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(54) **Title:** ENCODER, DECODER AND METHOD FOR ADAPTIVE QUANTIZATION IN MULTI-CHANNEL PICTURE CODING

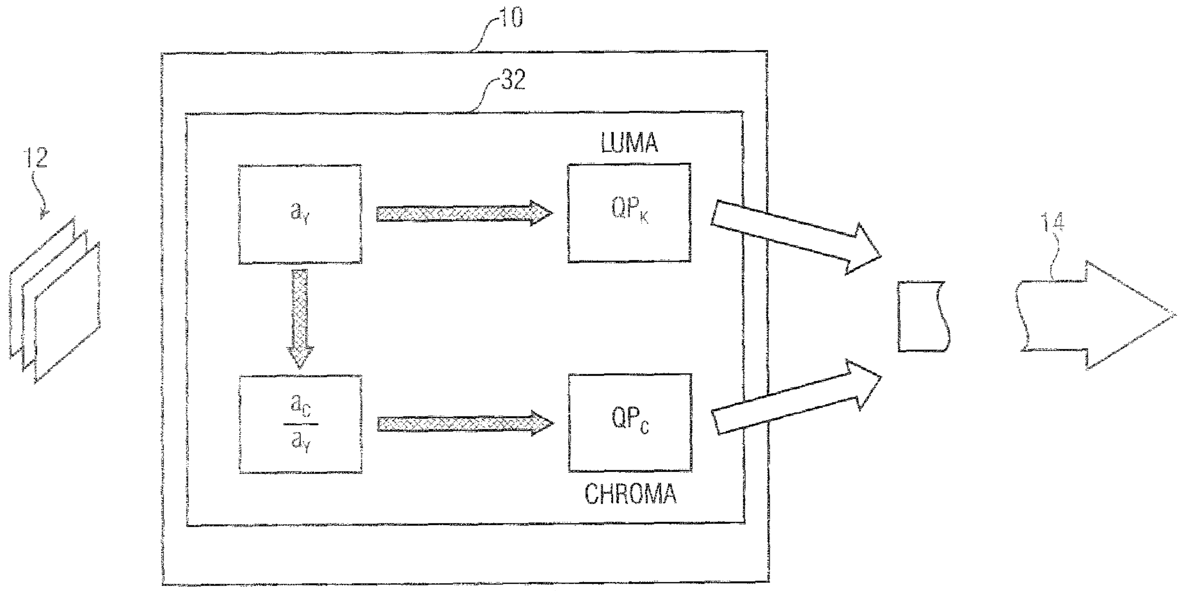

Fig. 4

(57) **Abstract:** The invention concerns an encoder (10), a decoder (20) and methods for an adaptive quantization in a multi-channel picture coding. The encoder (10) is configured to compute a quantization parameter(QP_K) for a luma component in units of blocks (B_K) of the picture (12), using an activity measure of the luma component, and to compute a quantization parameter(QP_C) for a chroma component based on a ratio, Formula (I) between an activity value (ay) of the luma component and an activity value (a_c) of the chroma component. The adaptation of the quantization parameter (QP_C) for the chroma component may be applied on a picture-wise basis and/or on a block-wise basis.

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ENCODER, DECODER AND METHOD FOR ADAPTIVE QUANTIZATION IN MULTI-CHANNEL PICTURE CODING

GENERAL DESCRIPTION

Embodiments of the present disclosure relate to an encoder for encoding a picture into a data stream, a decoder for decoding a picture from a data stream, corresponding methods for encoding and decoding, a computer readable digital storage medium, and a data stream. Particular embodiments may describe a concept of a luma-dependent adaptation of a chroma quantization parameter.

TECHNICAL BACKGROUND

In todays image processing lossy coding schemes may be exploited in which pictures may be quantized so as to obtain a reduced version of the picture. That is, a certain range of values of the picture may be compressed into a single quantum value. The higher the quantization the higher the reduction of the discrete symbols and, thus, the higher the compressibility of the picture.

The so-called quantization parameter (QP) defines the granularity of the quantization. The quantization parameter may be adaptively adjusted based on the content of the picture. The picture content may be indicated in terms of an activity. For example, a picture or a region of said picture, which contains a high activity may contain a high variance (dispersion) in the texture and/or in the color of the picture. In turn, a picture or a region of said picture, which contains a low activity may contain a low variance (dispersion) in the texture and/or in the color of the picture.

An example for a picture region comprising a high activity may be a crown of a tree, which may comprise a plurality of small leaves that may further comprise different green or other color shades. Owing to the leaves of the tree, the dispersion will be relatively high. This dispersion may, thus, be used to set the QP relatively high for this picture-region since the non-smooth or non-flat leaf texture hides for the human eye a relatively high amount of coding errors owing to quantization errors. In turn, an example for a picture region comprising a low activity may be a wall of a house, that may be monochrome or may at least comprise large monochrome areas (i.e. has a smooth or flat texture). Here, the dispersion will be relatively low and in fact, quantization errors might be liable to perception. Accordingly, the QP may be set considerably lower compared to the crown of the tree.

Furthermore, a picture that is to be compressed may be a still picture or a moving picture, the latter comprising a plurality of consecutive single frames. The picture can be a single-component picture or a multi-component picture. For example, a single-component picture may comprise a single color component, e.g. a grayscale or luminance (or luma) component only, while a multi-component picture may additionally comprise two or more color components, i.e. a luminance component and one or more chrominance (or chroma) components.

The Human Visual System (HVS) is considerably more sensitive to luma variations than to chroma variations. That means, the human eye perceives a variation in the luma component (brightness) of a picture to a considerably higher extent than a variation in the available chroma components (color shade). Accordingly, a variation in the luma component is more perceptual to a viewer than a variation of the chroma component.

For example, in HEVC a concept called perceptual AdaptiveQP may be used, wherein the quantization parameter may be adjusted based on the spatial activity of the pixel data in a luma coding block. That is, the more luma activity in a picture-region the higher the adaptive QP.

A further perceptual QO adaptation is described in [2], wherein the entire disclosure of [2] is incorporated herein by reference.

The perceptual QP adaptation (QPA) algorithm presented in [2] and employed in HHI's response to JVET's Call for Proposals (CfP) on video compression technology with capability beyond HEVC [4] is based on a subjectively motivated block-wise weighted distortion measure D derived from a local visual activity value:

$$D_{\text{pic}}^{wSSE} = \sum_k D_k^{wSSE} = \sum_k w_k \cdot D_k^{SSE} = \sum_k \left(\frac{a_{\text{pic}}}{a_k}\right)^{\beta} \cdot \sum_{(x,y)\in B_k} (s[x,y] - s'[x,y])^2,$$

where B denotes the sub-blocks (here CTUs) of the picture, indexed via k, w_k is the perceptual weight (also called visual sensitivity measure), a_k is the block's visual activity, a_{pic} is the picture's mean visual activity, and s, s' are the original and reconstructed pel values, respectively, of the picture's luma component. Using D_{pic}^{wSSE}, the picture's width W, height H, and component bit-depth BD, a *weighted* peak signal-to-noise ratio

$$\text{WPSNR} = 10 \cdot \log_{10}\left(\frac{W \cdot H \cdot 255^2 \cdot 2^{2BD-16}}{D_{\text{pic}}^{WSSE}}\right)$$

can be obtained. Notice that, when $w_k = 1$ for all blocks, this WPSNR definition reduces to the conventional PSNR metric used by the JVET. This is particularly true when $\beta = 0$. In [2], the use of $\beta = \frac{2}{3}$ was suggested.

During encoding, the perceptual QPA makes use of w_k to adapt in each CTU at k the perceptually optimized QP and Lagrange parameter based on the default pre-assigned *fixed* QP_{slice} and Lagrange parameter λ_{slice}:

$$QP_k = QP_{\text{slice}} - 3\log_2 w_k, \quad \lambda_k = \frac{\lambda_{\text{slice}}}{w_k}.$$

Using the adapted QP_k and λ_k in each CTU block ensures that, in terms of visual quality and WPSNR, the coding distortion is optimally distributed within the given picture and within the pictures of the video signal. In other words, the visual sensitivity measure for a picture block k is given by $w_k = \left(\frac{a_{\text{pic}}}{a_k}\right)^{\beta}$ with, preferably,

$$a_k = \max\left(a_{\min}^2;\left(\frac{1}{|B_k^*|}\sum_{[x,y]\in B_k^*}|h[x,y]|\right)^2\right), \quad a_{\text{pic}} = 2^{BD}\cdot\begin{cases}16 & \text{for UHD sequences,}\\ 32 & \text{for HD sequences,}\\ 64 & \text{otherwise,}\end{cases}$$

where weight exponent $0 \le \beta \le 1$, lower activity limit $0 \le a_{\min} \le 8$, and $h[\,] = \text{filter}(s[\,])$ are the high-pass filtered input (i.e., original) samples of the picture's luminance component, as described in detail in [2].

