further processed by:

```
mvAvgLX[0]=(mvAvgLX[0]>=0?(mvAvgLX[0]+1)
    >>1: −((−mvAvgLX[0]+1)>>1))

mvAvgLX[1]=(mvAvgLX[1]>=0?(mvAvgLX[1]+1)
    >>1:−((−mvAvgLX[1]+1)>>1))
```

It is noted that the way for averaging luma motion vectors presented herein is not limited as above and that the average function in the present disclosure can be implemented in different ways.

The derivation process for chroma motion vectors in clause 8.5.2.13 presented later in this disclosure is invoked with mvAvgLX and refIdxLX as inputs, and the chroma motion vector mvCLX[xSbIdx][ySbIdx] as output.

2. Another variant of the average vector mvAvgLX calculation in a derivation process for chroma motion vector of the proposed method could be described as follows in the format of the modification of the specification of the VVC draft:

. . .

The average luma motion vector mvAvgLX is derived as follows:

```
mvAvgLX=mvLX[(xSbIdx>>(SubWidthC−1)<<(Sub-
    WidthC−1))]

[(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))]+
    mvLX[(xSbIdx>>(SubWidthC−1)<<(Sub-
    WidthC−1))+(1>>(4−SubWidthC−Sub-
    HeightC))]

[(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))+
    (1>>(4−SubWidthC−SubHeightC))]
```

Explanatory notes: the above equation shows an example of selecting luma motion vectors for calculation of average motion vector (e.g. selection of luma subblock positions for a given chroma subblock position). The selected luma subblocks (and thus their respective positions) are represented by their respective subblock indexes in the horizontal direction and in the vertical direction. For example, and as shown above, for a given chroma subblock (xSbIdx, ySbIdx) where xSbIdx and ySbIdx are the subblock indexes of the chroma subblock in the horizontal and vertical direction, respectively, two luma subblocks (and thus their respective positions, e.g. their respective subblock indices) can be selected. One of the two selected luma subblocks can be represented by a subblock index in the horizontal direction as [(xSbIdx>>(SubWidthC−1)<<(SubWidthC−1))] and a subblock index in the vertical direction as [(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))]. Another selected luma subblock can be represented by a subblock index in the horizontal direction as [(xSbIdx>>(SubWidthC−1)<<(SubWidthC−1))+(1>>(4−SubWidthC−SubHeightC))] and a subblock index in the vertical direction as [(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))+(1>>(4−SubWidthC−SubHeightC))]). Accordingly, the selection of the luma blocks for averaging luma motion vectors is dependent on the picture chroma format. In particular, selection of the luma blocks for averaging luma motion vectors, is dependent on the chroma scaling factors SubWidthC and SubHeightC which are determined based on the picture chroma format.

Compared with the first variant, this variant uses different ways to determine the set of luma subblocks. In particular, 1>>(4−SubWidthC−SubHeightC) is used to determine the index of the second luma subblock (the neighboring luma subblock of the first luma subblock) in this variant, whereas 1>>(2−SubWidthC) and 1>>(2−SubHeightC) are used in the first variant. In the first variant, the first luma subblock itself, its diagonal neighbor, or its horizontal neighbor may be used as the second subblock. In the second variant, either the first luma subblock itself or its diagonal neighbor can be used as the second luma subblock depending on the values of the chroma scaling factor.

The mvAvgLX obtained above can be further processed by:

```
mvAvgLX[0]=(mvAvgLX[0]>=
    0?(mvAvgLX[0]+1)>>1:−
    ((−mvAvgLX[0]+1)>>1))

mvAvgLX[1]=(mvAvgLX[1]>=
    0?(mvAvgLX[1]+1)>>1:−
    ((−mvAvgLX[1]+1)>>1))
```

The derivation process for chroma motion vectors in clause 8.5.2.13 is invoked with mvAvgLX and refIdxLX as inputs, and the chroma motion vector mvCLX[xSbIdx] [ySbIdx] as output.

. . .

It is noted that the way for averaging luma motion vectors presented herein is not limited as above and that the average function in the present disclosure can be implemented in different ways.

3. Another variant of a derivation process for chroma motion vector of the proposed method could be described as follows in the format of the modification of the specification of the VVC draft:

. . .

The average luma motion vector mvAvgLX is derived as follows:

```
mvAvgLX=mvLX[(xSbIdx>>(SubWidthC−1)<<(Sub-
    WidthC−1))][(ySbIdx>>(SubHeightC−1)<<(Sub-
    HeightC−1))]
```

The derivation process for chroma motion vectors in clause 8.5.2.13 is invoked with mvAvgLX and refIdxLX as inputs, and the chroma motion vector mvCLX[xSbIdx] [ySbIdx] as output.

. . .

4. Another variant of a derivation process for a chroma motion vector of the proposed method could be described as follows in the format of the modification of the specification of the VVC draft:

. . .

The average luma motion vector mvAvgLX is derived as follows:

```
If SubWidthC==1 and SubHeightC==1:
    mvAvgLX = mvLX[xSbIdx][ySbIdx]
Otherwise
  xSbIdxL = (xSbIdx >> (SubWidthC − 1)) << (SubWidthC − 1);
  ySbIdxL = (ySbIdx >> (SubHeightC − 1)) << (SubHeightC − 1).
```

-continued

```
mvAvgLX = mvLX[ xSbIdxL ][ ySbIdxL ] + mvLX[ xSbIdxL +
(SubWidthC−1) ][ ySbIdxL+ (SubHeightC−1) ]
```

Explanatory notes: the above equation shows an example of selecting luma motion vectors for average motion vector calculation (e.g. selection of luma subblock positions for a given chroma subblock position). The selected luma subblocks (and thus their respective positions) are represented by their respective subblock indexes in the horizontal direction and in the vertical direction. For example, and as shown above, for a given chroma subblock (xSbIdx, ySbIdx) where xSbIdx and ySbIdx are the subblock indexes of the chroma subblock in the horizontal and vertical direction, respectively, two luma subblocks (and thus their respective positions, e.g. their respective subblock indices) can be selected. One of the two selected luma subblocks can be represented by a subblock index in the horizontal direction as [(xSbIdx>>(SubWidthC−1)<<(SubWidthC−1))] and a subblock index in the vertical direction as [(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))]. Another selected luma subblock can be represented by a subblock index in the horizontal direction as [(xSbIdx>>(SubWidthC−1)>>(SubWidthC−1))+(SubWidthC−1)] and a subblock index in the vertical direction as [(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))+(SubHeightC−1)]). Accordingly, the selection of the luma blocks for averaging luma motion vectors is dependent on the picture chroma format. In particular, selection of the luma blocks for averaging luma motion vectors is dependent on the chroma scaling factors SubWidthC and SubHeightC which are determined based on the picture chroma format.

The mvAvgLX obtained above can be further processed by:

```
mvAvgLX[0]=mvAvgLX[0]>=0?mvAvgLX[0]>>1−
    ((−mvAvgLX[0])>>1)

mvAvgLX[1]=mvAvgLX[1]>=0?mvAvgLX[1]>>1−
    ((−mvAvgLX[1])>>1)
```

It is noted that the way for averaging luma motion vectors presented herein is not limited as above and that the average function in the present disclosure can be implemented in different ways.

The details of determination of luma subblock positions, for example, further details in determination of the chroma motion vector for different chroma formats, will be explained in combination with FIG. **10**A-**10**C and FIGS. **11**A-**11**C as below.

FIG. **10**A shows an example illustrating co-located luma and chroma blocks which are included in a current image block (e.g. a coding block) of a current picture, where the chroma format of the current picture is 4:2:0. As shown in FIG. **10**A and table 1-1, when the chroma format of the current picture is 4:2:0, the SubWidthC=2 and SubHeightC=2. If the width of the luma block is W and the height of the luma block is H, the width of the corresponding chroma block is W/SubWidthC and the height of a corresponding chroma block is H/SubHeightC. Specifically, for the current image block comprising the co-located luma and chroma blocks, the luma block generally contains four times the number of samples of the corresponding chroma block.

FIG. **10**B is an example illustrating co-located luma and chroma blocks which are included in a current image block of a current picture, where the chroma format of the current picture is 4:2:2. As shown in FIG. **10**B and table 1-1 or 1-2, when the chroma format of the current picture is 4:2:2, the SubWidthC=2 and SubHeightC=1. If the width of the luma block is W and the height of the luma block is H, the width of the corresponding chroma block is W/SubWidthC and the height of a corresponding chroma block is H/SubHeightC. Specifically, for the current image block comprising the co-located luma and chroma blocks, the luma block generally contains two times the number of samples of the corresponding chroma block.

FIG. **10**C is an example illustrating co-located luma and chroma blocks which are included in a current image block of a current picture where the chroma format of the current picture is 4:4:4. As shown in FIG. **10**C and table 1-1 or 1-2, when the chroma format of the current picture is 4:4:4, the SubWidthC=1 and SubHeightC=1. If the width of the luma block is W and the height of the luma block is H, the width of the corresponding chroma block is W/SubWidthC and the height of a corresponding chroma block is H/SubHeightC. Specifically, for the current image block comprising the co-located luma and chroma blocks, the luma block generally contains the same number of samples of the corresponding chroma block.

FIG. **11**A is an example illustrating positions of two luma subblocks for a given position of a chroma subblock during chroma motion vectors derivation from luma motion vectors when the chroma format of the current picture is 4:2:0 as shown in FIG. **10**A.

The x and y indices of the co-located luma subblock are determined using corresponding x and y indices of the chroma subblock (denoted as xSbIdx, ySbIdx):

```
xSbIdxL=(xSbIdx>>(SubWidthC−1))<<(SubWidthC−
    1);

ySbIdxL=(ySbIdx>>(SubHeightC−1))<<(Sub-
    HeightC−1).
```

Two affine luma subblocks are selected for further averaging of their motion vectors. Positions of these two subblocks are defined as:

```
(xSbIdxL,ySbIdxL) and

(xSbIdxL+(SubWidthC−1),ySbIdxL+(SubHeightC−
    1)).
```

As shown in FIG. **11**A, in the case of YUV 4:2:0 format, motion vectors of two luma sub-blocks of a luma block **1010** (8×8 luma size) on diagonal are used for averaging, and the averaged MV is used for affine sub-block motion vector derivation process for chroma subblock. In particular,

- Index of the luma subblock or chroma subblock 0: xSbIdx=0, ySbIdx=0,
- Index of the luma subblock or chroma subblock 1: xSbIdx=1, ySbIdx=0
- Index of the luma subblock or chroma subblock 2: xSbIdx=0, ySbIdx=1, and
- Index of the luma subblock or chroma subblock 3: xSbIdx=1, ySbIdx=1.

Following the variant 4 design, motion vector of each chroma sublock is derived based on an averaged value, and the averaged value is obtained based on the motion vector of the luma sublock 0 (mvLX[0][0]) and the luma sublock 3 (mvLX[1][1]) which are diagonal.

FIG. **11**B is an example illustrating positions of two luma subblocks for a given position of a chroma subblock during chroma motion vectors derivation from luma motion vectors when the chroma format of the current picture is 4:2:2 as shown in FIG. **10**B. As shown in FIG. **11**B, in the case of YUV 4:2:2 format, motion vectors of two horizontally-adjacent luma sub-blocks of a luma block **1010** (8×8 luma

size) are used for averaging, and the averaged MV is used for affine sub-block motion vector derivation process for chroma subblock. In particular,

Index of the luma subblock or chroma subblock 0: xSbIdx=0, ySbIdx=0,

Index of the luma subblock or chroma subblock 1: xSbIdx=1, ySbIdx=0,

Index of the luma subblock or chroma subblock 2: xSbIdx=0, ySbIdx=1, and

Index of the luma subblock or chroma subblock 3: xSbIdx=1, ySbIdx=1.

