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(71) Applicant: **CANON KABUSHIKI KAISHA** [JP/JP]; 30-2 Shimomaruko 3-Chome, Ohta-Ku, Tokyo, 146-8501 (JP).

(71) Applicant *(for AE only)*: **CANON EUROPE LTD** [GB/GB]; 3 The Square, Stockley Park, Uxbridge Middlesex, UB11 1ET (GB).

(72) Inventors: **GISQUET, Christophe**; 18 Avenue de Cucillé, F-35000 Rennes (FR). **LAROCHE, Guillaume**; Le Haut Launay, F-35520 Melesse (FR). **ONNO, Patrice**; 16 allée Georges Palante, F-35000 Rennes (FR).

(74) Agent: **WALKER, Philip**; 3 The Square, Stockley Park, Uxbridge Middlesex UB11 1ET (GB).

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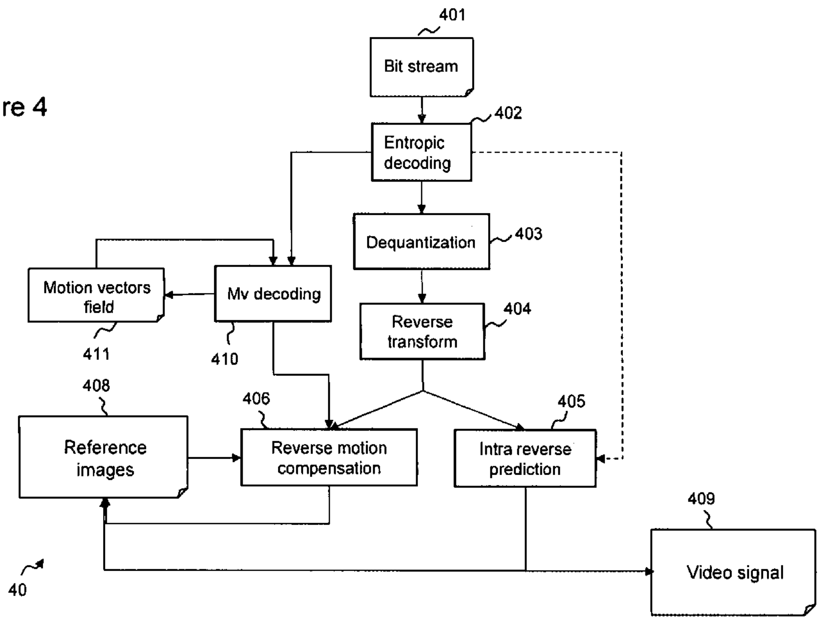
(54) **Title**: VIDEO ENCODING AND DECODING

Figure 4



(57) **Abstract**: A lossy codec, in particular an encoder or decoder compliant with HEVC, has tools (functions or capabilities) which are not useful for lossless compression. Surprisingly, these existing tools in the HEVC specifications do not bring any coding efficiency gain when dealing with lossless compression. These tools (functions or capabilities) can then either be omitted entirely from the encoder or decoder or, alternatively, they can be inhibited in the lossless mode but available when lossy compression is to be performed. The proposed modifications can alternatively be applied for the coding of screen content sequences, both for the lossless and the lossy cases, due to their particular properties.

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Video encoding and decoding

Field of the invention

The invention relates to a method and device for encoding a sequence of digital images and a method and device for decoding a corresponding bitstream.

The invention belongs to the field of digital signal processing, and in particular to the field of video compression using motion compensation to reduce spatial and temporal redundancies in video streams.

Description of the prior-art

High Efficiency Video Coding (HEVC) is a new standard for video compression developed by the ISO and ITU-T. The Moving Picture Experts Group (MPEG) and Video Coding Experts Group (VCEG) set up a Joint Collaborative Team on Video Coding (JCT-VC) to create the new standard. HEVC is a joint publication of ISO/IEC and ITU-T, formally known as ISO/IEC 23008-2 and ITU-T Recommendation H.265. The new HEVC standard received first stage approval in January 2013.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided an HEVC-compliant encoder arranged to not use sub-pel accuracy in motion estimation and/or motion compensation when encoding a screen content or other pattern-repetitive video sequence.

According to a second aspect of the present invention there is provided a method of encoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant encoder, wherein sub-pel accuracy is not used in motion estimation and/or motion compensation.

According to a third aspect of the present invention there is provided an HEVC-compliant decoder arranged to not use sub-pel accuracy in motion estimation and/or motion compensation when decoding a screen content or other pattern-repetitive video sequence..

According to a fourth aspect of the present invention there is provided a method of decoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant decoder, wherein sub-pel accuracy is not used in motion estimation and/or motion compensation.

According to a fifth aspect of the present invention there is provided, an HEVC-compliant encoder, capable of performing motion estimation and/or motion compensation involving an interpolation process, comprising control means operable, when encoding a screen content or other pattern-repetitive video sequence, to employ in the interpolation process for luma samples a filter having fewer taps than a filter used when the encoder is encoding a video sequence that is not a screen content or other pattern-repetitive video sequence.

Preferably, the number of taps for a screen content or other pattern-repetitive video sequence is 6 or fewer.

Preferably, the number of taps for a screen content or other pattern-repetitive video sequence is 4.

Preferably, the same filter is used for luma samples as for chroma samples when encoding a screen content or other pattern-repetitive video sequence.

According to a sixth aspect of the present invention there is provided an HEVC-compliant decoder, capable of performing motion estimation and/or motion compensation involving an interpolation process, comprising control means operable, when decoding a screen content or other pattern-repetitive video sequence, to employ in the interpolation process for luma samples a filter having fewer taps than a filter used when the decoder is decoding a video sequence that is not a screen content or other pattern-repetitive video sequence.

Preferably, the number of taps for a screen content or other pattern-repetitive video sequence is 6 or fewer.

Preferably, the number of taps for a screen content or other pattern-repetitive video sequence is 4.

Preferably, the same filter is used for luma samples as for chroma samples when decoding a screen content or other pattern-repetitive video sequence.

According to a seventh aspect of the present invention there is provided a method of encoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant encoder capable of performing motion estimation and/or motion compensation involving an interpolation process, the method comprising employing in the interpolation process for luma samples a filter having fewer taps than a filter used when the encoder is encoding a video sequence that is not a screen content or other pattern-repetitive sequence .

Preferably, the number of taps for a screen content or other pattern-repetitive video sequence is 6 or fewer.

Preferably, the number of taps for a screen content or other pattern-repetitive video sequence is 4.

Preferably, the same filter is used for luma samples as for chroma samples.

According to an eighth aspect there is provided a method of decoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant decoder capable of performing motion estimation and/or motion compensation involving an interpolation process, the method comprising employing in the interpolation process for luma samples a filter having fewer taps than a filter used when the decoder is decoding a video sequence that is not a screen content or other pattern-repetitive video sequence.

Preferably, the number of taps for a screen content or other pattern-repetitive video sequence is 6 or fewer.

Preferably, the number of taps for a screen content or other pattern-repetitive video sequence is 4.

Preferably, the same filter is used for luma samples as for chroma samples.

According to a ninth aspect of the present invention there is provided an HEVC-compliant encoder, capable of performing motion estimation and/or motion compensation involving an interpolation process, comprising control means operable, when encoding a screen content or other pattern-repetitive video sequence, to employ in the interpolation process for luma samples a filter having 6 or fewer taps.

Preferably, the number of taps for encoding a screen content or other pattern-repetitive video sequence is 4.

Preferably, the same filter is used for luma samples as for chroma samples when encoding a screen content or other pattern-repetitive video sequence.

According to a tenth aspect of the present invention there is provided an HEVC-compliant decoder, capable of performing motion estimation and/or motion compensation involving an interpolation process, comprising control means operable, when decoding a screen content or other pattern-repetitive video sequence, to employ in the interpolation process for luma samples a filter having 6 or fewer taps.

Preferably, the number of taps when decoding a screen content or other pattern-repetitive video sequence is 4.

Preferably, the same filter is used for luma samples as for chroma samples when decoding a screen content or other pattern-repetitive video sequence.

According to an eleventh aspect of the present invention there is provided a method of encoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant encoder capable of performing motion estimation and/or motion compensation involving an interpolation process, the method comprising employing in the interpolation process for luma samples a filter having 6 or fewer taps .

Preferably, the number of taps for a screen content or other pattern-repetitive video sequence is 4.

Preferably, the same filter is used for luma samples as for chroma samples.

According to a twelfth aspect of the present invention there is provided a method of decoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant decoder capable of performing motion estimation and/or motion compensation involving an interpolation process, the method comprising employing in the interpolation process for luma samples a filter having 6 or fewer taps.

Preferably, the number of taps for a screen content or other pattern-repetitive video sequence is 4.

Preferably, the same filter is used for luma samples as for chroma samples.

According to a thirteenth aspect of the present invention there is provided an HEVC-compliant encoder comprising control means operable, when encoding a screen content or other pattern-repetitive video sequence, to inhibit use of at least one preprocessing step used when encoding a video sequence that is not a screen content or other pattern-repetitive video sequence, said preprocessing step serving to preprocess the data before a prediction step to avoid some visual degradation.

According to a fourteenth aspect of the present invention there is provided an HEVC-compliant decoder comprising control means operable, when encoding a screen content or other pattern-repetitive video sequence, to inhibit use of at least one preprocessing step used when decoding a video sequence that is not a screen content or other pattern-repetitive video sequence, said preprocessing step serving to preprocess the data before the prediction step to avoid some visual degradation.

According to a fifteenth aspect of the present invention there is provided a method of encoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant encoder, comprising inhibiting use of at least one preprocessing step used when encoding a video sequence that is not a screen content or other pattern-repetitive video sequence, said preprocessing step serving to preprocess the data before a prediction step to avoid some visual degradation.

According to a sixteenth aspect of the present invention there is provided a method of decoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant decoder, comprising inhibiting use of at least one preprocessing step used when decoding a video sequence that is not a screen content or other pattern-repetitive video sequence, said preprocessing step serving to preprocess the data before the prediction step to avoid some visual degradation.

According to a seventeenth aspect of the present invention there is provided an HEVC-compliant encoder arranged to not use at least one preprocessing step when encoding a screen content or other pattern-repetitive video sequence, said preprocessing step serving to preprocess the data before a prediction step to avoid some visual degradation.