Note that, instead of the above *block*-wise adaptation, a generalized *picture*-wise adaptation of a fixed user-defined QP value QP_{slice} can be realized as follows, but with a picture-wise sensitivity value $w_{\text{Y}} = \left(\frac{a_{\text{pic}}}{a_{\text{Y}}}\right)^{\beta}$:

$$QP'_{\text{slice}} = QP_{\text{slice}} - 3\log_2 w_{\text{Y}}, \quad a_{\text{Y}} = \max\left(a_{\min}^2;\left(\frac{1}{|P_{\text{Y}}^*|}\sum_{[x,y]\in P_{\text{Y}}^*}|h[x,y]|\right)^2\right),$$

with Y denoting the image's luminance component, contained in the picture sample buffer P_Y, with $B_Y \in P_Y$.

The perceptual QP adaptation described in [2] leads to a much better coding efficiency compared to using fixed QP values instead.

However, it would be desirable to provide an even higher gain in coding efficiency without significant loss in the picture quality. Accordingly, it is an object of the present invention to improve existing quantization schemes, in particular for multi-component pictures.

According to the invention, this problem is solved with an encoder according to claim 1, a decoder according to claim 14, a method for encoding according to claim 22, a method for decoding according to claim 23, a data stream according to claim 24 and a computer readable digital storage medium according to claim 25. Particular and preferable embodiments are mentioned in the dependent claims.

The inventive encoder is configured to compute a quantization parameter QP_K for a luma component in units of blocks B_K of the picture, using an activity measure of the luma component. According to this aspect of the invention, the encoder is further configured to compute a quantization parameter QP_C for a chroma component based on a ratio $\frac{a_C}{a_Y}$ between an activity value a_Y of the luma component and an activity value a_c of the chroma component. That is, in a first step the quantization parameter QP_K for the luma component of the picture may be calculated for one or more blocks of the picture, and preferably for each block of the picture, i.e. on a block-wise basis. Accordingly, for one or more (or each) block of the picture, a QP can be obtained that may be adaptable to the luma component of the respective block. The adaptation of the luma-QP may be based on a measure of the visual activity of the luma component, i.e. of the luma coding block. The visual activity is indicated by an activity value a_Y of the luma component. Said activity value a_Y of the luma component of the respective block may be set in relation to an activity value a_c of a chroma component of the same block or of the entire picture. Then, in a second step, an adaptive QP for the chroma component is computed based on the above mentioned relation between the activity value a_Y of the luma component and the activity value a_c of the chroma component, i.e. on a ratio $\frac{a_C}{a_Y}$. The adaptive QP for the chroma component may be computed for one or more blocks separately, i.e. block-wise, or for a certain arrangement of blocks, e.g. slice-wise, or for the entire picture, i.e. frame-wise or picture-wise. In either case, the computed adaptive QP for the chroma component may then be transmitted in the bit stream to the decoder.

The inventive decoder may derive the above mentioned adaptive QPs from the bit stream. In particular, the decoder may derive the quantization parameter QP_K for the luma component in units of blocks of the picture, i.e. the block-wise computed QP_K. The decoder may further derive the quantization parameter QP_C for the chroma component in units of further blocks of the picture. Said further blocks may represent a single block or sub-block (e.g. a block-wise QP-adaptation) or a plurality of blocks being arranged in a certain order (e.g. a picture-wise QP-adaptation, e.g. slice-wise) or the entire picture (e.g. a picture-wise QP-adaptation, e.g. frame-wise). As mentioned above, the adaptive QP for the chroma component may have been computed for one or more blocks separately, i.e. block-wise, or for a certain arrangement of blocks, e.g. slice-wise, or for the entire picture, i.e. frame-wise or picture-wise.

Furthermore, a method for encoding a picture is suggested, wherein the method comprises steps of computing a quantization parameter QP_K for a luma component in units of blocks B_K of the picture, using an activity measure of the luma component, and computing a quantization parameter QP_C for a chroma component based on a ratio $\frac{a_C}{a_Y}$ between an activity value a_Y of the luma component and an activity value a_c of the chroma component.

Still further, a method for decoding a picture is suggested, wherein the method comprises steps of deriving from a bit stream a quantization parameter QP_K for a luma component of the picture, and a quantization parameter for a chroma component QP_C of the picture, wherein the quantization parameter (QP_C) for the chroma component is calculated based on a ratio $\frac{a_C}{a_Y}$ between an activity a_Y of the luma component and an activity a_c of the chroma component.

In the following, embodiments of the present disclosure are described in more detail with reference to the figures, in which

Fig. 1 shows a schematic block diagram of an encoder for block-based coding, which encoder may be used to apply the inventive principle,

Fig. 2 shows a schematic block diagram of a decoder for block-based decoding, which decoder may be used to apply the inventive principle,

Fig. 3 shows a schematic drawing of a picture being partitioned into block and sub blocks,

Fig. 4 shows a schematic block diagram of an encoder according to an embodiment,

Fig. 5 shows a schematic block diagram of an decoder according to an embodiment,

Fig. 6 shows a schematic block diagram of a method for encoding according to an embodiment, and

Fig. 7 shows a schematic block diagram of method for decoding according to an embodiment.

DESCRIPTION OF THE FIGURES

Equal or equivalent elements or elements with equal or equivalent functionality are denoted in the following description by equal or equivalent reference numerals.

Method steps which are depicted by means of a block diagram and which are described with reference to said block diagram may also be executed in an order different from the depicted and/or described order. Furthermore, method steps concerning a particular feature of a device may be replaceable with said feature of said device, and the other way around.

Furthermore, the following terminology may be used in order to provide a clear separation between different embodiments: For instance, a computation may be executed block-wise or picture-wise. The result of a block-wise computation may provide a block-related value being specific for the particular block on which the computation was executed. A picture-wise computation may be executed slice-wise, i.e. on a slice-by-slice basis, or frame-wise, i.e. on a frame-by-frame basis. The result of a picture-wise computation may provide a picture-related value being specific for the particular slice or frame on which the computation was executed.

The following description of the figures starts with a presentation of a description of an encoder and a decoder of a block-based predictive codec for coding pictures of a video in order to form an example for a coding framework into which embodiments of the present invention may be built in. The respective encoder and decoder are described with respect to Figures 1 to 3. Thereinafter the description of embodiments of the concept of the present invention is presented along with a description as to how such concepts could be built into the encoder and decoder of Figures 1 and 2, respectively, although the embodiments described with the subsequent Figures 4 and following, may also be used to form encoders and decoders not operating according to the coding framework underlying the encoder and decoder of Figures 1 and 2.

Figure 1 shows an apparatus for predictively coding a picture 12 into a data stream 14 exemplarily using transform-based residual coding. The apparatus, or encoder, is indicated using reference sign 10. Figure 2 shows a corresponding decoder 20, i.e. an apparatus 20 configured to predictively decode the picture 12' from the data stream 14 also using transform-based residual decoding, wherein the apostrophe has been used to indicate that the picture 12' as reconstructed by the decoder 20 deviates from picture 12 originally encoded by apparatus 10 in terms of coding loss introduced by a quantization of the prediction residual signal. Figure 1 and Figure 2 exemplarily use transform based prediction residual coding, although embodiments of the present application are not restricted to this kind of prediction residual coding. This is true for other details described with respect to Figures 1 and 2, too, as will be outlined hereinafter.

The encoder 10 is configured to subject the prediction residual signal to spatial-to-spectral transformation and to encode the prediction residual signal, thus obtained, into the data stream 14. Likewise, the decoder 20 is configured to decode the prediction residual signal from the data stream 14 and subject the prediction residual signal thus obtained to spectral-to-spatial transformation.

Internally, the encoder 10 may comprise a prediction residual signal former 22 which generates a prediction residual 24 so as to measure a deviation of a prediction signal 26 from the original signal, i.e. from the picture 12. The prediction residual signal former 22 may, for instance, be a subtractor which subtracts the prediction signal from the original signal, i.e. from the picture 12. The encoder 10 then further comprises a transformer 28 which subjects the prediction residual signal 24 to a spatial-to-spectral transformation to obtain a spectral-domain prediction residual signal 24' which is then subject to quantization by a quantizer 32, also comprised by the encoder 10. The thus quantized prediction residual signal 24'' is coded into bitstream 14. To this end, encoder 10 may optionally comprise an entropy coder 34 which entropy codes the prediction residual signal as transformed and quantized into data stream 14. The prediction signal 26 is generated by a prediction stage

36 of encoder 10 on the basis of the prediction residual signal 24'' encoded into, and decodable from, data stream 14. To this end, the prediction stage 36 may internally, as is shown in Figure 1, comprise a dequantizer 38 which dequantizes prediction residual signal 24'' so as to gain spectral-domain prediction residual signal 24''', which corresponds to signal 24' except for quantization loss, followed by an inverse transformer 40 which subjects the latter prediction residual signal 24''' to an inverse transformation, i.e. a spectral-to-spatial transformation, to obtain prediction residual signal 24'''', which corresponds to the original prediction residual signal 24 except for quantization loss. A combiner 42 of the prediction stage 36 then recombines, such as by addition, the prediction signal 26 and the prediction residual signal 24'''' so as to obtain a reconstructed signal 46, i.e. a reconstruction of the original signal 12. Reconstructed signal 46 may correspond to signal 12'. A prediction module 44 of prediction stage 36 then generates the prediction signal 26 on the basis of signal 46 by using, for instance, spatial prediction, i.e. intra-picture prediction, and/or temporal prediction, i.e. inter-picture prediction.