Following the above variant 4 design, the motion vector of each chroma sublock on the first row of a chroma block **920** is derived based on an averaged value, and the averaged value is obtained based on the motion vectors of the luma sublock 0 (mvLX[0][0]) and the luma sublock 1 (mvLX[1][0]) which are horizontally adjacent. The motion vector of each chroma sublock on the second row of the chroma block **920** is derived based on averaged value, and the averaged value is obtained based on the motion vectors of the luma sublock 2(mvLX[0][1]) and the luma sublock 3 (mvLX[1][1]) which are horizontally adjacent.

FIG. **11**C is an example illustrating a position of a luma subblock for a given position of a chroma subblock during chroma motion vectors derivation from luma motion vectors when the chroma format of the current picture is 4:4:4 as shown in FIG. **10**C.

As shown in FIG. **11**C, in the case of YUV 4:4:4 format, the motion vector(s) of the co-located luma subblock of a luma block **1010** (8×8 luma size) is used for each chroma subblock to perform affine prediction, i.e., a affine sub-block motion vector derivation process for chroma is same as that for luma.

It should be understood that no averaging is required, i.e. the motion vector can be determined by using the motion vector of the co-located luma sub-block or this averaging operation will take as an input the same MV twice and generate the same motion vector as the output. The luma or chroma subblock size may be 4×4 size.

FIG. **12**A shows several examples of a subset S that comprises positions of luma subblocks for the given position of chroma subblock when the chroma format is set to 4:4:4. In this example, four cases of subset S derivation are considered.

In a first case, a chroma position "A" (**1201**) has corresponding neighboring luma blocks located at positions "A" (**1202**).

In a second case, a chroma position "B" (**1203**) is selected on the bottom boundary of the chroma block. In this case (except for the right-bottom position), the corresponding positions **1204** of luma subblocks belonging to S are selected to be horizontally-adjacent.

In a third case, a chroma position "C" (**1205**) is selected on the right boundary of the chroma block. In this case (except for the right-bottom position), the corresponding positions **1206** of luma subblocks belonging to S are selected to be vertically-adjacent.

In a fourth case, a chroma position "D" (**1207**) is selected on the bottom-right corner of the chroma block. In this case, the set S comprises a single luma subblock that is located at the bottom-right corner of the luma block.

FIG. **12**B shows another embodiment of obtaining a subset S. In this embodiment, chroma blocks located on the boundary of chroma block have corresponding positions in the luma block as in the fourth case "D" shown in FIG. **12**A.

In the embodiments of the present disclosure described above, the number of chroma subblocks are the same as the number of co-located luma subblocks in case when chroma subsampling is used. In particular, the number of luma subblocks in the horizontal direction numSbX is the same as the number of chroma subblocks in the horizontal direction numSbX, and the number of luma subblocks in the vertical direction numSbY is the same as the number of chroma subblocks in vertical direction numSbY. Accordingly, chroma subblock sizes are different from the sizes of co-located luma subblocks in case when chroma subsampling is used.

In other scenarios, the sizes of the chroma subblocks and luma subblocks are kept the same regardless of the chroma format. In these scenarios, the number of chroma subblocks in a chroma block and the number of luma subblocks in a co-located luma block can be different. The following embodiment is directed to the chroma motion vector derivation for subblocks of the same size for chroma and luma component. That is, for a current picture comprising a current image block comprising co-located luma and chroma blocks, the luma block of the current picture includes a set of equally sized luma subblocks, and the chroma block of the current picture includes a set of equally sized chroma subblocks, and the size of a chroma subblock is set to be equal to the size of a luma sublock. It can be understood that the number of chroma subblocks are different from the number of co-located luma subblocks in case when chroma subsampling is used. In particular, the number of luma subblocks along the horizontal direction, numSbX, is different from the number of chroma subblocks along the horizontal direction, numSbX, and the number of luma subblocks along the vertical direction, numSbY, is different from the number of chroma subblocks along the vertical direction, numSbY.

As shown in FIG. **13**A, in the case of YUV 4:2:0 format, for example, the luma block of the current picture has a size of 8×8, four equally sized luma subblocks are included in the luma block, and a set of equally sized chroma subblocks are included in the chroma block of the current picture (a chroma subblock=the chroma block), wherein the size of a chroma subblock is set to be equal to the size of a luma sublock. Motion vectors of two luma sub-blocks on diagonal are averaged, and the averaged MV is used for affine sub-block motion vector derivation process for the chroma subblock. In particular, since the number of subblocks is different, xSbIdx (the subblock index of the luma subblock in the horizontal direction) would change with a step size of SubWidth and ySbIdx (the subblock index of the luma subblock in the vertical direction) would change with a step size of SubHeightC. For example, for the 4:2:0 format, xSbIdx=0, 2, 4, 6 . . . , and ySbIdx=0, 2, 4, 6 . . . .

As shown in FIG. **13**B, in the case of YUV 4:2:2 format, motion vectors of two horizontally-adjacent luma subblocks are used for averaging according to equation of the above variant 4 in order to generate the motion vector for a chroma sub-block. The averaged MV is used for affine sub-block motion vector derivation process for the chroma subblock. In particular, since the number of subblocks is different, xSbIdx would change with a step size of SubWidth and ySbIdx would change with a step size of SubHeightC. For example, for 4:2:2, xSbIdx=0, 2, 4, 8 . . . and ySbIdx=0, 1, 2, 3 . . . .

As shown in FIG. **13**C, in the case of YUV 4:4:4 format, both number and size are equal for luma subblocks and chroma subblocks. In this case, for each chroma subblock, the motion vector(s) of the co-located luma subblock is used to perform affine prediction. In other words, the affine sub-block motion vector derivation process for the chroma

block is same as that for the luma block. For example, for the 4:4:4 format, xSbIdx=0, 1, 2, 3 . . . and ySbIdx=0, 1, 2, 3 . . . . It should be noted that in this case, the averaging operation specified in equation of the above variant 4 does not need to be performed because the two sub-blocks used for averaging are the same and the averaging operation would output the same value as the input. As such, in this case, the motion vector of the luma subblock can be selected for the chroma subblock without going through the averaging operation formulated in equation of any previous variant.

From the above, it can be seen that a block will have a number of chroma subblocks that differs from the number of luma subblocks when SubWidthC is greater than 1 or SubHeightC is greater than 1. FIG. **14**A shows an example of subdivision of a 16×16 luma block and the subdivision of a collocated chroma block for the YUV 4:2:0 chroma format. In this example, the luma block is divided into 16 subblocks each having a size of 4×4. The chroma block has a size of 8×8 samples and is subdivided into a total of 4 subblocks each having a size of 4×4 samples. These 4 chroma subblocks are grouped into 2 rows with each row having 2 subblocks. Letters "A", "B", "C" and "D" indicate which luma subblocks are used to derive a motion vector for a corresponding chroma subblock denoted with the same letter.

FIG. **14**B illustrates the subdivision of a 16×16 luma block and its co-located chroma block in a picture having a YUV 4:2:2 chroma format. In this case, the chroma block has a size of 8×16 samples and is subdivided into a total of 8 subblocks grouped into 4 rows with each row having 2 subblocks. Each luma subblock and chroma subblock has a size of 4×4 samples. Letters "A", "B", "C", "D", "E", "F", "G" and "H" indicate which luma subblocks are used to derive a motion vector for a corresponding chroma subblock denoted with the same letter.

Assuming that the luma block is subdivided into numSbY rows of subblocks, each row having numSbX subblocks, and that a motion vector is specified or obtained for each of the luma subblocks, the embodiment presented herein could be specified as follows:

1. The first step is to determine values of SubWidthC and SubHeightC based on the chroma format information indicating the chroma format of the current coding or decoding picture (or frame). For example, the chroma format information can be contain information presented in the above table 1-1 or 1-2.
2. The second step may include: obtaining the number of chroma subblocks along the horizontal direction, numCSbX, and the number of chroma subblocks along the vertical directions, numCSbY, as follows:

numCSb*X*=numSb*X*>>(SubWidth*C*−1), wherein numSb*X* is the number of luma subblocks in a luma block along the horizontal direction;

numCSb*Y*=numSb*Y*>>(SubHeight*C*−1), wherein numSb*Y* is the number of luma subblocks in the luma block along the vertical direction.

The luma block can be a currently encoding or decoding block of a currently coding or decoding picture.

3. Denoting a chroma subblock located on row yCSbIdx and column xCSbIdx using the spatial indices (xCSbIdx, yCSbIdx), where xCSbIdx=0, . . . , numCSbX−1 and yCSbIdx=0 . . . numCSbY−1, the value of the chroma motion vector for the chroma subblock can be determined as follows:

Spatial indices (xSbIdxL, ySbIdxL) of the co-located luma subblock are determined as follows:

*x*SbIdxL=*x*CSbIdx<<(SubWidth*C*−1);

*y*SbIdxL=*y*CSbIdx<<(SubHeight*C*−1).

Spatial position of a chroma subblock (sbX, sbY) within a chroma block could be derived using spatial indices (xCSbIdx, yCSbIdx) as follows:

sb*X*=*x*CSbIdx*sb*X*;

sb*Y*=*y*CSbIdx*sb*Y*.

The same applies to determination of a spatial position for luma subblock within a luma block spatial indices (xSbIdx, ySbIdx) of a luma subblock:

sb*X*=*x*SbIdx*sb*X*;

sb*Y*=*y*SbIdx*sb*Y*.

The determined spatial indices of the collocated luma subblock (xSbIdxL, ySbIdxL) can be further used in determination of the chroma motion vector. For example, a set of luma subblocks can be defined as described below:

$S_0=(xSbIdx_L, ySbIdx_L)$

$S_1=(xSbIdx_L+(SubWidthC-1), ySbIdx_L+(SubHeightC-1))$

In this example, the set of luma subblocks includes two subblocks indexed by S_0 and S_1 calculated above. Each of S_0 and S_1 includes a pair of spatial indices defining a subblock position.

The set of luma subblocks is used to calculate the average motion vector mvAvgLX. Here and in motion vector denotations used in the following, X could be either 0 or 1, correspondingly indicating reference list index for a motion vector being either L0 or L1. L0 indicates a reference list 0, and L1 indicates a reference list 1. It is assumed that calculations of a motion vector is performed by apply corresponding formulas independently to horizontal component mvAvgLX[0] and vertical component mvAvgLX[1] of the motion vector.

If a luma motion vector of a subblock with spatial indices ($xSbIdx_L$, ySbIdxL) is denoted as mvLX[$xSbIdx_L$][ySbIdxL], average motion vector mvAvgLX could be obtained as follows:

$$mvAvgLX = \sum_i mvLX[S_i^x][S_i^y]$$

$$mvAvgLX = mvAvgLX >= 0\ ?\ mvAvgLX >> 1 : -((-mvAvgLX) >> 1)$$

where S_i^x and S_i^y are horizontal and vertical spatial indices of an element Si as discussed above, wherein i=0, 1 . . . .

The motion vector of a chroma subblock mvCLX with spatial indices (xCSbIdx, yCSbIdx) is obtained from the average motion vector mvAvgLX as follows:

mvCLX[0]=mvAvgLX[0]*2/SubWidth*C*

mvCLX[1]=mvAvgLX[1]*2/SubHeight*C*

The details of the derivation process for the luma and chroma motion vector according to the embodiments presented herein are described as follows in the format of a part of the specification of the VVC draft:

8.5.5.9 Derivation Process for Motion Vector Arrays from Affine Control Point Motion Vectors

Inputs to this process are:

a luma location (xCb, yCb) of the top-left sample of the current luma coding block relative to the top-left luma sample of the current picture,

two variables cbWidth and cbHeight specifying the width and the height of the luma coding block, respectively,

the number of control point motion vectors numCpMv,

the control point motion vectors cpMvLX[cpIdx], with cpIdx=0 . . . numCpMv−1 and X being 0 or 1,

the reference index refIdxLX and X being 0 or 1,

the number of luma coding subblocks in horizontal direction (numSbX) and in vertical direction (numSbY).