According to an eighteenth aspect of the present invention there is provided an HEVC-compliant decoder comprising control means arranged to not use at least one preprocessing step when decoding a screen content or other pattern-repetitive video sequence, said preprocessing step serving to preprocess the data before the prediction step to avoid some visual degradation.

According to a nineteenth aspect of the present invention there is provided a method of encoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant encoder, comprising not using at least one preprocessing step, said preprocessing step serving to preprocess the data before the prediction step to avoid some visual degradation.

According to a twentieth aspect of the present invention there is provided a method of decoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant decoder, comprising not using at least one preprocessing step, said preprocessing step serving to preprocess the data before the prediction step to avoid some visual degradation.

According to a twenty-first aspect of the present invention there is provided an HEVC-compliant encoder arranged to not use Mode Dependent Intra Smoothing when encoding a screen content or other pattern-repetitive video sequence.

According to a twenty-second aspect of the present invention there is provided an HEVC-compliant decoder arranged to not use Mode Dependent Intra Smoothing when decoding a screen content or other pattern-repetitive video sequence.

According to a twenty-third aspect of the present invention there is provided a method of encoding a screen content or other pattern-repetitive video sequence, using an HEVC-compliant encoder, wherein Mode Dependent Intra Smoothing is not used.

According to a twenty-fourth aspect of the present invention there is provided a method of decoding a screen content or other pattern-repetitive video sequence, using an HEVC-compliant decoder, wherein Mode Dependent Intra Smoothing is not used.

According to a twenty-fifth aspect of the present invention there is provided an HEVC-compliant encoder arranged to not use bi-directional prediction when encoding a screen content or other pattern-repetitive video sequence.

Preferably, the encoder is capable of including in a bitstream supplied to a decoder a syntax element specifying a type of prediction used for a slice, and the encoder is arranged to not use in said syntax element a slice type corresponding to bi-directional prediction.

According to a twenty-sixth aspect of the present invention there is provided an HEVC-compliant decoder arranged to not use bi-directional prediction when decoding a screen content or other pattern-repetitive video sequence.

Preferably, the decoder is capable of receiving in a bitstream supplied by an encoder a syntax element specifying a type of prediction used for a slice, and the decoder is arranged to not use in said syntax element a slice type corresponding to bi-directional prediction.

According to a twenty-seventh aspect of the present invention there is provided a method of encoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant encoder wherein bi-directional prediction is not used.

Preferably, the method comprises: including in a bitstream supplied to a decoder a syntax element specifying a type of prediction used for a slice, and not using in said syntax element a slice type corresponding to bi-directional prediction.

According to a twenty-eighth aspect of the present invention there is provided a method of decoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant decoder, wherein bi-directional prediction is not used.

Preferably, the method comprises: receiving in a bitstream supplied by an encoder a syntax element specifying a type of prediction used for a slice, and not using in said syntax element a slice type corresponding to bi-directional prediction.

According to a twenty-ninth aspect of the present invention there is provided an HEVC-compliant encoder arranged to not use at least one post-filtering process when encoding a screen content or other pattern-repetitive video sequence.

Preferably, the or one post-filtering process is a deblocking filtering process.

Preferably, the or one post-filtering process is a sample adaptive offset filtering process.

According to a thirtieth aspect of the present invention there is provided an HEVC-compliant decoder arranged to not use at least one post-filtering process when decoding a screen content or other pattern-repetitive video sequence.

Preferably, the or one post-filtering process is a deblocking filtering process.

Preferably, the or one post-filtering process is a sample adaptive offset filtering process.

According to a thirty-first aspect of the present invention there is provided a method of encoding a video sequence using an HEVC-compliant encoder, comprising not using at least one post-filtering process when encoding a screen content or other pattern-repetitive video sequence.

Preferably, the or one post-filtering process is a deblocking filtering process.

Preferably, the or one post-filtering process is a sample adaptive offset filtering process.

According to a thirty-second aspect of the present invention there is provided a method of decoding a video sequence using an HEVC-compliant decoder, comprising not using at least one post-filtering process used when decoding a screen content or other pattern-repetitive video sequence.

Preferably, the or one post-filtering process is a deblocking filtering process.

Preferably, the or one post-filtering process is a sample adaptive offset filtering process.

According to a thirty-third aspect of the present invention there is provided an HEVC-based decoder, not capable of using sub-pel accuracy in motion estimation and/or motion compensation when decoding a screen content or other pattern-repetitive video sequence.

According to a thirty-fourth aspect of the present invention there is provided an HEVC-compliant decoder, not capable of using sub-pel accuracy in motion estimation and/or motion compensation when decoding a screen content or other pattern-repetitive video sequence.

According to a thirty-fifth aspect of the present invention there is provided an HEVC-based decoder not capable of performing bi-directional prediction when decoding a screen content or other pattern-repetitive video sequence.

According to a thirty-sixth aspect of the present invention there is provided an HEVC-compliant decoder not capable of performing bi-directional prediction when decoding a screen content or other pattern-repetitive video sequence.

According to a thirty-seventh aspect of the present invention there is provided an HEVC-based decoder, capable of performing lossy and lossless decompression when decoding a screen content or other pattern-repetitive video sequence, where no post-filtering process is possible.

According to a thirty-eighth aspect of the present invention there is provided an HEVC-based decoder, capable of performing lossy and lossless decompression when decoding a screen content or other pattern-repetitive video sequence, where no deblocking or sample adaptive offset filtering process is possible.

According to a thirty-ninth aspect of the present invention there is provided an HEVC-compliant decoder, capable of performing lossy and lossless decompression when decoding a screen content or other pattern-repetitive video sequence, where no post-filtering process is possible.

According to a fortieth aspect of the present invention there is provided an HEVC-compliant decoder, capable of performing lossy and lossless decompression when decoding a screen content or other pattern-repetitive video sequence, where no deblocking or sample adaptive offset filtering process is possible.

Further aspects of the invention are presented in the section headed “Aspects” at the end of the present specification.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made, by way of example, to the accompanying drawings in which:

- Figure 1 is a block diagram showing parts of an HEVC-compliant encoder;

- Figure 2 is a block diagram showing parts of an HEVC-compliant decoder;

- Figure 3 is a block diagram showing parts of an encoder according to an embodiment of the present invention;

- Figure 4 is a block diagram showing parts of a decoder according to an embodiment of the present invention;

- Figure 5a is a schematic diagram for use in explaining a method of selecting reference frames in an HEVC-compliant encoder or decoder; and

- Figure 5b is a schematic diagram for use in explaining a method of selecting reference frames in an encoder or decoder embodying the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The invention is related to video coding and decoding. More precisely, certain embodiments of the present invention are directed to improving lossless coding. Compared to a video codec where generally the compression introduces a degradation on the image sequence, in lossless coding (also called lossless compression and the lossless mode) the initial quality of the video sequence is preserved after compression.

Although the following description is directed to measures that simplify a lossy encoder/decoder to target lossless compression, the measures presented can also be applied in a lossy encoder/decoder not performing lossless compression/decompression, especially for particular sequences such as the screen content. Screen content sequences are characterized by extremely repetitive patterns such as a video sequence representing a PC screen video, as distinct for example from a natural scene video sequence captured by a camcorder.

Before describing embodiments of the present invention, a general principle of video compression standards is to benefit from spatial and temporal redundancies to reduce the video bitrate. In Figures 1 and 2, we have respectively represented the different steps performed in an encoder and in a decoder compliant with HEVC or H.264/AVC for lossy compression.

HEVC encoder architecture

In a video sequence encoder compliant with HEVC, an original video sequence 101 is divided into blocks of pixels 102. A coding mode is then applied to each block. There are two families of coding modes: the modes based on spatial prediction (INTRA) 103 and the modes based on temporal prediction (INTER, Bidir, Skip) 104, 105.

An INTRA block is generally predicted from the encoded pixels at its causal boundary by a process called INTRA prediction. Intra prediction in HEVC can operate from blocks of size 4x4 to 32x32. For 64x64 CUs, they are split into 4 Transform Units and therefore into 4 Prediction Units. For the Intra prediction 103, the neighbouring pixels of adjacent CUs are used. The reference pixels correspond to the row of above samples and the column of the left samples. A padding process is performed for missing samples. A multi-directional process is then applied where the best prediction is selected based on a rate distortion algorithm among the 35 prediction modes. 33 modes are considered as directional predictions and the two remaining ones are considered as non-directional: the DC mode and the Planar mode.

As in most hybrid video codecs, discontinuity between prediction samples and reference pixels on the edge of the current block may be caused by intra prediction. Intra smoothing on the prediction samples is needed to reduce discontinuity between prediction samples and reference pixels on the edge of the current block. Mode-Dependent Intra Smoothing (MDIS) has been included in the HEVC specification and is included in step 103. It is based on the size of prediction unit (PU) and the intra prediction mode. The MDIS tool is based on three sub-tools. In the first sub-tool, reference samples are filtered before prediction by using a 3-tap filter ({1,2,1}/4). The MDIS is never applied on 4x4 blocks, for the DC mode (mode id=0), for the Horizontal mode (mode id=10) and the Vertical mode (mod_id=26). For blocks of size 8x8, it is applied only on modes 1, 2, 18 and 34. For the DC mode a specific process is applied: in order to reduce block artefacts, top/left prediction samples are pre-filtered: a 3-tap filter ({1,2,1}/4) is applied on the top-left corner pixel while a 2-tap filter ({1,3}/4) is applied for the first line and row of the prediction block.

The mode-dependent intra smoothing tool improves the overall coding efficiency for lossy compression.

Temporal prediction first consists in finding in a previous or future frame (i.e. a reference frame 116) the reference area which is the closest to the block to encode (motion estimation 104) and secondly in predicting this block using the selected area (motion compensation 105). This temporal prediction can be done by using one reference frame. This is referred to as uni-directional prediction. When two motion vectors are used for the prediction, a bi-directional prediction is used by averaging the blocks pointed by the two motion vectors in the reference frames. In the current standard of HEVC, the uni-directional or the bi-directional prediction can be respectively signaled in the bitstream through the *slice_type* syntax element in the slice header.