Likewise, decoder 20, as shown in Figure 2, may be internally composed of components corresponding to, and interconnected in a manner corresponding to, prediction stage 36. In particular, entropy decoder 50 of decoder 20 may entropy decode the quantized spectral-domain prediction residual signal 24'' from the data stream, whereupon dequantizer 52, inverse transformer 54, combiner 56 and prediction module 58, interconnected and cooperating in the manner described above with respect to the modules of prediction stage 36, recover the reconstructed signal on the basis of prediction residual signal 24'' so that, as shown in Figure 2, the output of combiner 56 results in the reconstructed signal, namely picture 12'.

Although not specifically described above, it is readily clear that the encoder 10 may set some coding parameters including, for instance, prediction modes, motion parameters and the like, according to some optimization scheme such as, for instance, in a manner optimizing some rate and distortion related criterion, i.e. coding cost. For example, encoder 10 and decoder 20 and the corresponding modules 44, 58, respectively, may support different prediction modes such as intra-coding modes and inter-coding modes. The granularity at which encoder and decoder switch between these prediction mode types may correspond to a subdivision of picture 12 and 12', respectively, into coding segments or coding blocks. In units of these coding segments, for instance, the picture may be subdivided into blocks being intra-coded and blocks being inter-coded. Intra-coded blocks are predicted on the basis of a spatial, already coded/decoded neighborhood of the respective block as is outlined in more detail below. Several intra-coding modes may exist and be selected for a respective intra-coded segment including directional or angular intra-coding modes according to which the respective segment is filled by extrapolating the sample values of the neighborhood along a certain direction which is specific for the respective directional intra-coding mode, into the respective intra-coded segment. The intra-coding modes may, for instance, also comprise one or more further modes such as a DC coding mode, according to which the prediction for the respective intra-coded block assigns a DC value to all samples within the respective intra-coded segment, and/or a planar intra-coding mode according to which the prediction of the respective block is approximated or determined to be a spatial distribution of sample values described by a two-dimensional linear function over the sample positions of the respective intra-coded block with driving tilt and offset of the plane defined by the two-dimensional linear function on the basis of the neighboring samples. Compared thereto, inter-coded blocks may be predicted, for instance, temporally. For inter-coded blocks, motion vectors may be signaled within the data stream, the motion vectors indicating the spatial displacement of the portion of a previously coded picture of the video to which picture 12 belongs, at which the previously coded/decoded picture is sampled in order to obtain the prediction signal for the respective inter-coded block. This means, in addition to the residual signal coding comprised by data stream 14, such as the entropy-coded transform coefficient levels representing the quantized spectral-domain prediction residual signal 24'', data stream 14 may have encoded thereinto coding mode parameters for assigning the coding modes to the various blocks, prediction parameters for some of the blocks, such as motion parameters for inter-coded segments, and optional further parameters such as parameters for controlling and signaling the subdivision of picture 12 and 12', respectively, into the segments. The decoder 20 uses these parameters to subdivide the picture in the same manner as the encoder did, to assign the same prediction modes to the segments, and to perform the same prediction to result in the same prediction signal.

Figure 3 illustrates the relationship between the reconstructed signal, i.e. the reconstructed picture 12', on the one hand, and the combination of the prediction residual signal 24'''' as signaled in the data stream 14, and the prediction signal 26, on the other hand. As already denoted above, the combination may be an addition. The prediction signal 26 is illustrated in Figure 3 as a subdivision of the picture area into intra-coded blocks which are illustratively indicated using hatching, and inter-coded blocks which are illustratively indicated not-hatched. The subdivision may be any subdivision, such as a regular subdivision of the picture area into rows and columns of square blocks or non-square blocks, or a multi-tree subdivision of picture 12 from a tree root block into a plurality of leaf blocks of varying size, such as a quadtree subdivision or the like, wherein a mixture thereof is illustrated in Figure 3 in which the picture area is first subdivided into rows and columns of tree root blocks which are then further subdivided in accordance with a recursive multi-tree subdivisioning into one or more leaf blocks.

Again, data stream 14 may have an intra-coding mode coded thereinto for intra-coded blocks 80, which assigns one of several supported intra-coding modes to the respective intra-coded block 80. For inter-coded blocks 82, the data stream 14 may have one or more motion parameters coded thereinto. Generally speaking, inter-coded blocks 82 are not restricted to being temporally coded. Alternatively, inter-coded blocks 82 may be any block predicted from previously coded portions beyond the current picture 12 itself, such as previously coded pictures of a video to which picture 12 belongs, or picture of another view or an hierarchically lower layer in the case of encoder and decoder being scalable encoders and decoders, respectively.

The prediction residual signal 24'''' in Figure 3 is also illustrated as a subdivision of the picture area into blocks 84. These blocks might be called transform blocks in order to distinguish same from the coding blocks 80 and 82. In effect, Figure 3 illustrates that encoder 10 and decoder 20 may use two different subdivisions of picture 12 and picture 12', respectively, into blocks, namely one subdivisioning into coding blocks 80 and 82, respectively, and another subdivision into transform blocks 84. Both subdivisions might be the same, i.e. each coding block 80 and 82, may concurrently form a transform block 84, but Figure 3 illustrates the case where, for instance, a subdivision into transform blocks 84 forms an extension of the subdivision into coding blocks 80, 82 so that any border between two blocks of blocks 80 and 82 overlays a border between two blocks 84, or alternatively speaking each block 80, 82 either coincides with one of the transform blocks 84 or coincides with a cluster of transform blocks 84. However, the subdivisions may also be determined or selected independent from each other so that transform blocks 84 could alternatively cross block borders between blocks 80, 82. As far as the subdivision into transform blocks 84 is concerned, similar statements are thus true as those brought forward with respect to the subdivision into blocks 80, 82, i.e. the blocks 84 may be the result of a regular subdivision of picture area into blocks (with or without arrangement into rows and columns), the result of a recursive multi-tree subdivisioning of the picture area, or a combination thereof or any other sort of blockation. Just as an aside, it is noted that blocks 80, 82 and 84 are not restricted to being of quadratic, rectangular or any other shape.

Figure 3 further illustrates that the combination of the prediction signal 26 and the prediction residual signal 24"" directly results in the reconstructed signal 12'. However, it should be noted that more than one prediction signal 26 may be combined with the prediction residual signal 24"" to result into picture 12' in accordance with alternative embodiments.

In Figure 3, the transform blocks 84 shall have the following significance. Transformer 28 and inverse transformer 54 perform their transformations in units of these transform blocks 84. For instance, many codecs use some sort of DST or DCT for all transform blocks 84. Some codecs allow for skipping the transformation so that, for some of the transform blocks 84, the prediction residual signal is coded in the spatial domain directly. However, in accordance with embodiments described below, encoder 10 and decoder 20 are configured in such a manner that they support several transforms. For example, the transforms supported by encoder 10 and decoder 20 could comprise:

- DCT-II (or DCT-III), where DCT stands for Discrete Cosine Transform
- DST-IV, where DST stands for Discrete Sine Transform
- DCT-IV
- DST-VII
- Identity Transformation (IT)

Naturally, while transformer 28 would support all of the forward transform versions of these transforms, the decoder 20 or inverse transformer 54 would support the corresponding backward or inverse versions thereof:

- Inverse DCT-II (or inverse DCT-III)
- Inverse DST-IV
- Inverse DCT-IV
- Inverse DST-VII
- Identity Transformation (IT)

As already outlined above, Figures 1 to 3 have been presented as an example where the inventive concept described further below may be implemented in order to form specific examples for encoders and decoders according to the present application. Insofar, the encoder and decoder of Figures 1 and 2, respectively, may represent possible implementations of the encoders and decoders described herein below. Figures 1 and 2 are, however, only examples. An encoder according to embodiments of the present application may, however, perform block-based encoding of a picture 12 using the concept outlined in more detail below and being different from the encoder of Figure 1 such as, for instance, in that same is no video encoder, but a still picture encoder, in that same does not support inter-prediction, or in that the sub-division into blocks 80 is performed in a manner different than exemplified in Figure 3. Likewise, decoders according to embodiments of the present application may perform block-based decoding of picture 12' from data stream 14 using the coding concept further outlined below, but may differ, for instance, from the decoder 20 of Figure 2 in that same is no video decoder, but a still picture decoder, in that same does not support intra-prediction, or in that same sub-divides picture 12' into blocks in a manner different than described with respect to Figure 3 and/or in that same does not derive the prediction residual from the data stream 14 in transform domain, but in spatial domain, for instance.