Outputs of this process are:

the luma subblock motion vector array mvLX[xSbIdx][ySbIdx] with xSbIdx=0 . . . numSbX−1, ySbIdx=0 . . . numSbY−1 and X being 0 or 1,

the chroma subblock motion vector array mvCLX[xSbIdx][ySbIdx] with xSbIdx=0 . . . numSbX−1, ySbIdx=0 . . . numSbY−1 and X being 0 or 1.

The following assignments are made for x=xCb . . . xCb+cbWidth−1 and y=yCb . . . yCb+cbHeight−1:

```
CpMvLX[x][y][0]=cpMvLX[0]

CpMvLX[x][y][1]=cpMvLX[1]

CpMvLX[x][y][2]=cpMvLX[2]
```

The variables log 2CbW and log 2CbH are derived as follows:

```
log 2CbW=Log 2(cbWidth)

log 2CbH=Log 2(cbHeight)
```

The variables mvScaleHor, mvScaleVer, dHorX and dVerX are derived as follows:

```
mvScaleHor=cpMvLX[0][0]<<7

mvScaleVer=cpMvLX[0][1]<<7

dHorX=(cpMvLX[1][0]−cpMvLX[0][0])<<(7−log
    2CbW)

dVerX=(cpMvLX[1][1]−cpMvLX[0][1])<<(7−log
    2CbW)
```

The variables dHorY and dVerY are derived as follows:

If numCpMv is equal to 3, the following applies:

```
dHorY=(cpMvLX[2][0]−cpMvLX[0][0])<<(7−log
    2CbH)

dVerY=(cpMvLX[2][1]−cpMvLX[0][1])<<(7−log
    2CbH
```

Otherwise (numCpMv is equal to 2), the following applies:

```
dHorY=−dVerX

dVerY=dHorX
```

For xSbIdx=0 . . . numSbX−1 and ySbIdx=0 . . . numSbY−1, the following applies:

The luma motion vector mvLX[xSbIdx][ySbIdx] is derived as follows:

```
xPosCb=2+(xSbIdx<<2)

yPosCb=2+(ySbIdx<<2)

mvLX[xSbIdx][ySbIdx][0]=(mvScaleHor+
    dHorX*xPosCb+dHorY*yPosCb)

mvLX[xSbIdx][ySbIdx][1]=(mvScaleVer+
    dVerX*xPosCb+dVerY*yPosCb)
```

The rounding process for motion vectors as specified in clause 8.5.2.14 is invoked with mvX set equal to mvLX[xSbIdx][ySbIdx], rightShift set equal to 7, and leftShift set equal to 0 as inputs and the rounded mvLX[xSbIdx][ySbIdx] as output.

The motion vectors mvLX[xSbIdx][ySbIdx] are clipped as follows:

```
mvLX[xSbIdx][ySbIdx][0]=Clip3(−217,217−1,mvLX
    [xSbIdx][ySbIdx][0])

mvLX[xSbIdx][ySbIdx][1]=Clip3(−217,217−1,mvLX
    [xSbIdx][ySbIdx][1])
```

The variables numCSbX and numCSbY are defined as follows:

```
numCSbX=numCSbX>>(SubWidthC−1)

numCSbY=numCSbY>>(SubHeightC−1)
```

It should be noted that this embodiment is different from previous embodiments. In the previous embodiments, the number of luma subblocks in a luma block and the number of chroma subblocks in the co-located chroma block are same. In this embodiment, however, for chroma formats 4:2:0 and 4:2:2, the number of luma subblocks in a luma block and the number of chroma subblocks in the co-located chroma block are different. Because the number of subblocks is different in the chroma block and the luma block, xSbIdx would change with a step size of SubWidth and ySbIdx would change with a step size of SubHeightC as can be seen from below.

For xCSbIdx=0 . . . numCSbX−1 and yCSbIdx=0 . . . numCSbY−1, the following applies:

The average luma motion vector mvAvgLX is derived as follows:

If SubWidthC==1 and SubHeightC==1

```
mvAvgLX=mvLX[xCSbIdx][yCSbIdx]

Otherwise,

xSbIdx_L=xCSbIdx<<(SubWidthC−1)

ySbIdxL=yCSbIdx<<(SubHeightC−1)

mvAvgLX=mvLX[xSbIdxL][ySbIdxL]+mvLX[xS-
    bIdxL+(SubWidthC−1)][ySbIdxL+(Sub-
    HeightC−1)]

mvAvgLX[0]=mvAvgLX[0]>=0?(mvAvgLX[0])>>1−
    ((−mvAvgLX[0])>>1)

mvAvgLX[1]=mvAvgLX[1]>=0?(mvAvgLX[1])>>1−
    ((−mvAvgLX[1])>>1)
```

The derivation process for chroma motion vectors in clause 8.5.2.13 presented below is invoked with mvAvgLX and refIdxLX as inputs, and the chroma motion vector array mvCLXSub[xCSbIdx][yCSbIdx] as output.

The chroma subblock motion vector array mvCLX[xSbIdx][ySbIdx] with xSbIdx=0 . . . numSbX−1, ySbIdx=0 . . . numSbY−1 is being derived from mvCLXSub as follows:

```
mvCLX[xSbIdx][ySbIdx]=mvCLXSub[xSbIdx>>
    (SubWidthC−1)][ySbIdx>>(SubHeightC−1)]
```

It should be noted that the averaging operation presented above is for illustration purpose and should not be construed

as limiting. Various other ways for performing an averaging operation can be utilized in the determination of the chroma motion vectors from luma motion vectors.

8.5.2.13 Derivation Process for Chroma Motion Vectors

8.5.2.14 Input to this Process are:

a luma motion vector in 1/16 fractional-sample accuracy mvLX,

the reference index refIdxLX.

Output of this process is a chroma motion vector in 1/32 fractional-sample accuracy mvCLX.

A chroma motion vector is derived from the corresponding luma motion vector.

The chroma motion vector mvCLX, is derived as follows:

$$mvCLX[0]=mvLX[0]*2/SubWidthC$$

$$mvCLX[1]=mvLX[1]*2/SubHeightC$$

The operations of this derivation process depend on how this process is invoked. For example, previously it has been described that "the derivation process for chroma motion vectors in clause 8.5.2.13 is invoked with mvAvgLX and refIdxLX as inputs, and the chroma motion vector array mvCLXSub[xCSbIdx] [yCSbIdx] as output." In this example, mvLX in section 8.5.2.13 described herein will be replaced with mvAvgLX in order to carry out the operations as it is invoked.

There are additional aspects relating to the embodiments that consider an offset between subsampled positions of chroma samples with respect to the position of luma samples.

Exemplary embodiment is to define or determine a set S of luma subblocks in accordance with the value of "sps_cclm_colocated_chroma_flag". In specific, When SubHeightC=1 and SubWidthC=2 and sps_cclm_colocated_chroma_flag is set equal to 1, the set S is composed of a single element S_0=(xSbIdxL, ySbIdxL)

Otherwise, the set S includes

$$S_0=(xSbIdxL,ySbIdxL)$$

$$S_1=(xSbIdxL+(SubWidthC-1),ySbIdxL+(SubHeightC-1))$$

Another exemplary embodiment introduces a dependency between the determination of average motion vector and the value of "sps_cclm_colocated_chroma_flag". In particular, weights are introduced in the averaging operations and may be specified differently for different luma subblocks. An exemplary process of average motion vector derivation is as follows:

$$xSbIdxL=xCSbIdx<<(SubWidthC-1)$$

$$ySbIdx_L=yCSbIdx<<(SubHeightC-1)$$

sps_cclm_colocated_chroma_flag is set equal to 1, weighting coefficients w0 and w1 are set as follows: w0=5, w1=3;

$$mvAvgLX=w0*mvLX[xSbIdx_L][ySbIdx_L]++w1*mvLX[xSbIdx_L+(SubWidthC-1)][ySbIdx_L+(SubHeightC-1)]$$

$$mvAvgLX[0]=mvAvgLX[0]>=0?(mvAvgLX[0]+3)>>3:-((-mvAvgLX[0]+3)>>3)$$

$$mvAvgLX[1]=mvAvgLX[1]>=0?(mvAvgLX[1]+3)>>3:-((-mvAvgLX[1]+3)>>3)$$

It should be noted that the averaging operation presented in this example is for illustration purpose and should not be construed as limiting. Various other ways for performing an averaging operation can be utilized in the determination of the chroma motion vectors from luma motion vectors.

FIG. **15** is a flowchart of an example method **1300** for affine based inter prediction of chroma subblocks, the method comprising:

At step **1501**, determining chroma scaling factors in horizontal and vertical directions based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the current image block belongs to;

At step **1503**, determining a set (S) of luma subblocks of the luma block based on values of the chroma scaling factors; and

At step **1505**, determining a motion vector for a chroma subblock of the chroma block based on motion vectors of one or more luma subblocks in the set (S) of luma subblocks.

FIG. **16** is a flowchart of another example method **1300** for affine based inter prediction of chroma subblocks, the method comprising:

At step **1601**, determining chroma scaling factors in horizontal and vertical directions based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the current image block belongs to;

At step **1603**, determining a value of a motion vector for each luma subblock in a plurality of luma subblocks, wherein the N luma subblocks are included in the luma block;

At step **1605**, averaging of motion vectors of the luma subblocks in the set S of luma subblocks, wherein the set (S) is determined based on the chroma scaling factors; and

At step **1607**, for a chroma subblock in a plurality of chroma subblocks, deriving the motion vector for the chroma subblock based on the average luma motion vector, wherein the chroma subblocks are included in the chroma block.

The present invention discloses a method to consider the chroma format of the picture when obtaining chroma motion vectors from luma motion vectors. By taking an average of luma vectors, linear subsampling of luma motion field is performed. When chroma color planes have the same height as that of a luma plane, it is found more appropriate to select motion vectors from luma blocks that are horizontally adjacent, so that they have the same vertical position. Selection of luma motion vectors depending on a picture chroma format leads to a more accurate chroma motion field due to a more accurate luma motion vector field subsampling. This dependency on a chroma format enables the selection of the most appropriate luma blocks' positions when averaging luma motion vectors. As a consequence of a more accurate motion field interpolation, prediction errors are reduced, which has a technical result in a compression performance improvement.

Further, when a number of chroma subblocks is defined to be equal to the number of luma subblocks, and when a size of a chroma color plane is not equal to a size of a luma plane, motion vectors of adjacent chroma subblocks may assume the same value. When implementing this processing steps, an optimization could be performed by skipping the repeated value calculation step. The proposed invention discloses a method to define a size of chroma subblocks equal to a size of luma subblocks. In this case, implementation could be simplified by unifying luma and chroma processing, and redundant motion vector calculations are naturally avoided.

FIG. **17** illustrates a device for affine based inter prediction according to another aspect of the invention. The device **1700** comprises:

a determining module **1701** configured to determine chroma scaling factors in horizontal and vertical directions respectively based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the current image block belongs to; and determine a set (S) of luma subblocks of the luma block based on values of the chroma scaling factors; and

a motion vector derivation module **1703** configured to determine a motion vector for a chroma subblock of the chroma block based on motion vectors of one or more luma subblocks in the set (S) of luma subblocks.