The motion estimation and motion compensation can be performed by using sub-pixel accuracy. An interpolation step of the reference picture is obtained by filtering the decoded picture with an interpolation filter. The filter can be of several types. H.264/AVC uses a 6-tap FIR filter to perform half-pixel interpolation and the average (bilinear) filter to perform quarter-pixel interpolation for luma components. For example, for the HEVC standard, in the case of Luma components, an 8-tap DCTIF is used for half-pel-precision ({ -1, 4, -11, 40, 40, -11, 4, -1}/64) and a 7-tap DCTIF ({ -1, 4, -10, 58, 17, -5, 1, 0}/64) for the quarter-pel positions. For the Chroma samples, a list of 4 4-tap filters is used to reach up to 1/8 pixel precision. The following table shows the filter coefficients according to the wanted sub-pel position.

Pel position	Filter coefficients
1/8	{ -2, 58, 10, -2}/64
1/4	{ -4, 54, 16, -2}/64
3/8	{ -6, 46, 28, -4}/64
1/2	{ -4, 36, 36, -4}/64

In both cases (spatial and temporal prediction), a residual is computed by subtracting the prediction from the original predicted block.

In the INTRA prediction, a prediction direction is encoded. In the temporal prediction, at least one motion vector is encoded. However, in order to further reduce the bitrate cost related to motion vector encoding, a motion vector is not directly encoded. Indeed, assuming that motion is homogeneous, it is particularly interesting to encode a motion vector as a difference between this motion vector, and a motion vector in its dyadic surrounding. In H.264 for instance, motion vectors are encoded with respect to a median vector computed between 3 blocks located above and on the left of the current block. Only a difference (also called residual motion vector) computed between the median vector and the current block motion vector is encoded in the bitstream. This is processed in module Mv prediction and coding 117. The value of each encoded vector is stored in the motion vector field 118. The neighboring motion vectors, used for the prediction, are extracted from the motion vector field 118.

Then, the mode optimizing the rate distortion performance is selected 106. In order to further reduce the redundancies, a transform (DCT) is applied to the residual block 107, and a quantization is applied to the coefficients 108. The quantized block of coefficients is then entropy coded 109 and the result is inserted in the bitstream 110. The encoder then performs a decoding of the encoded frame for the future motion estimation (111 to 116). These steps allow the encoder and the decoder to have the same reference frames.

To reconstruct the coded frame, the residual is inverse quantized 111 and inverse transformed 112 in order to provide the "decoded" residual in the pixel domain. According to the encoding mode (INTER or INTRA), this residual is added to the INTER predictor 114 or to the INTRA predictor 113.

Then, this first reconstruction is filtered 115 by one or several kinds of post filtering processes. These post filters are integrated in the encoding and decoding loop. It means that they need to be applied on the reconstructed frame at encoder and decoder side in order to use the same reference frame at encoder and decoder side. For example, a deblocking filter can remove blocking artifacts due to the DCT quantization of residual and to block motion compensation. In the current HEVC standard, 2 types of loop filters are used: the deblocking filter and a sample adaptive offset (SAO) filter.

The deblocking filter is applied first on the reconstructed frame to generate a deblocked frame. The aim of the deblocking filter is to remove block artifacts generated by residual quantization and block motion compensation or block Intra prediction. These artifacts are visually important at low bitrate. This filter consists in smoothing the block boundaries according to the characteristics of two neighboring blocks. This filter takes into account the encoding mode of each block, the quantization parameters used for the residual coding, and the neighboring pixel differences in the boundary. The same criterion/classification is applied for all frames and no additional data is transmitted in the bitstream to modify the deblocking filtering. This filter not only improves the visual quality of the current frame by removing blocking artifacts but also improves the motion estimation and motion compensation for the following frames. Indeed, high frequencies of the block artifact are removed, so these high frequencies do not need to be compensated with the texture residual of the following frames.

After the deblocking filter, the deblocked frame is filtered by the Sample Adaptive Offset (SAO) loop filter. SAO loop filters are based on a preliminary step of classification. The SAO filtering step consists in adding offset values to pixel values to correct some samples due to the quantization.

HEVC decoder architecture

Figure 2 represents the principle of a decoder which mainly applies the same global operations that the encoder described in Figure 1 applies but in a reverse way. The video stream 201 is first entropy decoded 202. The residual data are then inverse quantized 203 and inverse transformed 204 to obtain pixel values. The mode data are also entropy decoded and, in dependence upon the mode, an INTRA type decoding or an INTER type decoding is performed. In the case of INTRA mode, an INTRA predictor is determined in dependence upon the intra prediction mode specified in the bitstream 205. During the decoding of the INTRA mode, the Mode-Dependent Intra Smoothing tool (MDIS) can be applied on Luma samples depending on the PU size in the same way as in the encoder.

If the mode is INTER, the motion information is extracted from the bitstream 202. This is composed of the reference frame index and the motion vector residual. The motion vector predictor is added to the motion vector residual to obtain the motion vector 210. The motion vector is then used to locate the reference area in the reference frame 206. Depending on the accuracy of the motion vector (half-pel or quarter–pel accuracy), an interpolation filter is applied on the reference frame to reach the needed accuracy. For the motion compensation, the interpolation filter is the same as the one used at the encoder: it could be a 6-tap FIR filter (like AVC) or an 8-tap DCTIF filter.

The motion vector field data 211 is updated with the decoded motion vector in order to be used for the uni–prediction of the next decoded motion vectors. This first reconstruction of the decoded frame is then post filtered 207 with exactly the same post filters as used at encoder side. This post filter considered here is the Deblocking Filter (DBF) and the Sample Adaptive Offset (SAO). The output of the decoder is the reconstructed video 209.

Overview of embodiments

The following embodiments propose a simplified version of a typical video encoder or decoder to target lossless compression. These embodiments identify a set of current tools (functions or capabilities) defined for a lossy codec, in particular an encoder or decoder compliant with HEVC, which are not useful for lossless compression.

It has been recognized by the present inventors that, surprisingly, these existing tools in the HEVC specifications do not bring any coding efficiency gain when dealing with lossless compression. These tools (functions or capabilities) can then either be omitted entirely from the encoder or decoder or, alternatively, they can be inhibited in the lossless mode but available when lossy compression is to be performed.

The former implementation can provide an encoder and/or encoder optimized for the lossless mode, in particular to reach the best coding efficiency performance for lossless compression. It does not necessarily have to be capable of performing lossy compression.

The latter implementation might be convenient, for example, for a chip designer/manufacturer who wishes to provide a single chip or chipset, usable as an HEVC-compliant encoder and/or decoder, and having the capability to operate in the lossless mode as well as in the normal lossy compression mode.

Figure 3 shows parts of an encoder embodying the present invention, and Figure 4 shows parts of a decoder embodying the present invention. In this following embodiments, we propose a simplified encoder (and therefore a decoder) architecture compared to the one described in Figure 1 (respectively in Figure 2) to target lossless compression. Moreover, the proposed modifications can be applied for the coding of Screen content sequences, both for the lossless and the lossy cases, due to their particular properties. The steps of the encoder (decoder) are closed to the one proposed in Figure 1 (Figure 2) with the following changes.

First embodiment

In a first embodiment, during the step of motion estimation 304 and motion compensation 305, 406, the sub-pel accuracy is not used. This makes it possible to entirely remove the interpolation process (or disable the interpolation filter) for the motion estimation and the motion compensation steps. There is no change to the motion vector coding and interpolation is replaced by copying. In terms of hardware implementation, the complexity reduction is important since the memory to interpolate the reference images is not needed anymore. When the interpolation process is removed, the motion vectors can be defined with a full pixel position and the syntax of signaling sub-pel accuracy is not needed anymore. The performance results based on HEVC testing conditions for lossless (see Table 1 below) show a small loss of 1.1% in average over the testing sequences but for some specific video content like screen content some gains are observed, for example a gain of -1.66% on screen content sequences. The main advantage of this simplification is the drastic reduction (for example ~60%) in terms of the memory access compared to a decoder enabling the 1/4th pel precision.

	[illegible]		
	Bit-rate saving (Overall)	Bit-rate saving (Min)	Bit-rate saving (Max)
Class F	1.90%	0.05%	3.04%
Class B	3.80%	1.12%	6.38%
Class O	-1.66%	-6.62%	-0.32%
SC RGB 444	2.97%	-0.64%	7.59%
SC YUV 444	1.43%	-1.75%	7.59%
RangeExt	0.90%	0.17%	3.11%

Table 1

Second embodiment

In a second embodiment, during the step of motion estimation 304 and motion compensation 305, 406, the interpolation process is simplified in terms of the number of operations and in terms of memory requirement. Instead of using quite long filters like the DCTIF of 8 taps and DCTIF 7 taps defined in HEVC, the present embodiment uses shorter filters of 6 taps for example. It is also possible to use as DCTIF filters a 2-tap filter called a "bilinear filter" (corresponding to an average between two pixels values). The results obtained in such a case are an average gain of ~-0.1% and memory access is reduced to ~43%-45% compared to a conventional HEVC encoder/decoder.

Third embodiment

In a third embodiment, a 4-taps DCTIF filter is used for the Luma components instead of the classical 8-taps DCTIF filters. This enables a reduction in the complexity of the interpolation process for the motion estimation and the motion compensation steps. In terms of hardware implementation, the complexity reduction is important since the memory to interpolate the reference images is much smaller. Results are presented in Table 2 below. There is an average gain of ~-0.2% and a memory access is reduced to ~63%-75% compared to a conventional HEVC encoder/decoder.

	LB Main		
	Bit-rate saving (Overall)	Bit-rate saving (Min)	Bit-rate saving (Max)
Class F	-0.11%	-0.36%	0.16%
Class B	-0.40%	-0.68%	-0.12%
Class O	0.04%	-0.31%	7.55%
SC RGB 444	-0.17%	-0.54%	0.30%
SC YUV 444	-0.08%	-0.27%	0.30%
RangeExt	-0.21%	-0.35%	-0.09%
Enc Time[%]	102%		

Table 2

Fourth embodiment

In a fourth embodiment, the 4-taps DCTIF filters used in Luma are the same as the Chroma filters.

Fifth embodiment

In a fifth embodiment, the motion estimation at the encoder is performed with full-pel accuracy while the motion compensation (encoder and decoder) can handle sub-pel accuracy.