The innovative concepts described herein are concerned with an approach for a perceptual QP adaptation, and in particular with a luma-dependent QP-adaptation for a chroma component, that shall be explained in detail in the following with reference to the Figures.

Figure 4 shows an inventive encoder 10 for encoding a picture 12 exploiting the innovative QP-adaptation approach. The picture 12 may be a still picture or a moving picture sequence of consecutive images or frames. The encoder 10 may, for instance, comprise an above mentioned quantizer 32 for quantizing the picture 12.

The quantizer 32 and, thus, the encoder 10 may be configured to compute a quantization parameter QP_K for a luma component in units of blocks 80, 82, 84 of the picture 12. That is, for one or more blocks 80, 82, 84, and preferably for each block of the picture 12, its corresponding block-related or block-specific quantization parameter QP_K for the luma component may be determined. More generally speaking, the quantization parameter QP_K for the luma component may be determined in units of blocks B_K. The quantization parameter QP_K for the luma component may also be referred to as the luma-QP. Since the luma-QP is block-related or block-specific, the luma-QP is denoted by QP_K. The luma-QP QP_K may be determined by means of an activity measure of the luma component of the respective block. The activity measure gives an activity value a_Y of the luma component.

According to the herein described innovative principle, the encoder 10 may be configured to compute a quantization parameter for a chroma component depending on the luma component. The quantization parameter for the chroma component may also be referred to as the chroma-QP and may be denoted with QP_C. An activity measure for the chroma component may be executed, which gives an activity value a_c of the luma component. The computation of the chroma-QP QP_C is based on a ratio $\frac{a_c}{a_Y}$ between the activity value a_Y of the luma component and the activity value a_c of the chroma component. Accordingly, the innovative encoder 10 may be configured to determine an adaptive luma-dependent chroma-QP.

The block-based luma-QP QP_K and the chroma-QP QP_C may be signaled in the data stream 14. The chroma-QP QP_C may be signaled by means of a QP index value indicating the luma-QP plus/minus a chroma-QP offset value O_c or by means of the chroma-QP offset value O_c only. Details about the signaling will follow somewhat later in the text.

As mentioned above, the computation of the luma-QP QP_K may be executed on a block-wise basis. For example, the block-wise computed luma-QP QP_K may be determined by an approach according to [2], the content of which is explicitly incorporated herein by reference.

The luma-dependent computation of the chroma-QP QP_C according to the innovative principle as described herein may be executed on a block-wise basis or on a picture-wise basis. The following description firstly discusses the picture-wise computation of the luma-dependent chroma QP QP_C and subsequently the block-wise computation of the luma-dependent chroma QP QP_C.

Picture-wise chroma-QP adaptation

The chroma-QP QP_C may be computed on a *picture*-wise basis. That is, an adaptive chroma-QP QP_C may be computed that is applicable to the entire picture 12, which may be a single image or picture, respectively, or a plurality of consecutive images in a video. In the *picture*-wise approach, the chroma-QP QP_C may be referred to as a picture-related chroma-QP or as a picture-related quantization parameter QP_C for the chroma component, respectively.

The picture-related quantization parameter QP_C for the chroma component may be computed on a frame-by-frame basis, wherein the picture-related quantization parameter QP_C may be computed for at least one chroma component contained in at least one frame of a moving picture sequence, or on a slice-by-slice basis, wherein the picture-related quantization parameter QP_C may be computed for at least one chroma component contained in at least one slice of the picture 12. For example, a *mean* picture-related quantization parameter QP_C may be computed for the whole picture. For this, a *mean* value over one or more available chroma-QPs, and preferably over each available chroma-QP, may be calculated. Furthermore, a *mean* chroma activity value $\bar{a}_c$ over one or more available chroma components, and preferably over each available chroma component, may be calculated.

Furthermore, if the chroma-QP QP_C is computed on a *picture*-wise basis (e.g. frame-by-frame or slice-by-slice), a *mean* value over one or more block-wise computed luma-QPs QP_K, and preferably over each block-wise computed luma-QP QP_K, may be calculated. Accordingly, the luma-QP may be a *picture*-wise *mean* luma-QP denoted with $\overline{QP}_K$. Additionally or alternatively, also the activity value a_Y of the luma component may be a *picture*-wise *mean* activity value $\bar{a}_y$ over one or more block-wise activity values a_K, and preferably over each block-wise activity value a_K, of the luma component.

According to this exemplary embodiment, the quantization parameter QP_C for the chroma component may be computed *picture*-wise such that the chroma-QP QP_C is a picture-related quantization parameter in this case. The picture-related chroma-QP QP_C may be computed based on the ratio between the *picture*-wise activity value a_c of the chroma component and the *picture*-wise activity value a_y of the luma component, i.e. based on the ratio $\frac{a_C}{a_Y}$, wherein the *picture*-wise activity value a_y of the luma component may be the above mentioned *picture*-wise *mean* luma activity value $\bar{a}_y$. Additionally or alternatively, the *picture*-wise activity value a_c of the chroma component may be the above mentioned *picture*-wise *mean* chroma activity value $\bar{a}_c$.

Again, the picture-wise approach may include to apply the herein described concept on a slice-by-slice basis, wherein the herein described principle may be applied to one or more slices, and preferably to each slice, of the picture. Alternatively, the picture-wise approach may include to apply the herein described concept on a frame-by-frame basis, wherein the herein described principle may be applied to one or more frames, and preferably to each frame, of a plurality of consecutive frames in a vieo.

Briefly summarizing, the concept of this embodiment is to apply the above discussed *block*-wise perceptual QP adaptation to the luma component of an image or video first, wherein the concept of [2] may be applied. Then, as an inventive approach, a separate and independent adaptation of the *picture*-wise mean QP value applied to each chroma component, based on the previously determined visual activity statistics for the luma channel, is carried out.

In HEVC and its codec successors, a predefined *luma-QP-to-chroma-QP* mapping is employed during the quantization and reconstruction of 4:2:0 coded input (*ChromaArrayType* =1); see Table 8-10 in [10], Section 8.6.1 for details. This mapping effectively reduces the chroma QP – and, thereby, the chroma quantization distortion – at high luma QPs near $QP_{\max}$, which may explain why, at low coding bit-rates, the use of positive chroma QP offsets has recently been suggested. In combination with the proposed perceptual QPA, such a reduction of the chroma QP values relative to the luma QP values seems to be unnecessary in terms of visual reconstruction quality, particularly when a cross-component predictive coding technique such as the linear-model chroma (CCLM) predictor [11] is utilized. In fact, excessive *fixed* redistribution of coding bits to the chroma channels at low rates potentially leads to visible quality reduction on individual video sequences.

Given the abovementioned disadvantages of a *fixed* input-independent luma-to-chroma QP adjustment via, e. g., the transmission of nonzero *pps_cb_qp_offset* and *pps_cr_qp_offset* values in the PPS header [10], the inventive principle proposes to, when perceptual QPA is enabled, employ input-dependent *adaptive* luma-to-chroma QP offsets on a frame-by-frame or a slice-by-slice basis. Specifically, it is suggested to extend the luma-based QPA approach of [2] by the following backward-compatible HEVC syntax-compliant chroma QPA method:

1. When the --PerceptQPA or --SliceChromaQPOffsetPeriodicity encoder configuration parameter is provided with a positive value, *pps_slice_chroma_qp_offsets_present_flag* = 1 may be set in the coded PPS.

2. For each picture 12 (e.g. for each slice or frame) and chroma component $c \in$ [Cb, Cr] present in the coded image or video, a picture-related chroma-QP value QP_c may be determined from the ratio between said chroma channel's activity a_c and the luma activity a_Y:

$$QP_c = \begin{cases} \text{round}\left(3\beta \cdot \log_2\left(\alpha \cdot \dfrac{a_c}{a_Y}\right)\right), & \alpha \cdot a_c > a_Y, \\ 0, & \text{otherwise,} \end{cases}$$

$$\text{with } a_K = \max\left(a_{\min}^2;\ \left(\tfrac{1}{|P_k^*|}\textstyle\sum_{[x,y]\in P_k^*}|h[x,y]|\right)^2\right)$$

where the chroma channel's activity value a_c may be the chroma channel's *mean* activity value $\bar{a}_c$ and the luma activity value a_Y may be the *mean* luma activity value $\bar{a}_Y$; subscript Y denotes the luma component, $0 \leq \beta \leq 1$ as previously, $k \in$

[Y, Cb, Cr], and P_k^* is the component's frame buffer, excluding the border pel rows and columns to prevent the high-pass filter from extending beyond the picture boundaries. Value α is a constant. Preferably, $\alpha = 4$.