In an example, a motion vector derivation module **1703** may comprise:

a luma motion vector derivation module **1703***a* configured for determining a value of a motion vector for each luma subblock in a plurality of luma subblocks, wherein a plurality of luma subblocks are included in the luma block;

a chroma motion vector derivation module **1703***b* configured for, for a chroma subblock in a plurality of chroma subblocks, determining a motion vector for the chroma subblock based on the motion vector of at least one luma subblock in a set (S) of luma subblocks, wherein the set (S) is determined based on the chroma scaling factors; wherein the chroma subblocks are included in the chroma block. In an equal size design, a plurality of chroma subblocks may comprise only one chroma subblock.

The device **1700** further comprises: a motion compensation module **1705** configured for generating the prediction of the chroma subblock based on the determined motion vector.

Correspondingly, in an example, an example structure of the device **1700** may be corresponding to encoder **200** in FIG. **2**. In another example, an example structure of the device **1700** may be corresponding to the decoder **300** in FIG. **3**.

In another example, an example structure of the device **1700** may be corresponding to inter prediction unit **244** in FIG. **2**. In another example, an example structure of the device **1700** may be corresponding to the inter prediction unit **344** in FIG. **3**.

The present disclosure provides the following further aspects.

According to a first aspect of the invention, a method of chroma motion vector derivation used in affine motion compensation of an inter predicted unit (PU), a PU comprises co-located luma and chroma blocks is provided, the method comprising

determining chroma scaling factors in horizontal and vertical directions (SubWidthC and SubHeightC) based on a chroma format of a current picture (for example, current coding or decoding picture);

splitting a luma block of the current picture into a first set of luma subblocks; obtaining a value of a motion vector for each luma subblock in the first set of luma subblocks;

splitting a chroma block of the current picture (in an example, the chroma block and the luma block are comprised in same PU) into a set of chroma subblocks;

for a chroma subblock in the set of chroma subblocks, determining a second set of luma subblocks (S), wherein the positions of luma subblocks in the second set are determined by the chroma format of the current picture; and

deriving a motion vector for the chroma subblock based on the motion vectors of the luma subblocks in the second set S.

In a possible implementation form of the method according to the first aspect as such, the second set of luma subblocks (S) comprises any combination of the following subblocks:

$$S_0=(x\text{SbIdxL},y\text{SbIdxL}),$$

$$S_1=(x\text{SbIdxL},y\text{SbIdxL}+(\text{SubHeight}C-1)),$$

$$S_2=(x\text{SbIdxL}+(\text{SubWidth}C-1),y\text{SbIdxL}),\text{ or}$$

$$S_3=(x\text{SbIdxL}+(\text{SubWidth}C-1),y\text{SbIdxL}+(\text{SubHeight}C-1)).$$

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein the second set of luma subblocks (S) comprises two subblocks:

$$S_0=(x\text{SbIdxL},y\text{SbIdxL}),\text{ and}$$

$$S_1=(x\text{SbIdxL}+(\text{SubWidth}C-1),y\text{SbIdxL}+(\text{SubHeight}C-1)).$$

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein deriving a motion vector for the chroma subblock based on the motion vectors of the luma subblocks in the second set S comprises averaging of motion vectors of the luma subblocks in the second set S.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein averaging of motion vectors of the luma subblocks in the second set S comprises following steps:

$$\Sigma_i \text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvAvgLX}=$$

$$\Sigma_i \text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvAvgLX}[0]=(\text{mvAvgLX}[0]+N>>1)>>\log 2(N)$$

$$\Sigma_i \text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvAvgLX}[1]=(\text{mvAvgLX}[1]+N>>1)>>\log 2(N),$$

$\Sigma_i \text{mvLX}[S_i^x][S_i^y]\,S_i^xS_i^y\text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y$ where mvAvgLX is a result of averaging, mvAvgLX[0] is a horizontal component of motion vector mvAvgLX, mvAvgLX[1] is a vertical component of motion vector mvAvgLX, and are horizontal and vertical indices of subblock Si in a motion vector array, is a motion vector of Luma subblock with indices and, N—is a number of elements in the second set of luma subblocks (S), log 2(N) is the power to which the number 2 must be raised to obtain the value N and ">>" is a right arithmetic shift.

In a possible implementation form of the method according to any preceding implementation of the first aspect or the first aspect as such, wherein averaging of motion vectors of the luma subblocks in the second set S comprises following steps:

$$\Sigma_i \text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvAvgLX}=\Sigma_i \text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y \text{ if mvAvgLX[0] is greater or equal to 0 then}$$

$$\Sigma_i \text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvAvgLX}[0]=(\text{mvAvgLX}[0]+N>>1)>>\log 2(N),\text{otherwise,}$$

$$\Sigma_i \text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvLX}[S_i^x][S_i^y]S_i^xS_i^y\text{mvAvgLX}[0]=-((-\text{mvAvgLX}[0]+N>>1)>>\log 2(N))$$

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ if mvAvgLX[1] is greater or equal to 0 then

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1]=(mvAvgLX[1]+N>>1)>>\log 2(N)$,otherwise,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1]=-((-mvAvgLX[1]+N>>1)>>\log 2(N))$,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ where mvAvgLX is a result of averaging, mvAvgLX[0] is a horizontal component of motion vector mvAvgLX, mvAvgLX[1] is a vertical component of motion vector mvAvgLX, and are horizontal and vertical indices of subblock Si in a motion vector array, is a motion vector of Luma subblock with indices and, N—is a number of elements in the second set of luma subblocks (S), log 2(N) is the power to which the number 2 must be raised to obtain the value N and ">>" is a right arithmetic shift.

According to a second aspect of the invention, a method of chroma motion vector derivation used in affine motion compensation of an inter predicted unit, PU comprising co-located luma and chroma blocks is provided, the method comprising:

- obtaining a first set of luma subblocks, wherein the first set of luma subblocks are included in a luma block of a current picture (for example, current coding or decoding picture);
- obtaining a value of a motion vector for each luma subblock in the first set of luma subblocks;
- obtaining a set of chroma subblocks, wherein the set of chroma subblocks are included in a chroma block of the current picture (in an example, the chroma block and the luma block are comprised in same PU); and
- deriving a motion vector for the chroma subblock based on the motion vectors of the luma subblocks in a second set (S) of luma subblocks, wherein for a chroma subblock in the set of chroma subblocks, the second set (S) of luma subblocks (S) is determined from the first set of luma subblocks according to a chroma format of the current picture.

In a possible implementation form of the method according to the second aspect as such, wherein the second set of luma subblocks (S) comprises any combination of the following subblocks:

$S_0=(xSbIdxL,ySbIdxL)$,

$S_1=(xSbIdxL,ySbIdxL+(SubHeightC-1))$,

$S_2=(xSbIdxL+(SubWidthC-1),ySbIdxL)$, or

$S_3=(xSbIdxL+(SubWidthC-1),ySbIdxL+(SubHeightC-1))$.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein the second set of luma subblocks (S) comprises two subblocks:

$S_0=(xSbIdxL,ySbIdxL)$, and

$S_1=(xSbIdxL+(SubWidthC-1),ySbIdxL+(SubHeightC-1))$.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein the deriving a motion vector for the chroma subblock based on the motion vectors of the luma subblocks in the second set S comprises:

- averaging of motion vectors of the luma subblocks in the second set S.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein averaging of motion vectors of the luma subblocks in the second set S comprise:

- averaging of horizontal component of motion vectors of the luma subblocks in the second set S; and/or,
- averaging of vertical component of motion vectors of the luma subblocks in the second set S.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein averaging of elements comprise checking whether the sum of elements (such as mvLX[S-x] $[S_i^y]$ is greater or equal to 0,

- in the case that the sum of elements is greater or equal to 0, the sum of elements is divided by shifting operation depend on the number of elements;
- otherwise the absolute of the sum of elements is divided by shifting operation depend on the number of elements, and negative value is obtained from the shifted result.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein the dividing step by shifting operation comprising:

- rounding towards zero;
- rounding away from zero;
- rounding away from infinity; or
- rounding towards infinity.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein averaging step comprising: averaging or rounding away from zero.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein averaging step comprising averaging or rounding towards zero.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein averaging step comprising averaging or rounding away from infinity.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein averaging step comprising averaging or rounding towards infinity.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein averaging of motion vectors of the luma subblocks in the second set S comprises following steps:

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX=$

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0]=(mvAvgLX[0]+N>>1)>>\log 2(N)$

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1]=(mvAvgLX[1]+N>>1)>>\log 2(N)$,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ where mvAvgLX is a result of averaging, mvAvgLX[0] is a horizontal component of motion vector mvAvgLX, mvAvgLX[1] is a vertical component of motion vector mvAvgLX, and are horizontal and vertical indices of subblock Si in a motion vector array, is a motion vector of Luma subblock with indices and, N—is a number of elements in the second set of luma subblocks (S), log 2(N) is the power to which the number 2 must be raised to obtain the value N and ">>" is a right arithmetic shift.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein averaging of motion vectors of the luma subblocks in the second set S comprises following steps:

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX = \Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ if mvAvgLX[0] is greater or equal to 0 then

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0] = (mvAvgLX[0]+N>>1)>>\log 2(N)$, otherwise,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0] = -((-mvAvgLX[0]+N>1)>>\log 2(N))$

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ if mvAvgLX[1] is greater or equal to 0 then

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1] = (mvAvgLX[1]+N>>1)>>\log 2(N)$, otherwise,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1] = -((-mvAvgLX[1]+N>1)>>\log 2(N))$,

$\Sigma_i mvLX[S_i^x][S_i^y]\ S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ where mvAvgLX is a result of averaging, mvAvgLX[0] is a horizontal component of motion vector mvAvgLX, mvAvgLX[1] is a vertical component of motion vector mvAvgLX, and are horizontal and vertical indices of subblock Si in a motion vector array, is a motion vector of Luma subblock with indices and, N—is a number of elements in the second set of luma subblocks (S), log 2(N) is the power to which the number 2 must be raised to obtain the value N and ">>" is a right arithmetic shift.

In a possible implementation form of the method according to any preceding implementation of the second aspect or the second aspect as such, wherein averaging of motion vectors of the luma subblocks in the second set S comprises following steps:

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX = \Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ if mvAvgLX[0] is greater or equal to 0 then

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0] = (mvAvgLX[0]+(N>>1)-1)>>\log 2(N)$, otherwise,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0] = -((-mvAvgLX[0]+(N>>1)-1)>>\log 2(N))$

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ if mvAvgLX[1] is greater or equal to 0 then

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1] = (mvAvgLX[1]+(N>>1)-1)>>\log 2(N)$, otherwise,

$Z\ mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1] = -((-mvAvgLX[1]+(N>>1)-1)>>\log 2(N))$,

$\Sigma_i mvLX[S_i^x][S_i^y]\ S_i^xS_i^y mvLX[S_i^x][S_i^y]\ S_i^xS_i^y$ where mvAvgLX is a result of averaging, mvAvgLX[0] is a horizontal component of motion vector mvAvgLX, mvAvgLX [1] is a vertical component of motion vector mvAvgLX, and are horizontal and vertical indices of subblock Si in a motion vector array, is a motion vector of Luma subblock with indices and, N—is a number of elements in the second set of luma subblocks (S), log 2(N) is the power to which the number 2 is raised to obtain the value N and ">>" is a right arithmetic shift.

According to a third aspect of the invention, a method for affine motion compensation of a current picture is provided, the method comprises:

splitting the luma block of the current picture into a set of equally sized luma subblocks, and

splitting the chroma block of the current picture into a set of equally sized chroma subblocks, wherein a size of a chroma subblock is set equal to a size of a luma sublock.

In a possible implementation form of the method according to the third aspect as such, wherein the method further comprises:

determining the number of chroma subblocks in horizontal and vertical directions based on values of chroma scaling factors.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the chroma scaling factors in horizontal and vertical directions (SubWidthC and SubHeightC) are determined based on a chroma format of a current picture (for example, current coding or decoding picture).