Sixth embodiment

In a sixth embodiment, the intra prediction scheme 303, 405 for lossless compression is simplified. As described in Figure 1, the intra prediction for lossy compression may contain some preprocessing steps of the data before the prediction step to avoid some visual degradation. This method, called Mode Dependent Intra Smoothing (MDIS), enables correction of some artifacts before the prediction. In this embodiment and for the case of the lossless compression, the proposed encoder and decoder does not use this preprocessing tool which does not help for the coding efficiency.

Seventh embodiment

In a seventh embodiment, the slice type corresponding to 'enable bi-prediction' is forbidden for lossless compression. This can be done by forcing the slice_type to be 1 (P slice) or 2 (I slice), but never 0 (B slice). Our experiments regarding lossless compression (see Table 3 below) show that enabling B slices does not bring much gain. More specifically on the specific testing sequences of HEVC for the Range Extensions, the loss is about 1.2% when we are not using B slices. There is only a small impact on coding effciency in this case. For screen content sequences, the results show even some gains when only P frames are used. This is not the case for lossy compression where the B slices generally bring an important gain over P slices. The removal of the P slices for lossless compression brings several advantages: the first one is the memory access reduction by 50% since only one frame is used instead of two for the B slices, the second is the reduced number of operation needed to perform the bi-prediction. The encoding time is only 76% of that of a conventional HEVC encoder, i.e. a runtime reduction of 24% is achievable. The compromise between coding efficiency and complexity in the conventional HEVC encoder is not good enough in the example cases shown.

	LB Main vs LP Main		
	Bit-rate saving (Overall)	Bit-rate saving (Min)	Bit-rate saving (Max)
Class F	2.18%	0.41%	3.72%
Class B	2.06%	1.49%	2.62%
Class O	-0.09%	-4.50%	0.15%
SC RGB 444	1.23%	-0.11%	2.67%
SC YUV 444	0.77%	-0.09%	2.67%
RangeExt	1.25%	0.39%	2.56%
Enc Time[%]	76%		

Table 3

Eighth embodiment

In an eighth embodiment the syntax of the HEVC standard dealing with the slice_type equals to a B slice is entirely removed when targeting lossless decoder specifications. This means that B slices are not supported at all by the decoder according to the present embodiment which targets lossless compression.

Ninth embodiment

In a ninth embodiment, as represented in Figure 3, the step 115 presented in Figure 1 regarding the loop filtering is removed. Since the lossless compression guarantees the perfect reconstruction of the different neighboring Coding Units, it is not necessary to apply post filtering after decoding the frames. In that case, the deblocking filter (DBF) is not applied for the encoder. The same removal is also valid for the decoder (Figure 4) where the post processing to remove artifacts is not present anymore. In that case a lot of operations can be saved at the decoder by removing the deblocking filter.

Tenth embodiment

In a tenth embodiment, as represented in Figure 3 and Figure 4, the second process of post filtering in HEVC is also removed. This post filtering called Sample Adaptive Offset (SAO) is not used since no correction of the quantization is needed. As the residual information is not quantized for lossless compression, there is no need for correction. The removal of this tool enables a reduction in the complexity of a lossless decoder since no additional post filtering operation is performed at the decoder.

Eleventh embodiment

Figure 5a shows a diagram for use in explaining the selection of the reference frame for several given frames for a low delay configuration in an HEVC-compliant encoder or decoder. A low delay configuration means that a given picture can be decoded by using past decoded frames as reference frames. The reference frame selection presented in Figure 5a is used for lossy compression in the current HEVC for the low delay configuration. For example, the frame 16 uses the frames (pointed to by dotted lines) 15, 12, 8 and 4 as reference frames while the frame 14 uses 13, 12, 8 and 4 (pointed to by the dashed lines). In that particular case, the selection of the frames used as reference depends on the QP parameter of the past frames. As depicted in figure 5a, the closest (temporally) frame is always used as reference frame and the three others reference are selected by using the previous frames having the lowest QP parameters. In that particular case, it means that the prediction prefers the best quality images among the images already decoded over the closest (temporally speaking) frames. It was established though the standardization committee of HEVC that this reference frame selection is capable of providing the best coding efficiency when lossy compression is considered.

Figure 5b shows a different reference frame selection for the purpose of the present embodiment targeting lossless compression. In this selection, the reference frames are selected so that the closest frames are used as reference frames compared to Figure 5a. Thus, the present embodiment reduces the temporal distance between frames and selects the nearest reference frames. In our experiment based on the testing conditions for lossless purpose, the results of which are presented in Table 4 below, this current selection provides better compression for the lossless case compared to the scheme of reference frames presented in Figure 5a. The average gain is -0.42%.

	LB-RExt Config6 LDB				
	compression ratio (Overall)		Bit-rate saving (Overall)	Bit-rate saving (Min)	Bit-rate saving (Max)
	Ref.	Tested			
Class F	10.26	10.28	-0.19%	-2.28%	5.86%
Class B	2.55	2.56	-0.24%	-0.36%	-0.11%
Class O	76.52	76.71	-0.25%	-4.35%	6.00%
SC RGB 444	9.47	9.61	-1.47%	-6.31%	3.20%
SC YUV 444	8.47	8.53	-0.72%	-5.38%	3.20%
RangeExt	1.84	1.84	-0.10%	-0.34%	-0.01%
Enc Time[%]	97%				

Table 4

As described above, embodiments of the present invention propose to remove a certain number of classical coding tools to reduce the complexity of a lossless decoder based on an HEVC lossy codec. With the removal of some tools and in addition with some simplifications of existing tools our experiments show that these embodiments surprisingly bring some coding efficiency improvements.

Aspects of the present invention

Encoders

In the following encoder aspects (and in the encoding method aspects presented earlier and later) the expression 'HEVC-compliant encoder' is used. Strictly speaking only decoders are subject to standardization in accordance with the HEVC standard and therefore can be said to be strictly 'HEVC-compliant'. However, in the case of an encoder it is meaningful to refer to use the expression 'HEVC-compliant' to denote an encoder capable of delivering a suitable bitstream to an HEVC-compliant decoder. Such a bitstream may be referred to as an HEVC-compliant bitstream.

Herein also, an encoder compliant with the HEVC screen content extension (SCC extension) is an HEVC-compliant encoder. This is true even if the encoder compliant with the HEVC screen content extension does not have all the tools (functions or capabilities) necessary to function as an encoder compliant with the core HEVC standard. In particular, an HEVC-compliant decoder as used herein may be capable of functioning only in the screen content extension. The terms 'HEVC compliant decoder' and 'HEVC compliant bitstream' also include a decoder compliant with the HEVC screen content extension (only) and a bitstream delivered to such a decoder.

Aspect E1

An HEVC-compliant encoder capable of performing lossy compression, comprising control means operable, in a lossless mode, to inhibit use of sub-pel accuracy in motion estimation and/or motion compensation.

Preferably, the motion estimation and/or motion compensation involve(s) an interpolation process when the encoder is performing lossy compression, and the control means are further operable to inhibit use of the interpolation process in said lossless mode.

Preferably, the control means are operable, in said lossless mode, to inhibit use of sub-pel accuracy for motion estimation and to enable use of sub-pel accuracy for motion compensation.

Aspect E2

An HEVC-compliant encoder, capable of using sub-pel accuracy in motion estimation and/or motion compensation, comprising control means operable, in a lossless mode, to inhibit use of sub-pel accuracy in motion estimation and/or motion compensation.

Aspect E3

An encoder for encoding a video sequence losslessly, wherein full-pel accuracy is used in motion estimation and/or motion compensation.

Preferably, full-pel accuracy is used for motion estimation and sub-pel accuracy is used for motion compensation.

Aspect E4

An encoder for encoding a video sequence losslessly, wherein motion estimation and/or motion compensation is/are performed without using an interpolation process.

Preferably, no interpolation process is used for motion estimation and an interpolation process is used for motion compensation.

Aspect E5

An HEVC-compliant encoder, capable of performing motion estimation and/or motion compensation involving an interpolation process, comprising control means operable, in a lossless mode, to employ in the interpolation process for luma samples a filter having fewer taps than a filter used when the encoder is performing lossy compression.

Preferably, the number of taps in the lossless mode is 6 or fewer.

Preferably, the number of taps in the lossless mode is 4.

Preferably, the same filter is used for luma samples as for chroma samples in said lossless mode.

Aspect E6

An encoder, capable of performing motion estimation and/or motion compensation involving an interpolation process, comprising control means operable, in a lossless mode, to employ in the interpolation process for luma samples the same filter as is employed in the interpolation process for chroma samples.

Aspect E7

An HEVC-compliant encoder, capable of performing lossy compression, comprising control means operable, in a lossless mode, to inhibit use of at least one preprocessing step used when performing said lossy compression, said preprocessing step serving to preprocess the data before the prediction step to avoid some visual degradation.

Aspect E8

An HEVC-compliant encoder, capable of performing lossy compression, comprising control means operable, in a lossless mode, to inhibit use of Mode Dependent Intra Smoothing.

Aspect E9

An HEVC-compliant encoder, capable of performing lossy compression, comprising control means operable, in a lossless mode, to inhibit use of bi-directional prediction.

Preferably, the encoder is capable of including in a bitstream supplied to a decoder a syntax element specifying a type of prediction used for a slice, and the control means are operable to inhibit use in said syntax element of a slice type corresponding to bi-directional prediction.

Aspect E10

An HEVC-compliant encoder, capable of performing lossy compression, comprising control means operable, in a lossless mode, to inhibit use of at least one post-filtering process used when performing lossy compression.

Preferably, the or one post-filtering process is a deblocking filtering process.

Preferably, the or one post-filtering process is a sample adaptive offset filtering process.

Aspect E11

An HEVC-compliant encoder, capable of performing lossy compression, comprising control means operable, in a lossless mode, to use a method of selecting reference frames different from a method of selecting reference frames used when performing lossy compression.

Preferably, the method of selecting reference frames in said lossless mode comprises selecting a predetermined number of reference frames closest temporally to a current frame.

Preferably, the selection of reference frames in said lossless mode is independent of the frame quality.

Aspect E12

An encoder for encoding a video sequence losslessly, wherein a predetermined number of reference frames closest temporally to a current frame are selected irrespective of the frame quality.