3. The *picture*-wise (e.g. frame-wise or slice-wise) *mean* luma QP $\overline{QP}_Y$ may be obtained, e.g. by using the a_{pic} according to [2]:

$$\overline{QP}_Y = QP'_{\text{slice}}.$$

4. A difference d between $\overline{QP}_Y$ and the luma-to-chroma mapping of $\overline{QP}_Y$ may be obtained according to [10]:

$$d = \overline{QP}_Y - \text{Qp}_\text{C}(\overline{QP}_Y),\ \ \text{Qp}_\text{C}() \coloneqq \text{chroma QP lookup via HEVC Table } 8-10.$$

Note: steps 3 and 4 are optional. They can be bypassed by assuming a zero difference, i. e., $d = 0$.

5. A *picture*-related (e.g. slice-wise or frame-wise) offset O_c may be set according to $O_c = \min(O_{\max} + d; QP_c + d)$ with $O_{\max} = 3$. This chroma QP Adaptation effectively lowers the coding bit-rate of the chroma channel when its mean visual activity is relatively high compared to the luma channel's visual activity. At the same time, it compensates for the picture-averaged fixed luma-to-chroma QP mapping by $\text{Qp}_\text{C}()$ to prevent undesired re-shifting of coding bits from luma to chroma.

The upper limit $O_{\max}$ is introduced to prevent very coarse chroma-channel quantization on some sequences at lower bit-rates. Within the CTC sequence set, it only affects the encoding of the *ParkRunning3* sequence. It is worth mentioning that the slice-wise offsets O_c, which can be transmitted as the *slice_cb_qp_offset* and *slice_cr_qp_offset* elements in HEVC and VTM/BMS 1, can still be combined with non-zero PPS-wise QP chroma offsets (*pps_cb_qp_offset* and *pps_cr_qp_offset*) in the traditional fashion known from HEVC [10].

In summary, the additional derivation of a QP offset O_c for each chroma component c represents a separate, independent quantization parameter adaptation for the components of a multi-component image or video.

Said picture-wise chroma QP offset O_c may be applied in the encoding and decoding of the image or video. For example, use $\overline{QP}_Y + O_c$ in the encoder-side quantization and decoder-side dequantization (also called inverse quantization) of any prediction residual in the given chroma component c.

In order to allow for correct decoder-side dequantization according to this proposal, the chroma QP data $\overline{QP}_Y + O_c$, or at least the offsets O_c, may be conveyed from the encoder to the decoder. Therefore, for each picture 12, either a final chroma $\text{QP}\boldsymbol{index} = \overline{QP}_Y + O_c$ or a chroma QP***offset*** value O_c only may be transmitted as an additional part of the coded bit-stream 14. Note that both the final QP indices and the chroma QP offsets could be transmitted as entropy coded QP value differences (i.e., delta-QPs) according to the state of the art known from, e.g., HEVC [1], [2].

Summarizing, in the above discussed *picture*-wise approach the activity value of the luma component may be a *picture*-related *mean* luma activity value being valid for the entire picture 12, i.e.:

$$a_Y = \bar{a}_Y$$

and the luma-QP may be a *picture*-related *mean* luma-QP being valid for the entire picture 12, i.e.:

$$QP_K = \overline{QP}_Y$$

Additionally, the activity value of the chroma component may be a *picture*-related *mean* chroma activity value being valid for the entire picture 12, i.e.:

$$a_c = \bar{a}_c$$

and the chroma-QP may be a *picture*-related *mean* chroma-QP being valid for the entire picture, i.e.:

$$QP_c = \overline{QP}_c.$$

Block-wise chroma-QP adaptation

The chroma-QP QP_C may be computed on a *block*-wise basis. That is, an adaptive chroma-QP QP_C may be computed that is applicable to one or more available blocks or sub-blocks 80, 82, 84, and preferably to each available block or sub-block 80, 82, 84, of the picture 12. In the *block*-wise approach, the chroma-QP may be referred to as a block-related chroma-QP or as a block-related quantization parameter for the chroma component, respectively. In order to draw a distinction over the denotation of the above discussed *picture*-wise QP adaptation, the *block*-wise chroma QP may be denoted with $QP_C(B_K)$.

The block-related quantization parameter $QP_C(B_K)$ for the chroma component may be computed on a *block*-wise basis, wherein the block-related quantization parameter $QP_C(B_K)$ may be computed for at least one chroma component contained in at least one block (B_K) of the picture 12. In terms of HEVC, the at least one block may correspond to a Coding Tree Unit (CTU) or a Coding Unit (CU). Accordingly, the block-related quantization parameter $QP_C(B_K)$ may be computed on CTU-level and/or on CU-level. However, the inventive concept may also be applicable to other blocks or sub-blocks different from CUs and CTUs.

Furthermore, if the chroma-QP $QP_C(B_K)$ is computed on a *block*-wise basis, the activity value a_c of the chroma component may also be a *block*-related activity value, denoted with $a_c(B_K)$, and being computed on a *block*-wise basis. Furthermore, the activity value a_Y of the luma component may be a block-related activity value, denoted with $a_Y(B_K)$, and being computed on a *block*-wise basis. If the activity value of the luma component may be obtained according to [2], then it may directly be a *block*-related luma activity value $a_Y(B_K)$. This block-related luma activity value $a_Y(B_K)$ may be directly used in the inventive approach as described herein. There may be no need for determining a *mean* luma activity $\bar{a}_Y$ as in the above discussed picture-wise approach.

Briefly summarizing, the idea behind this embodiment is to apply, in an encoder 10, the above *block*-wise perceptual QP adaptation to the luma component of an image or video and, in a manner similar to that of the first inventive approach as discussed in the section (*picture*-wise QP adaptation) above, to apply an also *block*-wise QP adaptation to at least one chroma component of said image or video. Then, the adapted *block*-wise chroma QP values $QP_C(B_K)$ may be signaled to a decoder 20 alongside the existing signaled luma QP values $a_Y(B_K)$. In other words, instead of applying a *single* chroma QP adaptation in each chroma component of each picture 12 and signaling these adapted picture-wise chroma QP data according to the state of the art [1], [10], as in the above discussed Section, in this preferred alternative embodiment *multiple* block-wise (e.g. CTU-wise) chroma QP adaptations are conducted for each chroma component of each picture 12, wherein these multiple *block*-wise adapted chroma QP values $QP_C(B_K)$ may be signaled to a decoder 20 in a novel, inventive fashion.

Briefly summarizing, the *block*-wise chroma QP adaptation may be carried out in a manner identical to that described in the section above (*picture*-wise QP adaptation), except that each adaptation may be applied for a block or sub-block B_K of the picture 12 at index K, instead of the entire picture 12:

1. When the --PerceptQPA or a novel --CtuChromaQpOffsets encoder configuration parameter is provided with a positive value, *pps_ctu_chroma_qp_offsets_present_flag* = 1 may be set in the coded PPS.

2. For each slice and chroma component $c \in$ [Cb, Cr], the block-related chroma-QP $QP_C(B_K)$ may be computed separately for each block or sub-block B_k:

$$QP_c(B_K) = \begin{cases} \text{round}\left(3\beta \cdot \log_2\left(\alpha \cdot \frac{a_c(B_K)}{a_Y(B_K)}\right)\right), & \alpha \cdot a_c(B_K) > a_Y(B_K), \\ 0, & \text{otherwise,} \end{cases}$$

with $a_K(B_K) = \max\left(a_{\min}^2; \left(\frac{1}{|P_K^*|}\sum_{[x,y]\in P_K^*}|h[x,y]|\right)^2\right)$,

where subscript Y identifies the luma component. Notice that $a_Y(B_K)$ equals the a_K of [2].

3. A block-wise adapted luma-QP $QP_Y(B_K)$ may be obtained, e.g. by using the a_{pic} according to [2]:

$$QP_Y(B_K) = QP_K \text{, e.g. of [2].}$$

4. A difference d between $QP_Y(B_K)$ and the value mapping of $QP_Y(B_K)$ may be defined according to [10]:

$$d = QP_Y(B_K) - \mathrm{Qp_C}\big(QP_Y(B_K)\big), \quad \mathrm{Qp_C}() \coloneqq \text{chroma QP lookup via HEVC Table 8} - 10.$$

Note: steps 3 and 4 are optional. They can be bypassed by assuming a zero difference, i. e., $d = 0$.