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein

numCSbX=numSbX>>(SubWidth$C$−1) and

numCSbY=numSbY>>(SubHeight$C$−1);

numCSbX and numCSbY represent the number of chroma subblocks in horizontal and vertical directions, respectively.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the splitting the chroma block of the current picture comprises:

splitting the chroma block of the current picture (in an example, the chroma block and the luma block are comprised in same PU) into numCSbY rows, each row having numCSbX of chroma subblocks.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the method further comprises:

for each of chroma subblocks, determine a set of luma subblocks (S), wherein the positions of luma subblocks in the set are determined by the chroma format of the current picture; and

deriving a motion vector for the chroma subblock based on the motion vectors of the luma subblocks in the set S.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the motion vector is defined for each of the luma subblocks belonging to the set S.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the set of luma subblocks (S) comprises any combination of following subblocks:

S_0=(xSbIdxL,ySbIdxL),

S_1=(xSbIdxL,ySbIdxL+(SubHeight$C$−1)),

S_2=(xSbIdxL+(SubWidth$C$−1),ySbIdxL), or

S_3=(xSbIdxL+(SubWidth$C$−1),ySbIdxL+(SubHeight$C$−1)).

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the set of luma subblocks (S) comprises two subblocks:

$S_0=(x\text{SbIdxL}, y\text{SbIdxL})$, and

$S_1=(x\text{SbIdxL}+(\text{SubWidth}C-1), y\text{SbIdxL}+(\text{SubHeight}C-1))$.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein deriving a motion vector for the chroma subblock based on the motion vectors of the luma subblocks in the set S comprises averaging of motion vectors of the luma subblocks in the set S.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein averaging of motion vectors of the luma subblocks in the set S comprise:

averaging of horizontal component of motion vectors of the luma subblocks in the set S

averaging of vertical component of motion vectors of the luma subblocks in the set S.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein averaging of elements comprise checking whether sum of elements is greater or equal to 0.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein averaging means averaging away from zero.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein averaging means averaging towards zero.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein averaging means averaging away from infinity.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein averaging means averaging towards infinity.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein averaging of motion vectors of the luma subblocks in the set S comprises following steps:

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX=$,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0]=(mvAvgLX[0]+N>>1)>\log 2(N)$, and

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1]=(mvAvgLX[1]+N>>1)>\log 2(N)$,

$\Sigma_i mvLX[S_i^x][S_i^y]\ S_i^x S_i^y mvLX[S_i^x][S_i^y]S_i^x S_i^y$ where mvAvgLX is a result of averaging, mvAvgLX[0] is a horizontal component of motion vector mvAvgLX, mvAvgLX[1] is a vertical component of motion vector mvAvgLX, and are horizontal and vertical indices of subblock Si in a motion vector array, is a motion vector of Luma subblock with indices and, N—is a number of elements in the second set of luma subblocks (S), log 2(N) is the power to which the number 2 must be raised to obtain the value N and ">>" is a right arithmetic shift.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein averaging of motion vectors of the luma subblocks in the set S comprises following steps:

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]\ S_i^xS_i^y mvAvgLX=\Sigma_i>mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ if mvAvgLX[0] is greater or equal to 0 then

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0]=(mvAvgLX[0]+N>>1)>>\log 2(N)$,otherwise,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0]=-((-mvAvgLX[0]+N>1)>>\log 2(N))$

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ if mvAvgLX[1] is greater or equal to 0 then

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1]=(mvAvgLX[1]+N>>1)>>\log 2(N)$,otherwise,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]\ S_i^xS_i^y mvAvgLX[1]=-((-mvAvgLX[1]+N>1)>>\log 2(N))$,

$\Sigma_i mvLX[S_i^x][S_i^y]\ S_i^x\ S_i^y mvLX[S_i^x][S_i^y]\ S_i^xS_i^y$ where mvAvgLX is a result of averaging, mvAvgLX[0] is a horizontal component of motion vector mvAvgLX, mvAvgLX[1] is a vertical component of motion vector mvAvgLX, and are horizontal and vertical indices of subblock Si in a motion vector array, is a motion vector of Luma subblock with indices and, N—is a number of elements in the second set of luma subblocks (S), log 2(N) is the power to which the number 2 must be raised to obtain the value N and ">>" is a right arithmetic shift.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein averaging of motion vectors of the luma subblocks in the set S comprises following steps:

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]\ S_i^xS_i^y mvAvgLX=\Sigma_i>mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ if mvAvgLX[0] is greater or equal to 0 then

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0]=(mvAvgLX[0]+(N>>1)-1)>>\log 2(N)$,otherwise,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[0]=-((-mvAvgLX[0]+(N>>1)-1)>>\log 2(N))$

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y$ if mvAvgLX[1] is greater or equal to 0 then

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1]=(mvAvgLX[1]+(N>>1)-1)>>\log 2(N)$,otherwise,

$\Sigma_i mvLX[S_i^x][S_i^y]S_i^xS_i^y mvLX[S_i^x][S_i^y]S_i^xS_i^y mvAvgLX[1]=-((-mvAvgLX[1]+(N>>1)-1)>>\log 2(N))$,

$\Sigma_i mvLX[S_i^x][S_i^y]\ S_i^x\ S_i^y mvLX[S_i^x][S_i^y]S_i^x S_i^y$ where mvAvgLX is a result of averaging, mvAvgLX[0] is a horizontal component of motion vector mvAvgLX, mvAvgLX[1] is a vertical component of motion vector mvAvgLX, and are horizontal and vertical indices of subblock Si in a motion vector array, is a motion vector of Luma subblock with indices and, N—is a number of elements in the second set of luma subblocks (S), log 2(N) is the power to which the number 2 must be raised to obtain the value N and ">>" is a right arithmetic shift.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein N is equal to 1.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the set S is determined on the basis of the value of sps_cclm_colocated_chroma_flag.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the average motion vector derivation is performed on the basis of the value of sps_cclm_colocated_chroma_flag.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the chroma format is defined as YUV 4:2:2.

In a possible implementation form of the method according to any preceding implementation of the third aspect or the third aspect as such, wherein the chroma block and the luma block are comprised in same PU, and the luma and chroma blocks are co-located.

A fourth aspect of an encoder (**20**) comprises processing circuitry for carrying out the method according to any one of the first to third aspects.

A fifth aspect of a decoder (**30**) comprises processing circuitry for carrying out the method according to any one of the first to third aspects.

An sixth aspect of a computer program product comprises a program code for performing the method according to any one of the first to third aspects.

An seventh aspect of a decoder, comprising:

one or more processors; and a non-transitory computer-readable storage medium coupled to the processors and storing program for execution by the processors, wherein the program, when executed by the processors, configures the decoder to carry out the method according to any one of the first to third aspects.

A eighth aspect of an encoder, comprises:

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

Based on the above, the present disclosure is directed to discloses a method to consider the chroma format of the picture when obtaining chroma motion vectors from luma motion vectors. By taking an average of luma motion vectors, linear subsampling of luma motion field is performed. When chroma color planes have the same height as the luma plane, it is found more appropriate to select motion vectors from luma blocks that are horizontally adjacent, so that they have the same vertical position. Selecting luma motion vectors depending on the picture chroma format leads to a more accurate chroma motion field due to a more accurate luma motion vector field subsampling. This dependency on chroma format enables the selection of the most appropriate luma blocks when averaging luma motion vectors to generate the chroma motion vector. As a consequence of a more accurate motion field interpolation, prediction error is reduced, which leads to a technical result of a compression performance improvement.

Following is an explanation of the applications of the encoding method as well as the decoding method as shown in the above-mentioned embodiments, and a system using them.

FIG. **18** is a block diagram showing a content supply system **3100** for realizing content distribution service. This content supply system **3100** includes capture device **3102**, terminal device **3106**, and optionally includes display **3126**. The capture device **3102** communicates with the terminal device **3106** over communication link **3104**. The communication link may include the communication channel **13** described above. The communication link **3104** includes but not limited to WIFI, Ethernet, Cable, wireless (3G/4G/5G), USB, or any kind of combination thereof, or the like.

The capture device **3102** generates data, and may encode the data by the encoding method as shown in the above embodiments. Alternatively, the capture device **3102** may distribute the data to a streaming server (not shown in the Figures), and the server encodes the data and transmits the encoded data to the terminal device **3106**. The capture device **3102** includes but not limited to camera, smart phone or Pad, computer or laptop, video conference system, PDA, vehicle mounted device, or a combination of any of them, or the like. For example, the capture device **3102** may include the source device **12** as described above. When the data includes video, the video encoder **20** included in the capture device **3102** may actually perform video encoding processing. When the data includes audio (i.e., voice), an audio encoder included in the capture device **3102** may actually perform audio encoding processing. For some practical scenarios, the capture device **3102** distributes the encoded video and audio data by multiplexing them together. For other practical scenarios, for example in the video conference system, the encoded audio data and the encoded video data are not multiplexed. Capture device **3102** distributes the encoded audio data and the encoded video data to the terminal device **3106** separately.

In the content supply system **3100**, the terminal device **3106** receives and reproduces the encoded data. The terminal device **3106** could be a device with data receiving and recovering capability, such as smart phone or Pad **3108**, computer or laptop **3110**, network video recorder (NVR)/digital video recorder (DVR) **3112**, TV **3114**, set top box (STB) **3116**, video conference system **3118**, video surveillance system **3120**, personal digital assistant (PDA) **3122**, vehicle mounted device **3124**, or a combination of any of them, or the like capable of decoding the above-mentioned encoded data. For example, the terminal device **3106** may include the destination device **14** as described above. When the encoded data includes video, the video decoder **30** included in the terminal device is prioritized to perform video decoding. When the encoded data includes audio, an audio decoder included in the terminal device is prioritized to perform audio decoding processing.

For a terminal device with its display, for example, smart phone or Pad **3108**, computer or laptop **3110**, network video recorder (NVR)/digital video recorder (DVR) **3112**, TV **3114**, personal digital assistant (PDA) **3122**, or vehicle mounted device **3124**, the terminal device can feed the decoded data to its display. For a terminal device equipped with no display, for example, STB **3116**, video conference system **3118**, or video surveillance system **3120**, an external display **3126** is contacted therein to receive and show the decoded data.

When each device in this system performs encoding or decoding, the picture encoding device or the picture decoding device, as shown in the above-mentioned embodiments, can be used.

FIG. **19** is a diagram showing a structure of an example of the terminal device **3106**. After the terminal device **3106** receives stream from the capture device **3102**, the protocol

proceeding unit **3202** analyzes the transmission protocol of the stream. The protocol includes but not limited to Real Time Streaming Protocol (RTSP), Hyper Text Transfer Protocol (HTTP), HTTP Live streaming protocol (HLS), MPEG-DASH, Real-time Transport protocol (RTP), Real Time Messaging Protocol (RTMP), or any kind of combination thereof, or the like.

After the protocol proceeding unit **3202** processes the stream, stream file is generated. The file is outputted to a demultiplexing unit **3204**. The demultiplexing unit **3204** can separate the multiplexed data into the encoded audio data and the encoded video data. As described above, for some practical scenarios, for example in the video conference system, the encoded audio data and the encoded video data are not multiplexed. In this situation, the encoded data is transmitted to video decoder **3206** and audio decoder **3208** without through the demultiplexing unit **3204**.

Via the demultiplexing processing, video elementary stream (ES), audio ES, and optionally subtitle are generated. The video decoder **3206**, which includes the video decoder **30** as explained in the above mentioned embodiments, decodes the video ES by the decoding method as shown in the above-mentioned embodiments to generate video frame, and feeds this data to the synchronous unit **3212**. The audio decoder **3208**, decodes the audio ES to generate audio frame, and feeds this data to the synchronous unit **3212**. Alternatively, the video frame may store in a buffer (not shown in FIG. **19**) before feeding it to the synchronous unit **3212**. Similarly, the audio frame may store in a buffer (not shown in FIG. **19**) before feeding it to the synchronous unit **3212**.