Decoders

Aspect D1

An HEVC-compliant decoder capable of performing lossy decompression, comprising control means operable, in a lossless mode, to inhibit use of sub-pel accuracy in motion estimation and/or motion compensation.

Preferably, the motion estimation and/or motion compensation involve(s) an interpolation process when the decoder is performing lossy decompression, and the control means are further operable to inhibit use of the interpolation process in said lossless mode.

Preferably, the control means are operable, in said lossless mode, to inhibit use of sub-pel accuracy for motion estimation and to enable use of sub-pel accuracy for motion compensation.

Aspect D2

An HEVC-compliant decoder, capable of using sub-pel accuracy in motion estimation and/or motion compensation, comprising control means operable, in a lossless mode, to inhibit use of sub-pel accuracy in motion estimation and/or motion compensation.

Aspect D3

A decoder for decoding a video sequence losslessly, wherein full-pel accuracy is used in motion estimation and/or motion compensation.

Preferably, full-pel accuracy is used for motion estimation and sub-pel accuracy is used for motion compensation.

Aspect D4

A decoder for decoding a video sequence losslessly, wherein motion estimation and/or motion compensation is/are performed without using an interpolation process.

Preferably, no interpolation process is used for motion estimation and an interpolation process is used for motion compensation.

Aspect D5

An HEVC-compliant decoder, capable of performing motion estimation and/or motion compensation involving an interpolation process, comprising control means operable, in a lossless mode, to employ in the interpolation process for luma samples a filter having fewer taps than a filter used when the decoder is performing lossy decompression.

Preferably, the number of taps in the lossless mode is 6 or fewer.

Preferably, the number of taps in the lossless mode is 4.

Preferably, the same filter is used for luma samples as for chroma samples in said lossless mode.

Aspect D6

A decoder, capable of performing motion estimation and/or motion compensation involving an interpolation process, comprising control means operable, in a lossless mode, to employ in the interpolation process for luma samples the same filter as is employed in the interpolation process for chroma samples.

Aspect D7

An HEVC-compliant decoder, capable of performing lossy decompression, comprising control means operable, in a lossless mode, to inhibit use of at least one preprocessing step used when performing said lossy decompression, said preprocessing step serving to preprocess the data before the prediction step to avoid some visual degradation.

Aspect D8

An HEVC-compliant decoder, capable of performing lossy decompression, comprising control means operable, in a lossless mode, to inhibit use of Mode Dependent Intra Smoothing.

Aspect D9

An HEVC-compliant decoder, capable of performing lossy compression, comprising control means operable, in a lossless mode, to inhibit use of bi-directional prediction.

Preferably, the decoder is capable of receiving in a bitstream supplied by an encoder a syntax element specifying a type of prediction used for a slice, and the control means are operable to inhibit use in said syntax element of a slice type corresponding to bi-directional prediction.

Aspect D10

An HEVC-compliant decoder, capable of performing lossy decompression, comprising control means operable, in a lossless mode, to inhibit use of at least one post-filtering process used when performing lossy decompression.

Preferably, the or one post-filtering process is a deblocking filtering process.

Preferably, the or one post-filtering process is a sample adaptive offset filtering process.

Aspect D11

An HEVC-compliant decoder, capable of performing lossy decompression, comprising control means operable, in a lossless mode, to use a method of selecting reference frames different from a method of selecting reference frames used when performing lossy decompression.

Preferably, the method of selecting reference frames in said lossless mode comprises selecting a predetermined number of reference frames closest temporally to a current frame.

Preferably, the selection of reference frames in said lossless mode is independent of the frame quality.

Aspect D12

A decoder for decoding a video sequence losslessly, wherein a predetermined number of reference frames closest temporally to a current frame are selected irrespective of the frame quality.

Aspect D13

An HEVC-based decoder, not capable of using sub-pel accuracy in motion estimation and/or motion compensation in a lossless mode.

Aspect D14

An HEVC-based decoder not capable of performing bi-directional prediction, in a lossless mode.

Aspect D15

An HEVC-based decoder, capable of performing lossy and lossless decompression, where no post-filtering process is possible.

Encoding methods

Aspect EM1

A method of encoding a video sequence losslessly using an HEVC-compliant encoder, comprising inhibiting use of sub-pel accuracy in motion estimation and/or motion compensation.

Preferably, the motion estimation and/or motion compensation involve(s) an interpolation process when the encoder is performing lossy compression, and the method further comprises inhibiting use of the interpolation process.

Preferably, the method further comprises inhibiting use of sub-pel accuracy for motion estimation and enabling use of sub-pel accuracy for motion compensation.

Aspect EM3

A method of encoding a video sequence losslessly, wherein full-pel accuracy is used in motion estimation and/or motion compensation.

Preferably, full-pel accuracy is used for motion estimation and sub-pel accuracy is used for motion compensation.

Aspect EM4

A method of encoding a video sequence losslessly, wherein motion estimation and/or motion compensation is/are performed without using an interpolation process.

Preferably, no interpolation process is used for motion estimation and an interpolation process is used for motion compensation.

Aspect EM5

A method of encoding a video sequence losslessly using an HEVC-compliant encoder capable of performing motion estimation and/or motion compensation involving an interpolation process, the method comprising employing in the interpolation process for luma samples a filter having fewer taps than a filter used when the encoder is performing lossy compression..

Preferably, the number of taps used to encode the video sequence losslessly is 6 or fewer.

Preferably, the number of taps used to encode the video sequence losslessly is 4.

Preferably, the same filter is used for luma samples as for chroma samples.

Aspect EM6

A method of encoding a video sequence, comprising performing motion estimation and/or motion compensation involving an interpolation process, and employing in the interpolation process for luma samples the same filter as is employed in the interpolation process for chroma samples.

Aspect EM7

A method of encoding a video sequence losslessly using an HEVC-compliant encoder, comprising inhibiting use of at least one preprocessing step used when performing lossy compression, said preprocessing step serving to preprocess the data before the prediction step to avoid some visual degradation.

Aspect EM8

A method of encoding a video sequence losslessly using an HEVC-compliant encoder, comprising inhibiting use of Mode Dependent Intra Smoothing.

Aspect EM9

A method of encoding a video sequence losslessly using an HEVC-compliant encoder, comprising inhibiting use of bi-directional prediction.

Preferably, the method comprises: including in a bitstream supplied to a decoder a syntax element specifying a type of prediction used for a slice, and inhibiting use in said syntax element of a slice type corresponding to bi-directional prediction.

Aspect EM10

A method of encoding a video sequence losslessly using an HEVC-compliant encoder, comprising inhibiting use of at least one post-filtering process used when performing lossy compression.

Preferably, the or one post-filtering process is a deblocking filtering process.

Preferably, the or one post-filtering process is a sample adaptive offset filtering process.

Aspect EM11

A method of encoding a video sequence losslessly using an HEVC-compliant encoder, comprising using a method of selecting reference frames different from a method of selecting reference frames used when performing lossy compression.

Preferably, the method of selecting reference frames used for lossless encoding comprises selecting a predetermined number of reference frames closest temporally to a current frame.

Preferably, the selection of reference frames for lossless encoding is independent of the frame quality.

Aspect EM12

A method of encoding a video sequence losslessly, wherein a predetermined number of reference frames closest temporally to a current frame are selected irrespective of the frame quality.

Decoding methods

Aspect DM1

A method of decoding a video sequence losslessly using an HEVC-compliant decoder, comprising inhibiting use of sub-pel accuracy in motion estimation and/or motion compensation.

Preferably, the motion estimation and/or motion compensation involve(s) an interpolation process when the decoder is performing lossy decompression, and the method further comprises inhibiting use of the interpolation process.

Preferably, the method further comprises inhibiting use of sub-pel accuracy for motion estimation and enabling use of sub-pel accuracy for motion compensation.

Aspect DM3

A method of decoding a video sequence losslessly, wherein full-pel accuracy is used in motion estimation and/or motion compensation.

Preferably, full-pel accuracy is used for motion estimation and sub-pel accuracy is used for motion compensation.

Aspect DM4

A method of decoding a video sequence losslessly, wherein motion estimation and/or motion compensation is/are performed without using an interpolation process.

Preferably, no interpolation process is used for motion estimation and an interpolation process is used for motion compensation.

Aspect DM5

A method of decoding a video sequence losslessly using an HEVC-compliant decoder capable of performing motion estimation and/or motion compensation involving an interpolation process, the method comprising employing in the interpolation process for luma samples a filter having fewer taps than a filter used when the decoder is performing lossy decompression.

Preferably, the number of taps used for decoding the video sequence losslessly is 6 or fewer.

Preferably, the number of taps used for decoding the video sequence losslessly is 4.

Preferably, the same filter is used for luma samples as for chroma samples.

Aspect DM6

A method of decoding a video sequence, comprising performing motion estimation and/or motion compensation involving an interpolation process, and employing in the interpolation process for luma samples the same filter as is employed in the interpolation process for chroma samples.

Aspect DM7

A method of decoding a video sequence losslessly using an HEVC-compliant decoder, comprising inhibiting use of at least one preprocessing step used when performing lossy decompression, said preprocessing step serving to preprocess the data before the prediction step to avoid some visual degradation.

Aspect DM8

A method of decoding a video sequence losslessly using an HEVC-compliant decoder, comprising inhibiting use of Mode Dependent Intra Smoothing.

Aspect DM9

A method of decoding a video sequence losslessly using an HEVC-compliant decoder, comprising inhibiting use of bi-directional prediction.

Preferably, the method comprises: receiving in a bitstream supplied by an encoder a syntax element specifying a type of prediction used for a slice, and inhibiting use in said syntax element of a slice type corresponding to bi-directional prediction.

Aspect DM10

A method of decoding a video sequence losslessly using an HEVC-compliant decoder, comprising inhibiting use of at least one post-filtering process used when performing lossy decompression.

Preferably, the or one post-filtering process is a deblocking filtering process.

Preferably, the or one post-filtering process is a sample adaptive offset filtering process.

Aspect DM11

A method of decoding a video sequence losslessly using an HEVC-compliant decoder, comprising using a method of selecting reference frames different from a method of selecting reference frames used when performing lossy decompression.

Preferably, the method of selecting reference frames used for lossless decoding comprises selecting a predetermined number of reference frames closest temporally to a current frame.