5. A block-related offset $O_c(B_K)$ may be set according to $O_c(B_K) = \min(O_{\max} + d; QP_c(B_K) + d)$ with $O_{\max} = 3$. This chroma QP Adaptation effectively lowers the coding rate of the chroma sub-block K when its mean visual activity is quite high compared to the luma channel's visual activity in the same sub-block K. Unlike the first proposal of the above discussed section (*picture*-wise QP adaptation), this

chroma QP adaptation is performed in a *block*-wise manner, not only in a picture-wise fashion.

6. The block-related chroma QP offset $O_c(B_K)$ may be applied in the encoding and decoding of the image or video. For example, use $QP_Y(B_K) + O_c(B_K)$ in the encoder-side quantization and decoder-side dequantization (also called inverse quantization) of any prediction residual in the given chroma component c.

7. In order to allow for correct decoder-side dequantization according to this proposal, the block-related chroma QP data $QP_Y(B_K) + O_c(B_K)$, or at least the block-related offsets $O_c(B_K)$, may be conveyed from the encoder 10 to the decoder 20. Therefore, for each block or sub-block (e. g., CTU or CU), either a final block-related chroma $\mathrm{QP}\boldsymbol{index}(B_K) = QP_Y(B_K) + O_c(B_K)$ or a block-related chroma QP***offset*** value $O_c(B_K)$ may be transmitted as an additional part of the coded bit-stream 14. Note that both the final QP indices and the chroma QP offsets could be transmitted as entropy coded QP value differences (i.e., delta-QPs) according to the state of the art known from, e.g., HEVC [1], [2].

In summary, the additional derivation and signaling of a *block*-wise adapted QP***offset*** value $O_c(B_K)$ for a chroma component c represents a separate, independent quantization parameter adaptation and signaling for at least two components (one luma and at least one chroma) of a multi-component image/video according to the invention.

Summarizing, in the above discussed *block*-wise approach the activity value of the luma component may be a *block*-related luma activity value being valid for at least one block or sub-block B_K of the picture 12, i.e.:

$$a_Y = a_Y(B_K)$$

and the luma-QP may be a *block*-related luma-QP being valid for at least one block or sub-block B_K of the picture 12, i.e.:

$$QP_K = QP_Y(B_K)$$

Additionally, the activity value of the chroma component may be a *block*-related chroma activity value being valid for at least one block or sub-block B_K of the picture 12, i.e.:

$$a_c = a_c(B_K)$$

and the chroma-QP may be a *block*-related chroma-QP being valid for at least one block or sub-block B_K of the picture 12, i.e.:

$$QP_c = QP_c(B_K).$$

The above discussed inventive principles of picture-wise and block-wise chroma QP adaptations may preferably applied to a multi-component picture. For example, a multi-component picture may comprise at least one luma component, and additionally one or more color components, i.e. one or more chroma components. For example, the inventive principle may be applied to pictures being coded in the YCbCr color space. In case of block-based coding, each block may comprise a luma coding block and one or more chroma coding blocks.

As mentioned above, the picture-wise or block-wise computed luma-dependent adaptive chroma quantization parameter QP_C may be signaled to the decoder 20 in the data stream 14. For this, a chroma-QP offset-value O_C or a chroma-QP index may be signaled in the data stream 14, as discussed above.

Figure 5 shows a decoder 20 according to an embodiment. The decoder 20 may comprise a dequantizer 52, as explained with reference to Figure 2. The dequantizer 52 and, thus, the decoder 20 may be configured to derive from the data stream 14 the above discussed quantization parameter QP_K for the luma component in units of blocks B_K of the picture 12, and the above discussed quantization parameter QP_C for the chroma component in units of further blocks of the picture 12. Said further blocks may represent a single block or sub-block (e.g. an above described *block*-wise QP-adaptation) or a plurality of blocks arranged in a certain order (e.g. an above described *picture*-wise QP-adaptation, e.g. *slice*-wise) or the entire picture 12 (e.g. an above described *picture*-wise QP-adaptation, e.g. *frame*-wise).

As discussed above, the quantization parameter QP_C for the chroma component may have been computed by the encoder 10 based on a ratio $\frac{a_c}{a_Y}$ between the activity a_Y of the luma component and the activity a_c of the chroma component. Thus, the activity values a_Y, a_c are depicted in hatched lines in Figure 5.

If the derived chroma-QP QP_C has been computed *picture*-wise, then the activity value of the luma component may be a *picture*-wise *mean* activity value $\bar{a}_Y$ over one or more block-wise activity values a_K of the luma component. Furthermore, the quantization parameter for the chroma component may be a *picture*-related mean chroma-QP $\overline{QP_C}$. According to this embodiment, the decoder 20 may be configured to apply, during decoding, the *picture*-related quantization parameter QP_C for the chroma component on a picture-wise basis, i.e. the adaptive chroma-QP QP_C may be applied onto the entire picture 12, which may be a single still image, wherein the adaptive chroma-QP QP_C may be applied slice-by-slice, or the picture 12 may comprise a plurality of consecutive frames, wherein the adaptive chroma-QP QP_C may be applied frame-by-frame.

Accordingly, the decoder 20 may be configured to apply, during decoding, the *picture*-related quantization parameter QP_C for the chroma component on a frame-by-frame basis, wherein the *picture*-related quantization parameter QP_C is to be applied onto at least one chroma component contained in at least one frame of a moving picture sequence, or on a slice-by-slice basis, wherein the *picture*-related quantization parameter QP_C is to be applied onto at least one chroma component contained in at least one slice of the picture 12.

In this case, the *picture*-related quantization parameter QP_C for the chroma component may be indicated in the data stream 14 by means of

a) the above described *picture*-related quantization-parameter-offset-value O_c only, or

b) the above described *picture*-related QP**index** value calculated from the *picture*-related mean quantization parameter $\overline{QP_Y}$ for the luma component and the *picture*-related quantization-parameter-offset-value O_c of the chroma component according to equation:

$$QP\boldsymbol{index} = \overline{QP_Y} \pm O_c,$$

As discussed above, the quantization parameter offset value may be a *picture*-related quantization parameter offset value O_c indicating a frame-wise or a slice-wise calculated offset between a *picture*-related quantization parameter QP_C for the chroma component and a *picture*-related *mean* quantization parameter $\overline{QP_Y}$ for the luma component, the *picture*-related *mean* quantization parameter $\overline{QP_Y}$ comprising one or more *block*-wise computed quantization parameters QP_K for the luma component.

Alternatively, if the derived chroma-QP QP_C has been computed *block*-wise, then the activity value a_Y of the luma component may be a *block*-related activity value $a_Y(B_K)$ being computed on a *block*-wise basis, wherein the quantization parameter QP_C for the chroma component may be a *block*-related quantization parameter $QP_C(B_K)$ being computed on a *block*-wise basis, and wherein the decoder 20 may be configured to apply, during decoding, the *block*-related chroma-QP $QP_C(B_K)$ on at least one chroma component contained in at least one block or sub-block B_K of the picture 12.

In this case, the *block*-related quantization parameter $QP_C(B_K)$ for the chroma component may be indicated in the data stream 14 by means of

a) the above described *block*-related quantization-parameter-offset-value $O_c(B_K)$ only, or

b) the above described block-related $QP\boldsymbol{index}(B_K)$ calculated from the *block*-related quantization parameter $QP_Y(B_K)$ for the luma component and the block-related quantization-parameter-offset-value $O_c(B_K)$ of the chroma component according to equation:

$$QP\boldsymbol{index}(B_K) = QP_Y(B_K) \pm O_c(B_K),$$

wherein the *block*-related quantization parameter offset value $O_c(B_K)$ indicates a *block*-wise calculated offset between the *block*-related quantization parameter $QP_C(B_K)$ for the chroma component and the *block*-related quantization parameter $QP_Y(B_K)$ for the luma component.

Figure 6 shows a block diagram of a method for encoding a picture 12.

In block 61 a quantization parameter QP_K for a luma component may be computed in units of blocks B_K of the picture, using an activity measure of the luma component.

In block 62 a quantization parameter QP_C for a chroma component may be computed based on a ratio $\frac{a_C}{a_Y}$ between an activity value a_Y of the luma component and an activity value a_C of the chroma component.

Figure 7 shows a block diagram of a method for decoding a picture 12.

In block 71 a quantization parameter QP_K for a luma component of the picture 12 is derived from the data stream 14.

In block 72 a quantization parameter QP_c for a chroma component of the picture 12 is derived from the data stream 14.

According to the inventive principle, the quantization parameter QP_C for the chroma component is calculated based on a ratio $\frac{a_c}{a_Y}$ between an activity a_Y of the luma component and an activity a_c of the chroma component.