The synchronous unit **3212** synchronizes the video frame and the audio frame, and supplies the video/audio to a video/audio display **3214**. For example, the synchronous unit **3212** synchronizes the presentation of the video and audio information. Information may code in the syntax using time stamps concerning the presentation of coded audio and visual data and time stamps concerning the delivery of the data stream itself.

If subtitle is included in the stream, the subtitle decoder **3210** decodes the subtitle, and synchronizes it with the video frame and the audio frame, and supplies the video/audio/subtitle to a video/audio/subtitle display **3216**.

The present invention is not limited to the above-mentioned system, and either the picture encoding device or the picture decoding device in the above-mentioned embodiments can be incorporated into other system, for example, a car system.

Mathematical Operators

The mathematical operators used in this application are similar to those used in the C programming language. However, the results of integer division and arithmetic shift operations are defined more precisely, and additional operations are defined, such as exponentiation and real-valued division. Numbering and counting conventions generally begin from 0, e.g., "the first" is equivalent to the 0-th, "the second" is equivalent to the 1-th, etc.

Arithmetic Operators

The following arithmetic operators are defined as follows:

+ Addition

− Subtraction (as a two-argument operator) or negation (as a unary prefix operator)

* Multiplication, including matrix multiplication

x^y Exponentiation. Specifies x to the power of y. In other contexts, such notation is used for superscripting not intended for interpretation as exponentiation.

/ Integer division with truncation of the result toward zero. For example, 7/4 and −7/−4 are truncated to 1 and −7/4 and 7/−4 are truncated to −1.

÷ Used to denote division in mathematical equations where no truncation or rounding is intended.

$$\frac{x}{y}$$

Used to denote division in mathematical equations where no truncation or rounding is intended.

$$\sum_{i=x}^{y} f(i)$$

The summation of f(i) with i taking all integer values from x up to and including y.

Modulus. Remainder of x divided by y, defined only for integers x and y with x>=0 x % y and y>0.

Logical Operators

The following logical operators are defined as follows:

x && y Boolean logical "and" of x and y

x||y Boolean logical "or" of x and y

! Boolean logical "not"

x? y: z If x is TRUE or not equal to 0, evaluates to the value of y; otherwise, evaluates to the value of z.

Relational Operators

The following relational operators are defined as follows:

>Greater than

>=Greater than or equal to

<Less than

<=Less than or equal to

==Equal to

!=Not equal to

When a relational operator is applied to a syntax element or variable that has been assigned the value "na" (not applicable), the value "na" is treated as a distinct value for the syntax element or variable. The value "na" is considered not to be equal to any other value.

Bit-Wise Operators

The following bit-wise operators are defined as follows:

& Bit-wise "and". When operating on integer arguments, operates on a two's complement representation of the integer value. When operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0.

| Bit-wise "or". When operating on integer arguments, operates on a two's complement representation of the integer value. When operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0.

^ Bit-wise "exclusive or". When operating on integer arguments, operates on a two's complement representation of the integer value. When operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0.

x>>y Arithmetic right shift of a two's complement integer representation of x by y binary digits. This function is defined only for non-negative integer values of y. Bits shifted into the most significant bits (MSBs) as a result

of the right shift have a value equal to the MSB of x prior to the shift operation.

x<<y Arithmetic left shift of a two's complement integer representation of x by y binary digits. This function is defined only for non-negative integer values of y. Bits shifted into the least significant bits (LSBs) as a result of the left shift have a value equal to 0.

Assignment Operators

The following arithmetic operators are defined as follows:

= Assignment operator

++ Increment, i.e., x++ is equivalent to x=x+1; when used in an array index, evaluates to the value of the variable prior to the increment operation.

— Decrement, i.e., x— is equivalent to x=x−1; when used in an array index, evaluates to the value of the variable prior to the decrement operation.

+= Increment by amount specified, i.e., x+=3 is equivalent to x=x+3, and x+=(−3) is equivalent to x=x+(−3).

−= Decrement by amount specified, i.e., x−=3 is equivalent to x=x−3, and x−=(−3) is equivalent to x=x−(−3).

Range Notation

The following notation is used to specify a range of values:

x=y . . . z, x takes on integer values starting from y to z, inclusive, with x, y, and z being integer numbers and z being greater than y.

Mathematical Functions

The following mathematical functions are defined:

$$\mathrm{Abs}(x) = \begin{cases} x; & x >= 0 \\ -x; & x < 0 \end{cases}$$

A sin(x) the trigonometric inverse sine function, operating on an argument x that is in the range of −1.0 to 1.0, inclusive, with an output value in the range of −π÷2 to π÷2, inclusive, in units of radians

A tan(x) the trigonometric inverse tangent function, operating on an argument x, with an output value in the range of −π÷2 to π÷2, inclusive, in units of radians

$$Atan2(y, x) = \begin{cases} \mathrm{Atan}\left(\frac{y}{x}\right); & x > 0 \\ \mathrm{Atan}\left(\frac{y}{x}\right) + \pi; & x < 0 \,\&\&\, y >= 0 \\ \mathrm{Atan}\left(\frac{y}{x}\right) - \pi; & x < 0 \,\&\&\, y < 0 \\ +\frac{\pi}{2}; & x == 0 \,\&\&\, y >= 0 \\ -\frac{\pi}{2}; & \text{otherwise} \end{cases}$$

Ceil(x) the smallest integer greater than or equal to x.

$\mathrm{Clip1}_Y(x)=\mathrm{Clip3}(0, (1<<\mathrm{BitDepth}_Y)-1, x)$

$\mathrm{Clip1}_C(x)=\mathrm{Clip3}(0, (1<<\mathrm{BitDepth}_C)-1, x)$

$$\mathrm{Clip3}(x, y, z) = \begin{cases} x; & z < x \\ y; & z > y \\ z; & \text{otherwise} \end{cases}$$

Cos(x) the trigonometric cosine function operating on an argument x in units of radians.

Floor(x) the largest integer less than or equal to x.

$$GetCurrMsb(a, b, c, d) = \begin{cases} c + d; & b - a >= d/2 \\ c - d; & a - b > d/2 \\ c; & \text{otherwise} \end{cases}$$

Ln(x) the natural logarithm of x (the base-e logarithm, where e is the natural logarithm base constant 2.718 281 828 . . .).

Log 2(x) the base-2 logarithm of x.

Log 10(x) the base-10 logarithm of x.

$$\mathrm{Min}(x, y) = \begin{cases} x; & x <= y \\ y; & x > y \end{cases}$$

$$\mathrm{Max}(x, y) = \begin{cases} x; & x >= y \\ y; & x < y \end{cases}$$

$$\mathrm{Round}(x) = \mathrm{Sign}(x) * \mathrm{Floor}(\mathrm{Abs}(x) + 0.5)$$

$$\mathrm{Sign}(x) = \begin{cases} 1; & x > 0 \\ 0; & x == 0 \\ -1; & x < 0 \end{cases}$$

Sin(x) the trigonometric sine function operating on an argument x in units of radians

Sqrt(x)=$\sqrt{x}$

Swap(x, y)=(y, x)

Tan(x) the trigonometric tangent function operating on an argument x in units of radians

Order of Operation Precedence

When an order of precedence in an expression is not indicated explicitly by use of parentheses, the following rules apply:

Operations of a higher precedence are evaluated before any operation of a lower precedence.

Operations of the same precedence are evaluated sequentially from left to right.

The table below specifies the precedence of operations from highest to lowest; a higher position in the table indicates a higher precedence.

For those operators that are also used in the C programming language, the order of precedence used in this Specification is the same as used in the C programming language.

TABLE

Operation precedence from highest (at top of table) to lowest (at bottom of table)
operations (with operands x, y, and z)
"x++", "x− −"
"!x", "−x" (as a unary prefix operator)
x^y
"x * y", "x / y", "x ÷ y", "$\frac{x}{y}$", "x % y"
"x + y", "x − y" (as a two-argument operator), "$\sum_{i=x}^{y} f(i)$"
"x << y", "x >> y"
"x < y", "x <= y", "x > y", "x >= y"
"x = = y", "x != y"
"x & y"
"x | y"
"x && y"
"x | | y"
"x ? y : z"
"x . . . y"
"x = y", "x += y", "x −= y"

Text Description of Logical Operations

In the text, a statement of logical operations as would be described mathematically in the following form:

```
if( condition 0 )
   statement 0
else if( condition 1 )
   statement 1
...
else /* informative remark on remaining condition */
   statement n
may be described in the following manner:
      ... as follows / ... the following applies:
      – If condition 0, statement 0
      – Otherwise, if condition 1, statement 1
      – ...
      – Otherwise (informative remark on remaining condition),
      statement n
```

Each "If . . . Otherwise, if . . . Otherwise, . . . "statement in the text is introduced with" . . . as follows" or " . . . the following applies" immediately followed by "If . . . ". The last condition of the "If . . . Otherwise, if . . . Otherwise, . . . " is always an "Otherwise, . . . ". Interleaved "If . . . Otherwise, if . . . Otherwise, . . . "statements can be identified by matching" . . . as follows" or " . . . the following applies" with the ending "Otherwise . . . ".

In the text, a statement of logical operations as would be described mathematically in the following form:

```
if( condition 0a && condition 0b )
   statement 0
else if( condition 1a | | condition 1b )
   statement 1
...
else
   statement n
```

may be described in the following manner:

. . . as follows/ . . . the following applies:

If all of the following conditions are true, statement 0:

condition 0a

condition 0b

Otherwise, if one or more of the following conditions are true, statement 1:

condition 1a

condition 1b

. . .

Otherwise, statement n

In the text, a statement of logical operations as would be described mathematically in the following form:

```
if( condition 0)
   statement 0
if( condition 1)
   statement 1
```

may be described in the following manner:

When condition 0, statement 0

When condition 1, statement 1

The invention has been described in conjunction with various embodiments herein. However, other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in usually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. A computer program may be stored/distributed on a suitable medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the internet or other wired or wireless communication systems.

The person skilled in the art will understand that the "blocks" ("units") of the various figures (method and apparatus) represent or describe functionalities of embodiments of the invention (rather than necessarily individual "units" in hardware or software) and thus describe equally functions or features of apparatus embodiments as well as method embodiments (unit=step).

The terminology of "units" is merely used for illustrative purposes of the functionality of embodiments of the encoder/decoder and are not intended to limiting the disclosure.

In the several embodiments provided in the present application, it should be understood that the disclosed system, apparatus, and method may be implemented in other manners. For example, the described apparatus embodiment is merely exemplary. For example, the unit division is merely logical function division and may be other division in actual implementation. For example, a plurality of units or components may be combined or integrated into another system, or some features may be ignored or not performed. In addition, the displayed or discussed mutual couplings or direct couplings or communication connections may be implemented by using some interfaces. The indirect couplings or communication connections between the apparatuses or units may be implemented in electronic, mechanical, or other forms.

The units described as separate parts may or may not be physically separate, and parts displayed as units may or may not be physical units, may be located in one position, or may be distributed on a plurality of network units. Some or all of the units may be selected according to actual needs to achieve the objectives of the solutions of the embodiments.

In addition, functional units in the embodiments of the present invention may be integrated into one processing unit, or each of the units may exist alone physically, or two or more units are integrated into one unit.

Embodiments of the invention may further comprise an apparatus, e.g. encoder and/or decoder, which comprises a processing circuitry configured to perform any of the methods and/or processes described herein.