Preferably, the selection of reference frames used for lossless decoding is independent of the frame quality.

Aspect DM12

A method of decoding a video sequence losslessly, wherein a predetermined number of reference frames closest temporally to a current frame are selected irrespective of the frame quality.

Other aspects

Any of the encoders, decoders, encoding methods and decoding methods described above can be modified as follows.

Instead of being applied to lossless coding/decoding (lossless mode), the aspects above can apply to screen content sequences or other pattern-repetitive sequences. Screen content sequences are characterized by extremely repetitive patterns such as a video sequence representing a PC screen video, as distinct for example from a natural scene video sequence captured by a camcorder.

For example, aspect E1 above may be modified as follows to apply to screen content sequence encoding.

Aspect E1-SC

An HEVC-compliant encoder capable of performing lossy compression, comprising control means operable, when a screen content or other pattern-repetitive video sequence is encoded, to inhibit use of sub-pel accuracy in motion estimation and/or motion compensation.

Preferably, the motion estimation and/or motion compensation involve(s) an interpolation process when the encoder is performing lossy compression, and the control means are further operable to inhibit use of the interpolation process when a screen content or other pattern-repetitive video sequence is encoded.

Preferably, the control means are operable, when a screen content or other pattern-repetitive video sequence is encoded, to inhibit use of sub-pel accuracy for motion estimation and to enable use of sub-pel accuracy for motion compensation.

All other aspects E2-E11, D1-D15, EM1, EM3-EM12, DM1, DM3-DM12 can be adapted in the same way.

CLAIMS

1. An HEVC-compliant encoder arranged to not use sub-pel accuracy in motion estimation and/or motion compensation when encoding a screen content or other pattern-repetitive video sequence.

2. An HEVC-compliant encoder as claimed in claim 1, comprising control means operable, when a screen content or other pattern-repetitive video sequence is encoded, to inhibit use of sub-pel accuracy in motion estimation and/or motion compensation.

3. An HEVC-compliant encoder as claimed in claim 2, wherein the control means are operable, when encoding a video sequence other than a screen content or pattern-repetitive video sequence, to enable use of sub-pel accuracy in motion estimation and/or motion compensation.

4. An HEVC-compliant encoder as claimed in any preceding claim, capable of performing lossy compression.

5. An HEVC-compliant encoder as claimed in claim 1, incapable of performing lossy compression.

6. An HEVC-compliant encoder as claimed in claim 2, comprising means for encoding the screen content or other pattern-repetitive sequence losslessly.

7. An HEVC-compliant encoder as claimed in claim 2, comprising means for encoding the screen content or other pattern-repetitive sequence lossily.

8. An HEVC-compliant encoder as claimed in claim 4 when read as appended to claim 2, wherein the motion estimation and/or motion

compensation involve(s) an interpolation process when the encoder is performing lossy compression, and the control means are further operable to inhibit use of the interpolation process when a screen content or other pattern-repetitive video sequence is encoded.

9. An HEVC-compliant encoder as claimed in any preceding claim, arranged to not use sub-pel accuracy for motion estimation and to use of sub-pel accuracy for motion compensation when encoding a screen content or other pattern-repetitive video sequence.

10. A method of encoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant encoder, wherein sub-pel accuracy is not used in motion estimation and/or motion compensation.

11. An HEVC-compliant decoder arranged to not use sub-pel accuracy in motion estimation and/or motion compensation when decoding a screen content or other pattern-repetitive video sequence.

12. An HEVC-compliant decoder as claimed in claim 11, comprising control means operable, when a screen content or other pattern-repetitive video sequence is decoded, to inhibit use of sub-pel accuracy in motion estimation and/or motion compensation.

13. An HEVC-compliant decoder as claimed in claim 12, wherein the control means are operable, when decoding a video sequence other than a screen content or pattern-repetitive video sequence, to enable use of sub-pel accuracy in motion estimation and/or motion compensation.

14. An HEVC-compliant decoder as claimed in any one of claims 11 to 13, capable of performing lossy decompression.

15. An HEVC-compliant decoder as claimed in any one of claims 11 to 14, incapable of performing lossy decompression.

16. An HEVC-compliant decoder as claimed in claim 12, comprising means for decoding the screen content or other pattern-repetitive sequence losslessly.

17. An HEVC-compliant decoder as claimed in claim 12, comprising means for decoding the screen content or other pattern-repetitive sequence lossily.

18. An HEVC-compliant decoder as claimed in claim 14 when read as appended to claim 12, wherein the motion estimation and/or motion compensation involve(s) an interpolation process when the decoder is performing lossy decompression, and the control means are further operable to inhibit use of the interpolation process when decoding a screen content or other pattern-repetitive video sequence.

19. An HEVC-compliant decoder as claimed in any one of claims 11 to 18, arranged to not use sub-pel accuracy for motion estimation and to use of sub-pel accuracy for motion compensation when decoding a screen content or other pattern-repetitive video sequence.

20. A method of decoding a screen content or other pattern-repetitive video sequence using an HEVC-compliant decoder, wherein sub-pel accuracy is not used in motion estimation and/or motion compensation.

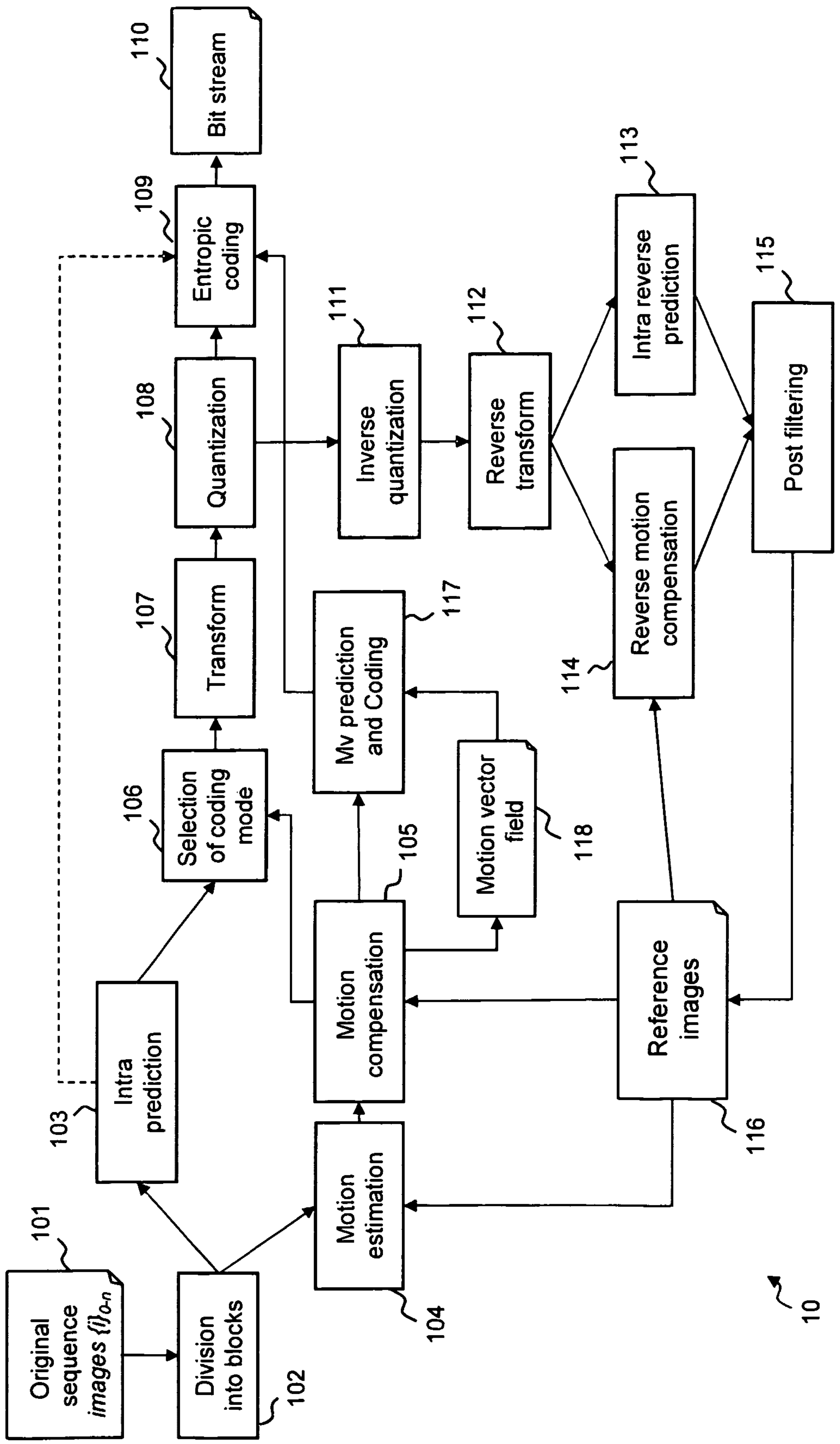
Original sequence images {I}0-n
101
Division into blocks
102
Intra prediction
103
Motion estimation
104
Motion compensation
105
Selection of coding mode
106
Transform
107
Quantization
108
Entropic coding
109
Bit stream
110
Inverse quantization
111
Reverse transform
112
Intra reverse prediction
113
Reverse motion compensation
114
Post filtering
115
Reference images
116
Mv prediction and Coding
117
Motion vector field
118
10