The inventive concept as described herein may additionally or alternatively be realized by the following embodiments:

1. Apparatus for encoding a picture, configured to

- compute a quantization parameter (QP_k) for a luma component in units of blocks (B_k) of the picture, using an activity measure (a_k) of the luma component, and

- compute a quantization parameter (QP_c) for a chroma component based on a ratio ($\frac{a_c}{a_Y}$) of an activity of the luma component (a_Y) and an activity (a_c) of the chroma component.

2. The apparatus according to embodiment 1, configured to

compute the quantization parameter (QP_c) for the chroma component in units larger than the blocks [slice-by-slice] or globally for the picture [frame-by-frame].

3. The apparatus according to embodiment 2, configured to

insert the quantization parameter (QP_c) for the chroma component in the units larger than the blocks [slice-by-slice] or globally for the picture [frame-by-frame] into the data stream.

4. The apparatus according to any one of embodiments 1 to 3, configured to

insert an information on the quantization parameter for a luma component into a data stream for each of the blocks.

5. The apparatus according to any one of embodiments 1 to 4, configured to

determine a value QPc of the quantization parameter for the chroma component (QP_c) from the ratio $\frac{a_c}{a_Y}$ between a chroma channel's mean activity a_c and a luma channel's mean activity a_Y, for each slice of the picture or the whole picture, depending on a logarithm of $\alpha \cdot \frac{a_c}{a_Y}$ if $\alpha \cdot a_c > a_Y$ and to be zero if $\alpha \cdot a_c \leq a_Y$.

6. The apparatus according to any one of embodiments 1 to 5, configured to

determine a value QPc of the quantization parameter for the chroma component (QP_c) for each slice of the picture or the whole picture, wherein

$$QPc = \text{round}\left(3\beta \cdot \log \left(\alpha \cdot \frac{a_c}{a_Y}\right)\right)$$

if $\alpha \cdot a_c > a_Y$ and to be zero if $\alpha \cdot a_c \leq a_Y$,

wherein α having a constant value between $½ \leq \alpha < 5$.

7. The apparatus according to embodiment 6,

wherein a weight exponent β has a value between $0 \leq \beta \leq 1$, and/or

wherein a base of the logarithm is 2.

8. The apparatus according to any one of embodiments 1 to 7, configured to

in computing the quantization parameter (QP_c) for the chroma component,

compute a picture-wise or a slice-wise mean luma quantization parameter (QP_Y), and

adapting the quantization parameter (QP_c) for the chroma component using a luma-to-chroma-mapping function applied to the picture-wise or slice-wise mean luma quantization parameter (QP_Y).

9. The apparatus according to any one of embodiments 1 to 8, configured to

compute the quantization parameter for the chroma component in units of further blocks of the picture.

10. The apparatus according to embodiment 9, wherein the further blocks coincide with the blocks (B_k) or form super blocks each composed of one or more of the blocks (B_k).

11. The apparatus according to any one of embodiments 1 to 10, configured to

determine a value $QP_c(B_k)$ of the quantization parameter for the chroma component (QP_c) from the ratio $\frac{a_c(B_k)}{a_Y(B_k)}$ between a chroma channel's mean activity $a_c(B_k)$ and a luma channel's mean activity $a_Y(B_k)$ for each block of the picture or the whole picture, depending on a logarithm of $\alpha \cdot \frac{a_c(B_k)}{a_Y(B_k)}$ if $\alpha \cdot a_c(B_k) > a_Y(B_k)$ and to be zero if $\alpha \cdot a_c(B_k) \leq a_Y(B_k)$.

12. The apparatus according to any one of embodiments 1 to 11, configured to

determine a value QPc of the quantization parameter for each slice and chroma component $QP_c(B_k)$ for each sub-block of the picture, wherein

$$QP_c(B_k) = \mathrm{round}\left(3\beta \cdot \log\left(\alpha \cdot \frac{a_c(B_k)}{a_Y(B_k)}\right)\right)$$

if $\alpha \cdot a_c(B_k) > a_Y(B_k)$ and to be zero if $\alpha \cdot a_c(B_k) \leq a_Y(B_k)$,

wherein α having a (constant) value between $½ \leq \alpha < 5$.

13. The apparatus according to embodiment 12,

wherein a weight exponent β has a value between $0 \leq \beta \leq 1$, and/or

wherein a base of the logarithm is 2.

Although some aspects have been described in the context of an apparatus, it is clear that these aspects also represent a description of the corresponding method, where a block or device corresponds to a method step or a feature of a method step. Analogously, aspects described in the context of a method step also represent a description of a corresponding block or item or feature of a corresponding apparatus.

Some or all of the method steps may be executed by (or using) a hardware apparatus, like for example, a microprocessor, a programmable computer or an electronic circuit. In some embodiments, one or more of the most important method steps may be executed by such an apparatus.

Depending on certain implementation requirements, embodiments of the invention can be implemented in hardware or in software or at least partially in hardware or at least partially in software. The implementation can be performed using a digital storage medium, for example a floppy disk, a DVD, a Blu-Ray, a CD, a ROM, a PROM, an EPROM, an EEPROM or a FLASH memory, having electronically readable control signals stored thereon, which cooperate (or are capable of cooperating) with a programmable computer system such that the respective method is performed. Therefore, the digital storage medium may be computer readable.

Some embodiments according to the invention comprise a data carrier having electronically readable control signals, which are capable of cooperating with a programmable computer system, such that one of the methods described herein is performed.

Generally, embodiments of the present invention can be implemented as a computer program product with a program code, the program code being operative for performing one of the methods when the computer program product runs on a computer. The program code may for example be stored on a machine readable carrier.

Other embodiments comprise the computer program for performing one of the methods described herein, stored on a machine readable carrier.

In other words, an embodiment of the inventive method is, therefore, a computer program having a program code for performing one of the methods described herein, when the computer program runs on a computer.

A further embodiment of the inventive methods is, therefore, a data carrier (or a digital storage medium, or a computer-readable medium) comprising, recorded thereon, the computer program for performing one of the methods described herein. The data carrier, the digital storage medium or the recorded medium are typically tangible and/or non-transitory.

A further embodiment of the inventive method is, therefore, a data stream or a sequence of signals representing the computer program for performing one of the methods described herein. The data stream or the sequence of signals may for example be configured to be transferred via a data communication connection, for example via the Internet.

A further embodiment comprises a processing means, for example a computer, or a programmable logic device, configured to or adapted to perform one of the methods described herein.

A further embodiment comprises a computer having installed thereon the computer program for performing one of the methods described herein.

A further embodiment according to the invention comprises an apparatus or a system configured to transfer (for example, electronically or optically) a computer program for performing one of the methods described herein to a receiver. The receiver may, for example, be a computer, a mobile device, a memory device or the like. The apparatus or system may, for example, comprise a file server for transferring the computer program to the receiver.

In some embodiments, a programmable logic device (for example a field programmable gate array) may be used to perform some or all of the functionalities of the methods described herein. In some embodiments, a field programmable gate array may cooperate with a microprocessor in order to perform one of the methods described herein. Generally, the methods are preferably performed by any hardware apparatus.

The apparatus described herein may be implemented using a hardware apparatus, or using a computer, or using a combination of a hardware apparatus and a computer.

The methods described herein may be performed using a hardware apparatus, or using a computer, or using a combination of a hardware apparatus and a computer.

While this disclosure has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of this disclosure, will be apparent to persons skilled in the art upon reference to the description. It is therefore intended that the appended claims encompass any such modifications or embodiments.

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CLAIMS

1. An apparatus (10) for encoding a picture (12), configured to

compute a quantization parameter (QP_K) for a luma component in units of blocks (B_K) of the picture (12), using an activity measure of the luma component, and

compute a quantization parameter (QP_C) for a chroma component based on a ratio ($\frac{a_C}{a_Y}$) between an activity value (a_Y) of the luma component and an activity value (a_c) of the chroma component.

2. The apparatus (10) according to claim 1, wherein

at least one of the quantization parameter (QP_K) for the luma component and the quantization parameter (QP_C) for the chroma component is adaptively computed so as to be adaptable to at least one of a current content of the picture (12) or a current content of at least one block or sub-block (80, 82, 84) of the picture (12).

3. The apparatus (10) according to claim 1 or 2,

wherein the quantization parameter (QP_C) for the chroma component is computed picture-wise such that the quantization parameter (QP_C) is a picture-related quantization parameter,

wherein the activity value (a_Y) of the luma component is a picture-related mean activity value ($\bar{a}_y$) over one or more block-related activity values (a_K) of the luma component.

4. The apparatus (10) according to claim 3,

wherein the picture-related quantization parameter (QP_C) for the chroma component is computed

on a frame-by-frame basis, wherein the picture-related quantization parameter (QP_C) is computed for at least one chroma component contained in at least one frame of a moving picture sequence, or on a slice-by-slice basis, wherein the picture-related quantization parameter (QP_C) is computed for at least one chroma component contained in at least one slice of the picture (12).