Although embodiments of the invention have been primarily described based on video coding, it should be noted that embodiments of the coding system **10**, encoder **20** and decoder **30** (and correspondingly the system **10**) and the other embodiments described herein may also be configured for still picture processing or coding, i.e. the processing or coding of an individual picture independent of any preceding or consecutive picture as in video coding. In general only inter-prediction units **244** (encoder) and **344** (decoder) may not be available in case the picture processing coding is limited to a single picture **17**. All other functionalities (also referred to as tools or technologies) of the video encoder **20** and video decoder **30** may equally be used for still picture processing, e.g. residual calculation **204/304**, transform processing unit **206**, quantization **208**, inverse quantization **210/310**, (inverse) transform **212/312**, partitioning **262/362**,

intra-prediction **254**/**354**, and/or loop filtering **220**, **320**, and entropy coding **270** and entropy decoding unit **304**.

Embodiments, e.g. of the encoder **20** and the decoder **30**, and functions described herein, e.g. with reference to the encoder **20** and the decoder **30**, may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on a computer-readable medium or transmitted over communication media as one or more instructions or code and executed by a hardware-based processing unit. Computer-readable media may include computer-readable storage media, which corresponds to a tangible medium such as data storage media, or communication media including any medium that facilitates transfer of a computer program from one place to another, e.g., according to a communication protocol. In this manner, computer-readable media generally may correspond to (1) tangible computer-readable storage media which is non-transitory or (2) a communication medium such as a signal or carrier wave. Data storage media may be any available media that can be accessed by one or more computers or one or more processors to retrieve instructions, code and/or data structures for implementation of the techniques described in this disclosure. A computer program product may include a computer-readable medium.

By way of example, and not limiting, such computer-readable storage media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage, or other magnetic storage devices, flash memory, or any other medium that can be used to store desired program code in the form of instructions or data structures and that can be accessed by a computer. Also, any connection is properly termed a computer-readable medium. For example, if instructions are transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. It should be understood, however, that computer-readable storage media and data storage media do not include connections, carrier waves, signals, or other transitory media, but are instead directed to non-transitory, tangible storage media. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc, where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

Instructions may be executed by one or more processors, such as one or more digital signal processors (DSPs), general purpose microprocessors, application specific integrated circuits (ASICs), field programmable logic arrays (FPGAs), or other equivalent integrated or discrete logic circuitry. Accordingly, the term "processor," as used herein may refer to any of the foregoing structure or any other structure suitable for implementation of the techniques described herein. In addition, in some aspects, the functionality described herein may be provided within dedicated hardware and/or software modules configured for encoding and decoding, or incorporated in a combined codec. Also, the techniques could be fully implemented in one or more circuits or logic elements.

The techniques of this disclosure may be implemented in a wide variety of devices or apparatuses, including a wireless handset, an integrated circuit (IC) or a set of ICs (e.g., a chip set). Various components, modules, or units are described in this disclosure to emphasize functional aspects of devices configured to perform the disclosed techniques, but do not necessarily require realization by different hardware units. Rather, as described above, various units may be combined in a codec hardware unit or provided by a collection of interoperative hardware units, including one or more processors as described above, in conjunction with suitable software and/or firmware.

The invention claimed is:

1. An image encoding method, comprising:

performing an image encoding process for an image block coded in an inter prediction mode, to output an encoded bitstream, wherein the image block comprises a luma block and a co-located chroma block, and wherein the performing the image encoding process comprises a chroma motion vector derivation process, comprising:

obtaining an averaged luma motion vector mvAvgLX by:

determining chroma scaling factors in horizontal and vertical directions based on chroma format information indicating a chroma format of a current picture which the image block belongs to, wherein the chroma format comprises one of a YUV 4:2:2 format, a YUV 4:2:0 format or a YUV 4:4:4 format;

determining a set (S) of luma subblocks of the luma block based on values of the chroma scaling factors; and

generating the averaged luma motion vector mvAvgLX by averaging motion vectors of the luma subblocks in the set (S), in a case that more than one luma subblocks in the set (S);

deriving a chroma motion vector for a chroma subblock mvCLX[xSbIdx][ySbIdx] of the chroma block based on the averaged luma motion vector mvAvgLX; wherein a process of deriving the chroma motion vector is invoked as follows with the mvAvgLX as input, and the chroma motion vector mvCLX[xSbIdx][ySbIdx] as output:

mvCLX[0]=mvLX[0]*2/SubWidth*C*

mvCLX[1]=mvLX[1]*2/SubHeight*C*–, if a reference picture corresponding to refIdxLX for the image block is not a current picture; or

mvCLX[0]=((mvLX[0]>>(3+SubWidth*C*))*32

mvCLX[1]=((mvLX[1]>>(3+SubHeight*C*))*32, if the reference picture corresponding to the refIdxLX for the image block is the current picture,

wherein mvLX[0] corresponds to a horizontal component of the mvAvgLX, and mvLX[1] corresponds to a vertical component of the mvAvgLX,

wherein when both SubWidthC and SubHeightC are equal to 1, the set of luma subblocks (S) is a luma subblock indexed by S_0=(xSbIdx, ySbIdx);

when at least one of SubWidthC and SubHeightC is not equal to 1, the set of luma subblocks (S) is: a first luma subblock indexed by S_0=

((*x*SbIdx>>(SubWidth*C*−1)<<(SubWidth*C*−1)),

(*y*SbIdx>>(SubHeight*C*−1)<<(SubHeight*C*−1))), and a second luma subblock indexed by

S_1=((*x*SbIdx>>(SubWidth*C*−1)<<(SubWidth*C*−1))+(SubWidth*C*−1),(*y*SbIdx>>(SubHeight*C*−1)<<(SubHeight*C*−1))+(SubHeight*C*−1))

wherein SubWidthC and SubHeightC represent the chroma scaling factors in horizontal and vertical directions, respectively;

xSbIdx and ySbIdx represent a subblock index in the horizontal direction and a subblock index in the vertical direction, respectively, for a luma subblock in the set (S);

"<<" represents a left arithmetic shift;

">>" represents a right arithmetic shift;

xSbIdx is an integer number ranging from 0 to numSbX−1 and ySbIdx is an integer ranging from 0 to numSbY−1;

numSbX indicates the number of luma subblocks in the luma block along the horizontal direction; and

numSbY indicates the number of luma subblocks in the luma block along the vertical direction.

2. The method of claim **1**, wherein each of the one or more luma subblocks in the set (S) is represented by a subblock index in a horizontal direction and a subblock index in a vertical direction.

3. The method of claim **1**, wherein the number of the chroma subblocks in the chroma block along the horizontal direction and the vertical direction are the same as the number of the luma subblocks in the luma block along the horizontal and vertical directions, respectively.

4. The method of claim **1**,

wherein when the chroma format is 4:4:4, the set (S) is one luma subblock co-located with the chroma subblock;

wherein when the chroma format is 4:2:2, the set (S) is two luma subblocks horizontally adjacent to each other;

wherein when the chroma format is 4:2:0, the set (S) is two luma subblocks which are diagonal.

5. The method of claim **1**, wherein the averaging motion vectors of the luma subblocks in the set (S) comprise one or more of:

averaging horizontal component of the motion vectors of the luma subblocks in the set (S); or

averaging vertical component of the motion vectors of the luma subblocks in the set (S).

6. The method of claim **1**, wherein the generating an averaged luma motion vector by averaging motion vectors of the luma subblocks in the set (S) comprises calculating the averaged luma motion vector based on an equation:

$$mvAvgLX=\Sigma_i\, mvLX[S_i^x][S_i^y]$$

when mvAvgLX[0] is greater or equal to 0,mvAvgLX[0](mvAvgLX[0]+(N>>1)−1)>>log 2(N), otherwise,

$$mvAvgLX[0]=-((-mvAvgLX[0]+(N>>1)-1)>>\log 2(N));$$

when mvAvgLX[1] is greater or equal to 0,mvAvgLX[1](mvAvgLX[1]+(N>>1)−1)>>log 2(N), otherwise,

$$mvAvgLX[1]-((-mvAvgLX[1]+(N>>1)-1)>>\log 2(N)),$$

wherein:

mvAvgLX is a resulting motion vector of the averaging;

S_i^x and S_i^y are horizontal and vertical indices of subblock Si in the set of luma subblocks (S) in motion vector array,

$mvLX[S_i^x][S_i^y]$ is a motion vector of a luma subblock with indices S_i^x and S_i^y, N is a number of elements in the set (S) of luma subblocks, log 2(N) represents the logarithm of N to the base 2 and is the power to which the number 2 is raised to obtain the value N.

7. The method of claim **1**, wherein the averaging of motion vectors of the luma subblocks in the set (S) comprises:

mvAvgLX=mvLX[(xSbIdx>>(SubWidthC−1)<<(SubWidthC−1))][(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))]+mvLX[(xSbIdx>>(SubWidthC−1)<<(SubWidthC−1))+(SubWidthC−1)][(ySbIdx>>(SubHeightC−1)<<(SubHeightC−1))+(SubHeightC−1)]

if mvAvgLX[0]>=0 then

mvAvgLX[0]=(mvAvgLX[0]+1−(mvAvgLX[0]>=0))>>1

if mvAvgLX[1]>=0 then

mvAvgLX[1]=(mvAvgLX[1]+1−(mvAvgLX[1]>=0))>>1.

8. The method of claim **1**, wherein the determining chroma scaling factors in horizontal and vertical directions respectively based on chroma format information comprises: determining the chroma scaling factors in the horizontal and vertical directions based on a mapping between the chroma format information and a pair of chroma scaling factors in the horizontal and vertical directions respectively.

9. The method of claim **1**, wherein the performing the image encoding process further comprises:

generating a prediction of the chroma subblock based on the determined chroma motion vector;

obtaining a residual of the chroma subblock according to a prediction of the chroma subblock, wherein a residual of the image block comprises the residual of the chroma subblock of the chroma block; and

performing transformation, quantization, and entropy coding on the residual of the image block, to output the encoded bitstream.

10. The method of claim **1**, wherein the image block is coded in an affine based inter prediction mode.

11. An encoding apparatus, comprising:

a video data memory; and

a video encoder configured to:

perform an image encoding process for an image block coded in an inter prediction mode, to output an encoded bitstream, wherein the image block comprises a luma block and a co-located chroma block, and wherein the performing the image encoding process comprises a chroma motion vector derivation process, comprising:

obtaining an averaged luma motion vector mvAvgLX by:

determining chroma scaling factors in horizontal and vertical directions based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the image block belongs to, wherein the chroma format comprises one of a YUV 4:2:2 format, a YUV 4:2:0 format or a YUV 4:4:4 format;

determining a set (S) of luma subblocks of the luma block based on values of the chroma scaling factors; and

generating the averaged luma motion vector mvAvgLX by averaging motion vectors of the luma subblocks in the set (S), in a case that more than one luma subblocks in the set (S); and

deriving a chroma motion vector for a chroma subblock mvCLX[xSbIdx][ySbIdx] of the chroma block based on the averaged luma motion vector mvAvgLX;

wherein a process of deriving the chroma motion vector is invoked as follows with the mvAvgLX as input, and the chroma motion vector mvCLX[xSbIdx][ySbIdx] as output:

mvCLX[0]=mvLX[0]*2/SubWidth*C*

mvCLX[1]=mvLX[1]*2/SubHeight*C*, if a reference picture corresponding to refIdxLX for the image block is not a current picture; or

mvCLX[0]=((mvLX[0]>>(3+SubWidth*C*))*32

mvCLX[1]=((mvLX[1]>>(3+SubHeight*C*))*32, if the reference picture corresponding to the refIdxLX for the image block is the current picture,

wherein mvLX[0] corresponds to a horizontal component of the mvAvgLX, and mvLX[1] corresponds to a vertical component of the mvAvgLX,

wherein when both SubWidthC and SubHeightC are equal to 1, the set of luma subblocks (S) is a luma subblock indexed by S_0=(xSbIdx, ySbIdx);

when at least one of SubWidthC and SubHeightC is not equal to 1, the set of luma subblocks (S) is: a first luma subblock indexed by S_0=

((*x*SbIdx>>(SubWidth*C*−1)<<(SubWidth*C*−1)),

(*y*SbIdx>>(SubHeight*C*−1)<<(SubHeight*C*−1))), and a second luma subblock indexed by

S_1=((*x*SbIdx>>(SubWidth*C*−1)<<(SubWidth*C*−1))+(SubWidth*C*−1),(*y*SbIdx>>(SubHeight*C*−1)<<(SubHeight*C*−1))+(SubHeight*C*−1))

wherein SubWidthC and SubHeightC represent the chroma scaling factors in horizontal and vertical directions, respectively;

xSbIdx and ySbIdx represent a subblock index in the horizontal direction and a subblock index in the vertical direction, respectively, for a luma subblock in the set (S);

"<<" represents a left arithmetic shift;

">>" represents a right arithmetic shift;

xSbIdx is an integer number ranging from 0 to numSbX−1 and ySbIdx is an integer ranging from 0 to numSbY−1;

numSbX indicates the number of luma subblocks in the luma block along the horizontal direction; and

numSbY indicates the number of luma subblocks in the luma block along the vertical direction.