Figure 1

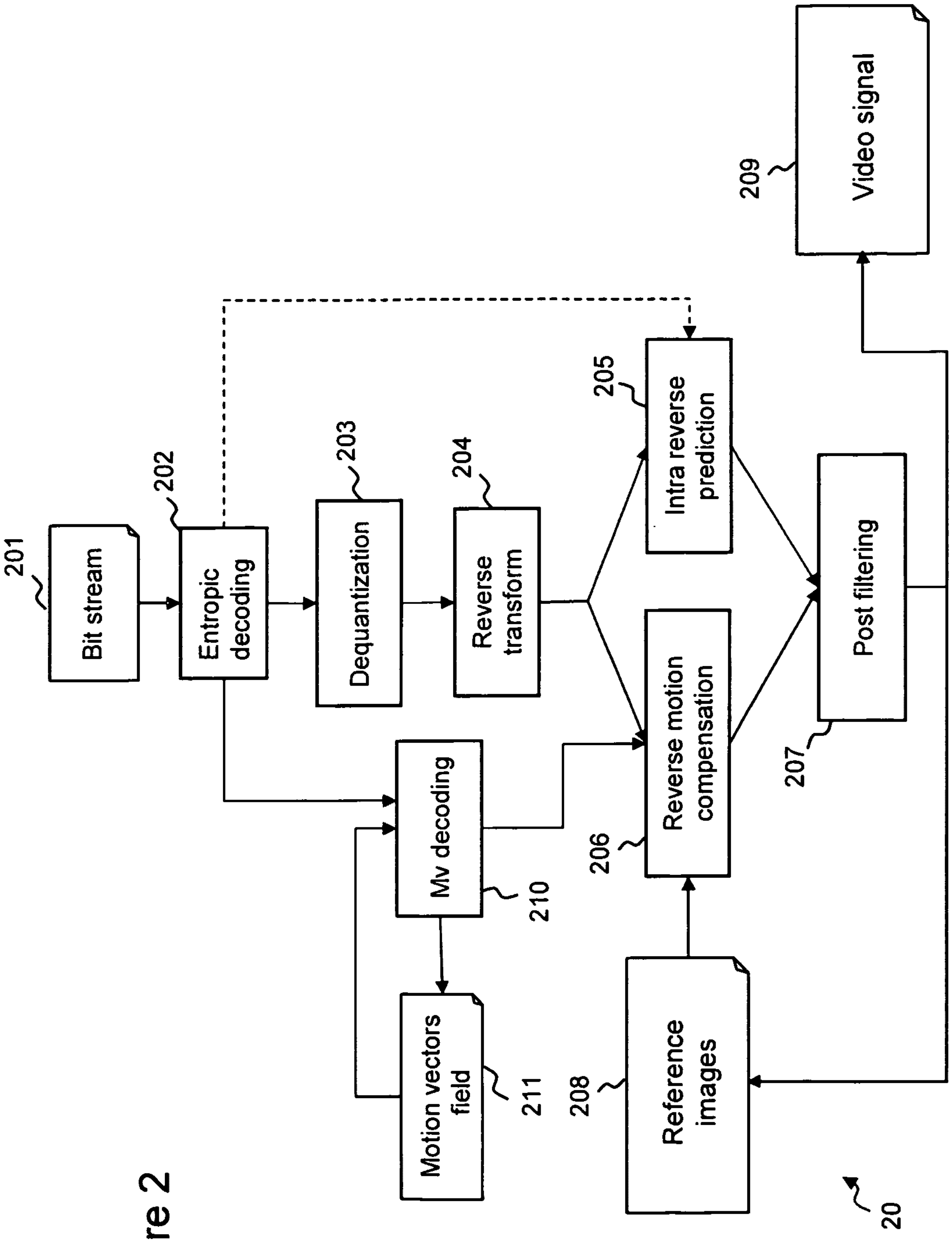
201
Bit stream
202
Entropic decoding
203
Dequantization
204
Reverse transform
205
Intra reverse prediction
206
Reverse motion compensation
207
Post filtering
208
Reference images
209
Video signal
210
Mv decoding
211
Motion vectors field
20

Figure 2

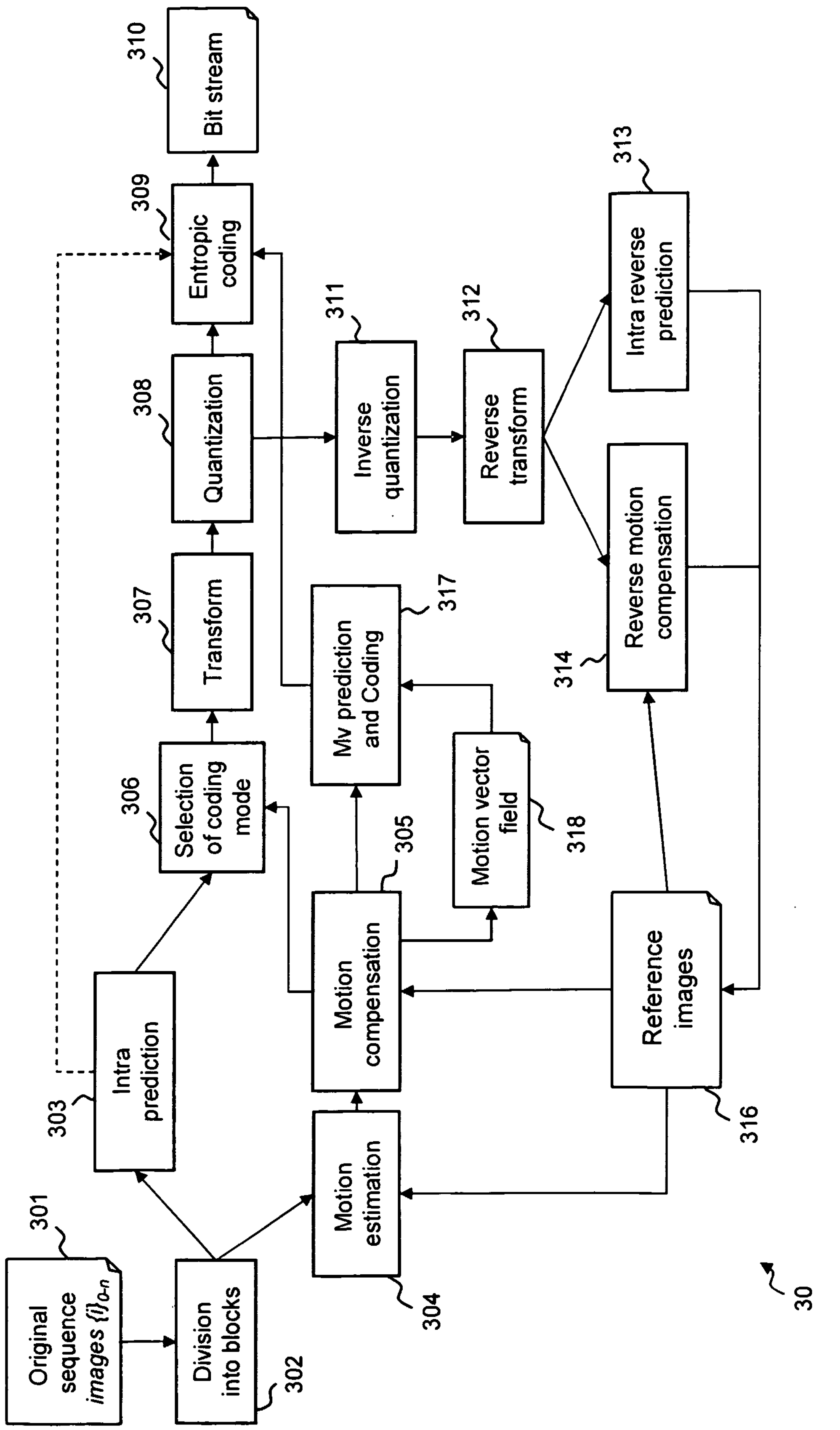
Original sequence images {I}0-n
301
Division into blocks
302
Intra prediction
303
Motion estimation
304
Motion compensation
305
Selection of coding mode
306
Transform
307
Quantization
308
Entropic coding
309
Bit stream
310
Inverse quantization
311
Reverse transform
312
Intra reverse prediction
313
Reverse motion compensation
314
Reference images
316
Mv prediction and Coding
317
Motion vector field
318
30

Figure 3

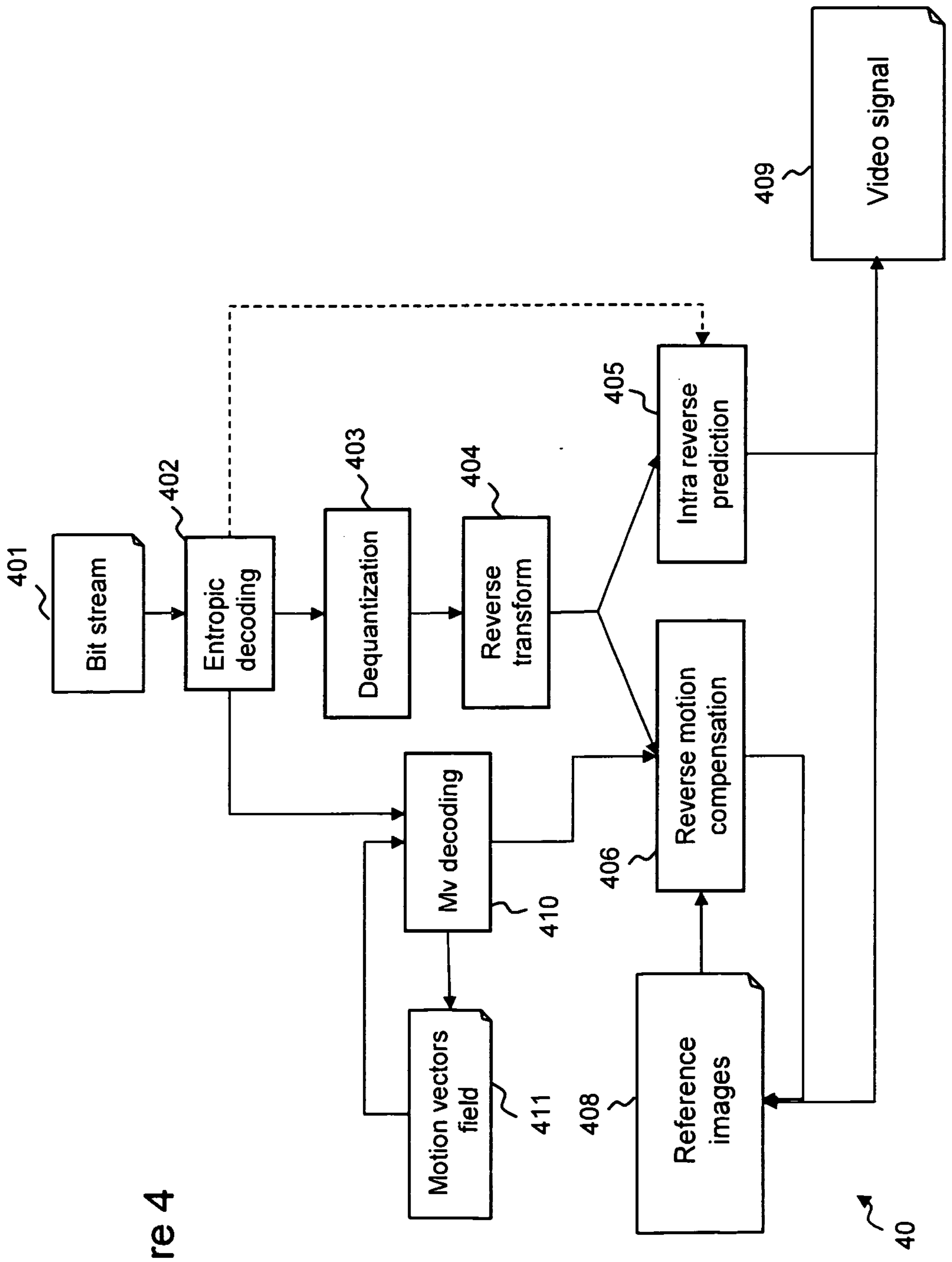
Bit stream
401
Entropic decoding
402
Dequantization
403
Reverse transform
404
Intra reverse prediction
405
Reverse motion compensation
406
Mv decoding
410
Motion vectors field
411
Reference images
408
Video signal
409
40