12. The apparatus of claim **11**, wherein each of the one or more luma subblocks in the set (S) is represented by a subblock index in a horizontal direction and a subblock index in a vertical direction.

13. The apparatus of claim **11**, wherein the number of the chroma subblocks in the chroma block along the horizontal direction and the vertical direction are the same as the number of the luma subblocks in the luma block along the horizontal and vertical directions, respectively.

14. The apparatus of claim **11**,

wherein when the chroma format is 4:4:4, the set (S) is one luma subblock co-located with the chroma subblock;

wherein when the chroma format is 4:2:2, the set (S) is two luma subblocks horizontally adjacent to each other; and

wherein when the chroma format is 4:2:0, the set (S) is two luma subblocks which are diagonal.

15. The apparatus of claim **11**, wherein the video encoder is further configured to:

average horizontal component of the motion vectors of the luma subblocks in the set (S); or

average vertical component of the motion vectors of the luma subblocks in the set (S).

16. The apparatus of claim **11**, wherein the video encoder is further configured to generate an averaged luma motion vector by averaging motion vectors of the luma subblocks in the set (S) as follows:

mvAvgLX=Σ_i mvLX[S_i^x][S_i^y]

when mvAvgLX[0] is greater or equal to 0,mvAvgLX[0](mvAvgLX[0]+(*N*>>1)−1)>>log 2(*N*), otherwise,

mvAvgLX[0]−((−mvAvgLX[0]+(*N*>>1)−1)>>log 2(*N*));

when mvAvgLX[1] is greater or equal to 0,mvAvgLX[1]=(mvAvgLX[1]+(*N*>>1)−1)>>log 2(*N*), otherwise,

mvAvgLX[1]−((−mvAvgLX[1]+(*N*>>1)−1)>>log 2(*N*)),

wherein:

mvAvgLX is a resulting motion vector of the averaging;

S_i^x and S_i^y are horizontal and vertical indices of subblock Si in the set of luma subblocks (S) in motion vector array,

mvLX[S_i^x][S_i^y] is a motion vector of a luma subblock with indices S_i^x and S_i^y, N is a number of elements in the set (S) of luma subblocks, log 2(N) represents the logarithm of N to the base 2 and is the power to which the number 2 is raised to obtain the value N.

17. The apparatus of claim **11**, wherein the encoder is further configured to generate an averaged luma motion vector by averaging motion vectors of the luma subblocks in the set (S) as follows:

mvAvgLX=mvLX[(*x*SbIdx>>(SubWidth*C*−1)<<(SubWidth*C*−1))][(*y*SbIdx>>(SubHeight*C*−1)<<(SubHeight*C*−1))]+mvLX[(*x*SbIdx>>(SubWidth*C*−1)<<(SubWidth*C*−1))+(SubWidth*C*−1)][(*y*SbIdx>>(SubHeight*C*−1)<<(SubHeight*C*−1))+(SubHeight*C*−1)]

if mvAvgLX[0]>=0 then

mvAvgLX[0]=(mvAvgLX[0]+1−(mvAvgLX[0]>=0))>>1

if mvAvgLX[1]>=0 then

mvAvgLX[1]=(mvAvgLX[1]+1−(mvAvgLX[1]>=0))>>1.

18. The apparatus of claim **11**, wherein the video encoder is further configured to determine the chroma scaling factors in the horizontal and vertical directions based on a mapping between the chroma format information and a pair of chroma scaling factors in the horizontal and vertical directions respectively.

19. The apparatus of claim **11**, wherein the video encoder is further configured to:

generate a prediction of the chroma subblock based on the determined chroma motion vector;

obtain a residual of the chroma subblock according to a prediction of the chroma subblock, wherein a residual of the image block comprises the residual of the chroma subblock of the chroma block; and

perform transformation, quantization, and entropy coding on the residual of the image block, to output the encoded bitstream.

20. The apparatus of claim **11**, wherein the image block is coded in an affine based inter prediction mode.

21. A non-transitory computer-readable medium storing program instructions which, when executed by one or more processors, cause the one or more processors to perform operations of chroma motion vector derivation used in an affine based inter prediction of a current image block comprises a luma block and a co-located chroma block, the operations comprising:

performing an image encoding process for an image block coded in an inter prediction mode, to output an encoded bitstream, wherein the image block comprises a luma block and a co-located chroma block, and wherein the performing the image encoding process comprises a chroma motion vector derivation process, comprising:

obtaining an averaged luma motion vector mvAvgLX by:

determining chroma scaling factors in horizontal and vertical directions based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the image block belongs to, wherein the chroma format comprises one of a YUV 4:2:2 format, a YUV 4:2:0 format or a YUV 4:4:4 format;

determining a set (S) of luma subblocks of the luma block based on values of the chroma scaling factors; and

generating the averaged luma motion vector mvAvgLX by averaging motion vectors of the luma subblocks in the set (S), in a case that more than one luma subblocks in the set (S);

deriving a chroma motion vector for a chroma subblock mvCLX[xSbIdx][ySbIdx] of the chroma block based on the averaged luma motion vector mvAvgLX; wherein a process of deriving the chroma motion vector is invoked as follows with the mvAvgLX as input, and the chroma motion vector mvCLX[xSbIdx][ySbIdx] as output:

mvCLX[0]=mvLX[0]*2/SubWidth*C*

mvCLX[1]=mvLX[1]*2/SubHeight*C*, if a reference picture corresponding to refIdxLX for the image block is not a current picture; or

mvCLX[0]=((mvLX[0]>>(3+SubWidth*C*))*32

mvCLX[1]=((mvLX[1]>>(3+SubHeight*C*))*32, if the reference picture corresponding to the refIdxLX for the image block is the current picture,

wherein mvLX[0] corresponds to a horizontal component of the mvAvgLX, and mvLX[1] corresponds to a vertical component of the mvAvgLX,

wherein when both SubWidthC and SubHeightC are equal to 1, the set of luma subblocks (S) is a luma subblock indexed by S_0=(xSbIdx, ySbIdx);

when at least one of SubWidthC and SubHeightC is not equal to 1, the set of luma subblocks (S) is: a first luma subblock indexed by S_0=

((*x*SbIdx>>(SubWidth*C*−1)<<(SubWidth*C*−1)),

(*y*SbIdx>>(SubHeight*C*−1)<<(SubHeight*C*−1))), and a second luma subblock indexed by

S_1=((*x*SbIdx>>(SubWidth*C*−1)<<(SubWidth*C*−1))+(SubWidth*C*−1),(*y*SbIdx>>(SubHeight*C*−1)<<(SubHeight*C*−1))+(SubHeight*C*−1))

wherein SubWidthC and SubHeightC represent the chroma scaling factors in horizontal and vertical directions, respectively;

xSbIdx and ySbIdx represent a subblock index in the horizontal direction and a subblock index in the vertical direction, respectively, for a luma subblock in the set (S);

"<<" represents a left arithmetic shift;

">>" represents a right arithmetic shift;

xSbIdx is an integer number ranging from 0 to numSbX−1 and ySbIdx is an integer ranging from 0 to numSbY−1;

numSbX indicates the number of luma subblocks in the luma block along the horizontal direction; and

numSbY indicates the number of luma subblocks in the luma block along the vertical direction.

22. A non-transitory computer-readable medium

storing an encoded bitstream for a video signal and one or more instructions executable by one or more processors to perform operations of encoding of the bitstream, the operations comprising:

performing an image encoding process for an image block coded in an inter prediction mode, to output the encoded bitstream, wherein the image block comprises a luma block and a co-located chroma block, and wherein the performing the image encoding process comprises a chroma motion vector derivation process, comprising:

obtaining an averaged luma motion vector mvAvgLX by:

determining chroma scaling factors in horizontal and vertical directions based on chroma format information, wherein the chroma format information indicates a chroma format of a current picture which the image block belongs to, wherein the chroma format comprises one of a YUV 4:2:2 format, a YUV 4:2:0 format or a YUV 4:4:4 format;

determining a set (S) of luma subblocks of the luma block based on values of the chroma scaling factors; and

generating the averaged luma motion vector mvAvgLX by averaging motion vectors of the luma subblocks in the set (S), in a case that more than one luma subblocks in the set (S);

deriving a chroma motion vector for a chroma subblock mvCLX[xSbIdx][ySbIdx] of the chroma block based on the averaged luma motion vector mvAvgLX; wherein a process of deriving the chroma motion vector is invoked as follows with the mvAvgLX as input, and the chroma motion vector mvCLX[xSbIdx][ySbIdx] as output:

mvCLX[0]=mvLX[0]*2/SubWidth*C*

mvCLX[1]=mvLX[1]*2/SubHeight*C*, if a reference picture corresponding to refIdxLX for the image block is not a current picture; or

mvCLX[0]=((mvLX[0]>>(3+SubWidth*C*))*32

mvCLX[1]=((mvLX[1]>>(3+SubHeight*C*))*32, if the reference picture corresponding to the refIdxLX for the image block is the current picture,

wherein mvLX[0] corresponds to a horizontal component of the mvAvgLX, and mvLX[1] corresponds to a vertical component of the mvAvgLX,

wherein when both SubWidthC and SubHeightC are equal to 1, the set of luma subblocks (S) is a luma subblock indexed by S_0=(xSbIdx, ySbIdx);

when at least one of SubWidthC and SubHeightC is not equal to 1, the set of luma subblocks (S) is: a first luma subblock indexed by S_0=

$$((xSbIdx>>(SubWidthC-1)<<(SubWidthC-1)),$$

$$(ySbIdx>>(SubHeightC-1)<<(SubHeightC-1))),$$ and a second luma subblock indexed by

$$S_1=((xSbIdx>>(SubWidthC-1)<<(SubWidthC-1))+(SubWidthC-1),(ySbIdx>>(SubHeightC-1)<<(SubHeightC-1))+(SubHeightC-1))$$

wherein SubWidthC and SubHeightC represent the chroma scaling factors in horizontal and vertical directions, respectively;

xSbIdx and ySbIdx represent a subblock index in the horizontal direction and a subblock index in the vertical direction, respectively, for a luma subblock in the set (S);

"<<" represents a left arithmetic shift;

">>" represents a right arithmetic shift;

xSbIdx is an integer number ranging from 0 to numSbX−1 and ySbIdx is an integer ranging from 0 to numSbY−1;

numSbX indicates the number of luma subblocks in the luma block along the horizontal direction; and

numSbY indicates the number of luma subblocks in the luma block along the vertical direction.

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