Figure 4

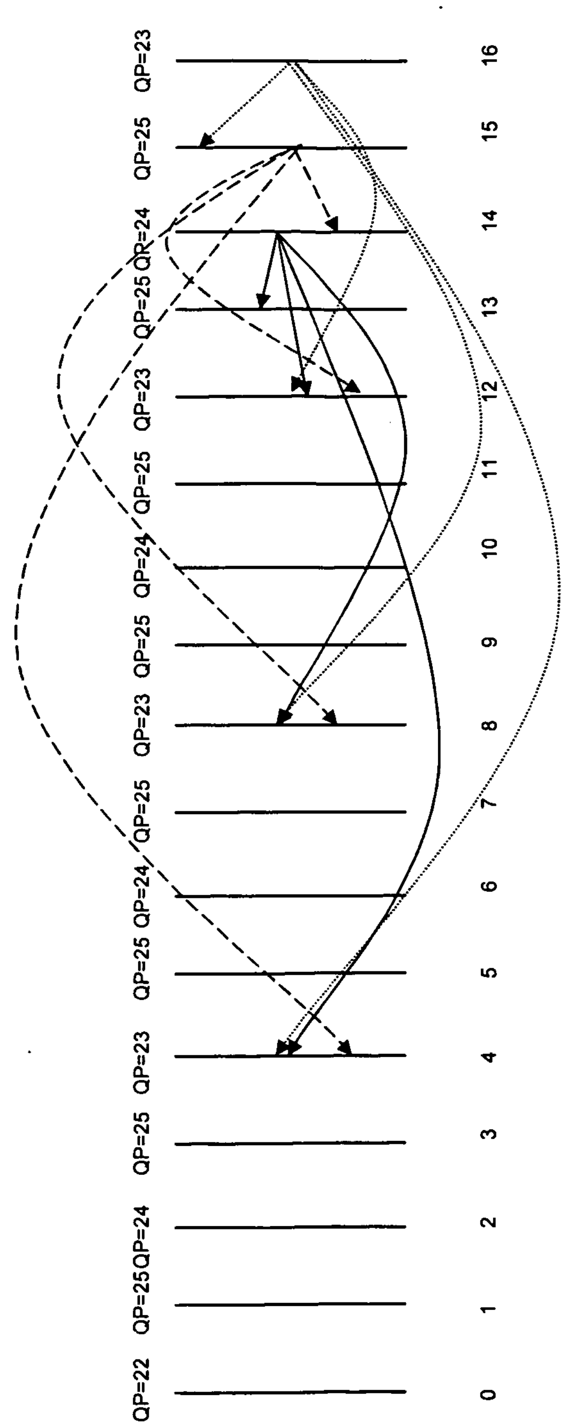

Figure 5a

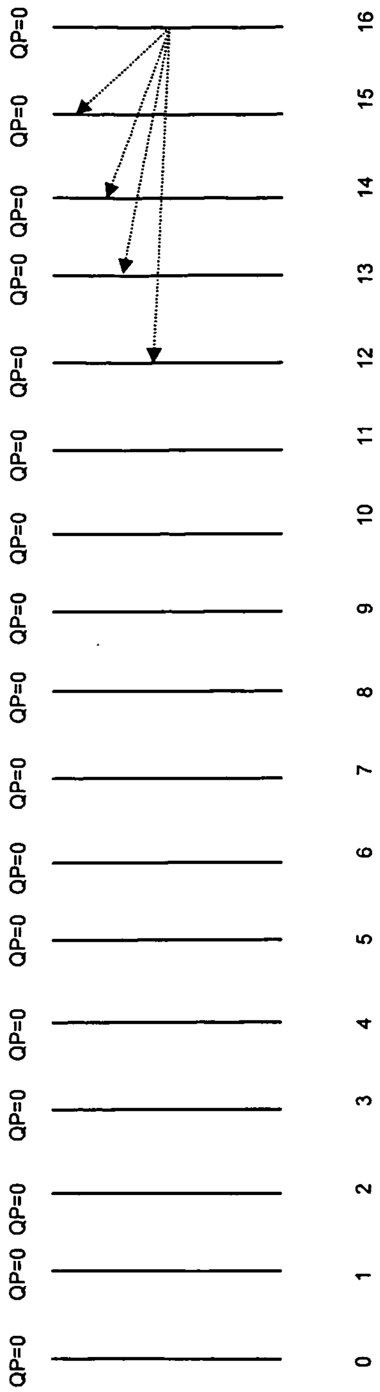

Figure 5b

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/002746

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N19/117 H04N19/523
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	LAI P ET AL: "Description of screen content coding technology proposal by MediaTek", 17. JCT-VC MEETING; 27-3-2014 - 4-4-2014; VALENCIA; (JOINT COLLABORATIVE TEAM ON VIDEO CODING OF ISO/IEC JTC1/SC29/WG11 AND ITU-T SG.16); URL: HTTP://WFTP3.ITU.INT/AV-ARCH/JCTVC-SITE/,, no. JCTVC-Q0033-v4, 26 March 2014 (2014-03-26), XP030115920, the whole document ----- -/--	1-8, 10-18,20

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 December 2014	09/01/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Cakiroglu Garton, S

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	ZHOU Y ET AL: "Motion Vector Resolution Control for Screen Content Coding", 16. JCT-VC MEETING; 9-1-2014 - 17-1-2014; SAN JOSE; (JOINT COLLABORATIVE TEAM ON VIDEO CODING OF ISO/IEC JTC1/SC29/WG11 AND ITU-T SG.16); URL: HTTP://WFTP3.ITU.INT/AV-ARCH/JCTVC-SITE/,, no. JCTVC-P0277, 9 January 2014 (2014-01-09), XP030115825, the whole document -----	1-4,7,8, 10-14, 17,18,20
X	US 2013/182770 A1 (KONDO KENJI [JP]) 18 July 2013 (2013-07-18) paragraph [0012] paragraph [0015] - paragraph [0022] paragraph [0021] - paragraph [0022] paragraph [0076] - paragraph [0086] paragraph [0116] - paragraph [0128] paragraph [0147] paragraph [0172] - paragraph [0176] -----	1-20
A	US 2011/194602 A1 (ANDERSSON KENNETH [SE] ET AL) 11 August 2011 (2011-08-11) paragraph [0012] - paragraph [0014] paragraph [0036] - paragraph [0037] paragraph [0047] - paragraph [0048] paragraph [0051] paragraph [0055] - paragraph [0000] paragraph [0016] paragraph [0018] -----	1-20
A	UGUR K ET AL: "CE3: Interpolation filter with shorter tap-length for small PU's", 6. JCT-VC MEETING; 97. MPEG MEETING; 14-7-2011 - 22-7-2011; TORINO; (JOINT COLLABORATIVE TEAM ON VIDEO CODING OF ISO/IEC JTC1/SC29/WG11 AND ITU-T SG.16); URL: HTTP://WFTP3.ITU.INT/AV-ARCH/JCTVC-SITE/,, no. JCTVC-F248, 1 July 2011 (2011-07-01), XP030009271, the whole document -----	1-20
A	LOU J ET AL: "Motorola Mobility's adaptive interpolation filter", 96. MPEG MEETING; 21-3-2011 - 25-3-2011; GENEVA; (MOTION PICTURE EXPERT GROUP OR ISO/IEC JTC1/SC29/WG11),, no. m19888, 16 March 2011 (2011-03-16), XP030048455, the whole document ----- -/--	1-20

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	YOSHINO T ET AL: "CE3 : Switching interpolation filter scheme", 20110311, no. JCTVC-E188, 11 March 2011 (2011-03-11), XP030008694, ISSN: 0000-0007 the whole document -----	1-20
A,P	WO 2013/159119 A1 (HUAWEI TECH CO LTD [CN]; FUTUREWEI TECHNOLOGIES INC [US]) 24 October 2013 (2013-10-24) the whole document -----	1-20
A	US 2012/170650 A1 (CHONG IN SUK [US] ET AL) 5 July 2012 (2012-07-05) the whole document -----	1-20

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/002746

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013182770 A1	18-07-2013	CN 103190148 A	03-07-2013
		JP 2012104945 A	31-05-2012
		US 2013182770 A1	18-07-2013
		WO 2012063604 A1	18-05-2012
US 2011194602 A1	11-08-2011	CN 102742270 A	17-10-2012
		EP 2532163 A2	12-12-2012
		US 2011194602 A1	11-08-2011
		WO 2011095583 A2	11-08-2011
WO 2013159119 A1	24-10-2013	CN 104185989 A	03-12-2014
		CN 104205843 A	10-12-2014
		US 2013279583 A1	24-10-2013
		WO 2013158998 A1	24-10-2013
		WO 2013159119 A1	24-10-2013
US 2012170650 A1	05-07-2012	CN 103339939 A	02-10-2013
		EP 2661888 A1	13-11-2013
		JP 2014502822 A	03-02-2014
		KR 20130105904 A	26-09-2013
		US 2012170650 A1	05-07-2012
		WO 2012094414 A1	12-07-2012