5. The apparatus (10) according to claim 3 or 4,

wherein the picture-related quantization parameter (QP_C) of the chroma component is computed according to the following equation:

$$QP_c = \begin{cases} \text{round}\left(3\beta \cdot \log_2\left(\alpha \cdot \frac{a_c}{\bar{a}_Y}\right)\right), & \alpha \cdot a_c > \bar{a}_Y, \\ 0, & \text{otherwise,} \end{cases}$$

with $a_k = \max\left(a_{\min}^2; \left(\frac{1}{|P_k^*|}\sum_{[x,y]\in P_k^*}|h[x,y]|\right)^2\right)$, wherein

$k \in$ [Y, Cb, Cr],

$0 \leq \beta \leq 1$,

subscript Y denotes the luma component,

P_k^* is the component's frame buffer, excluding the border pel rows and columns, and

α is a constant.

6. The apparatus (10) according to any one of claims 1 to 5,

wherein the apparatus (10) is configured to

determine for the luma component a picture-related mean quantization parameter ($\overline{QP}_Y$) over one or more block-related quantization parameters (QP_K) for the luma component, and

determine for the chroma component a picture-related quantization-parameter-offset-value (O_c) indicating a frame-wise or a slice-wise offset of the picture-related quantization parameter (QP_C) for the chroma component relative to the picture-related mean quantization parameter ($\overline{QP}_Y$) for the luma component, and to signal the picture-related quantization parameter (QP_C) for the chroma component in the data stream (14) by means of:

a) the picture-related quantization-parameter-offset-value (O_c) only, or

b) a picture-related quantization parameter index value ($QP\boldsymbol{index}$) calculated from the picture-related mean quantization parameter ($\overline{QP}_Y$) for the luma component and the picture-related quantization-parameter-offset-value (O_c) of the chroma component according to equation:

$$QP\boldsymbol{index} = \overline{QP}_Y \pm O_c.$$

7. The apparatus (10) according to claim 6,

wherein the picture-related quantization-parameter-offset-value (O_c) is computed according to

$$O_c = \min(O_{\max} + d; QP_c + d),$$

wherein $O_{\max}$ is a variable upper offset-limit of the picture-related quantization parameter (QP_C) for the chroma component relative to the picture-related mean quantization parameter ($\overline{QP}_Y$) for the luma component, and

d is a difference between the picture-related mean quantization parameter ($\overline{QP}_Y$) for the luma component and a fixed luma-to-chroma-mapping.

8. The apparatus (10) according to claim 7, wherein

the difference *d* is zero.

9. The apparatus (10) according to claims 1 or 2,

wherein the activity value (a_Y) of the luma component is a block-related activity value ($a_Y(B_K)$) being computed on a block-wise basis, and

wherein the quantization parameter (QP_C) for the chroma component is a block-related quantization parameter ($QP_C(B_K)$) being computed on a block-wise basis, wherein the block-related quantization parameter ($QP_C(B_K)$) is computed for at least one chroma component contained in at least one block or sub-block (80, 82, 84) of the picture (12).

10. The apparatus (10) according to claim 9,

wherein the block-related quantization parameter ($QP_C(B_K)$) of the chroma component is computed according to the following equation:

$$QP_c(B_K) = \begin{cases} \text{round}\left(3\beta \cdot \log_2\left(\alpha \cdot \frac{a_c(B_K)}{a_Y(B_K)}\right)\right), & \alpha \cdot a_c(B_K) > a_Y(B_K), \\ 0, & \text{otherwise}, \end{cases}$$

with $a_K(B_K) = \max\left(a_{\min}^2; \left(\frac{1}{|P_K^*|}\sum_{[x,y]\in P_K^*}|h[x,y]|\right)^2\right)$, wherein

(B_K) represents a block of the picture (12),

$k \in$ [Y, Cb, Cr],

$0 \leq \beta \leq 1$,

subscript Y denotes the luma component,

P_K^* is the component's frame buffer, excluding the border pel rows and columns, and

α is a constant.

11. The apparatus (10) according to claim 9 or 10,

wherein the quantization parameter (QP_K) for the luma component is a block-related quantization parameter ($QP_Y(B_K)$), and

wherein the apparatus (10) is configured to

determine for the chroma component a block-related quantization-parameter-offset-value ($O_c(B_K)$) indicating a block-wise offset of the block-related quantization parameter ($QP_C(B_K)$) for the chroma component relative to the block-related quantization parameter ($QP_Y(B_K)$) for the luma component, and to signal the block-related quantization parameter ($QP_C(B_K)$) for the chroma component in the data stream (14) by means of:

a) the block-related quantization-parameter-offset-value ($O_c(B_K)$) only, or

b) a block-related quantization parameter index value ($QP\boldsymbol{index}(B_K)$) calculated from the block-related quantization parameter ($QP_Y(B_K)$) for the luma component and the block-related quantization-parameter-offset-value ($O_c(B_K)$) of the chroma component according to equation:

$$QP\boldsymbol{index}(B_K) = QP_Y(B_K) \pm O_c(B_K).$$

12. The apparatus (10) according to claim 11,

wherein the block-related quantization-parameter-offset-value ($O_c(B_K)$) is computed according to

$$O_c(B_K) = \min(O_{\max} + d; QP_c(B_K) + d),$$

wherein $O_{\max}$ is a variable upper offset-limit of the block-related quantization parameter ($QP_C(B_K)$) for the chroma component relative to the block-related quantization parameter ($QP_Y(B_K)$) for the luma component, and

d is a difference between the block-related quantization parameter ($QP_Y(B_K)$) for the luma component and a fixed luma-to-chroma-mapping.

13. The apparatus (10) according to claim 12, wherein

the difference *d* is zero.

14. An apparatus (20) for decoding a picture (12), configured to

derive from a data stream (14)

a quantization parameter (QP_K) for a luma component in units of blocks of the picture (12), and

a quantization parameter for a chroma component (QP_C) in units of further blocks of the picture (12).

15. The apparatus (20) according to claim 14,

wherein the quantization parameter (QP_K) for the luma component and

the quantization parameter (QP_C) for the chroma component are computed according to one of claims 1 to 13.

16. The apparatus (20) according to claim 14 or 15,

wherein the quantization parameter (QP_C) for the chroma component is computed based on a ratio ($\frac{a_c}{a_Y}$) between an activity (a_Y) of the luma component and an activity (a_c) of the chroma component.

17. The apparatus (20) according to claim 16,

wherein the activity value (a_Y) of the luma component is a picture-related mean activity value ($\bar{a}_Y$) over one or more block-related activity values (a_K) of the luma component,

wherein the quantization parameter (QP_C) for the chroma component is computed picture-wise such that the quantization parameter (QP_C) is a picture-related quantization parameter, and

wherein the apparatus is configured to apply, during decoding, the picture-related quantization parameter (QP_C) for the chroma component on a picture-wise basis.

18. The apparatus (20) according to claim 17,

wherein the apparatus (20) is configured to apply, during decoding, the picture-related quantization parameter (QP_C) for the chroma component

on a frame-by-frame basis, wherein the picture-related quantization parameter (QP_C) is to be applied onto at least one chroma component contained in at least one frame of a moving picture sequence, or

on a slice-by-slice basis, wherein the picture-related quantization parameter (QP_C) is to be applied onto at least one chroma component contained in at least one slice of the picture (12).

19. The apparatus (20) according to any one of claims 16 to 18,

wherein the picture-related quantization parameter (QP_C) for the chroma component is indicated in the data stream (14) by means of

a) a picture-related quantization-parameter-offset-value (O_c) only, or

b) a picture-related quantization parameter index value ($QP\boldsymbol{index}$) being calculated from a picture-related mean quantization parameter ($\overline{QP_Y}$) for the luma component and the picture-related quantization-parameter-offset-value (O_c) of the chroma component according to equation:

$$QP\boldsymbol{index} = \overline{QP_Y} \pm O_c,$$

wherein the quantization parameter offset value (O_c) is a picture-related quantization parameter offset value indicating a frame-wise or a slice-wise calculated offset between a picture-related quantization parameter (QP_C) for the chroma component and the picture-related mean quantization parameter ($\overline{QP_Y}$) for the luma component, the picture-related mean quantization parameter ($\overline{QP_Y}$) comprising one or more block-related quantization parameters (QP_K) for the luma component.

20. The apparatus (20) according to claim 16,

wherein the activity value (a_Y) of the luma component is a block-related activity value ($a_Y(B_K)$) being computed on a block-wise basis,

wherein the quantization parameter (QP_C) for the chroma component is a block-related quantization parameter ($QP_C(B_K)$) being computed on a block-wise basis,

and wherein the apparatus (20) is configured to apply, during decoding, the block-related quantization parameter ($QP_C(B_K)$) on at least one chroma component contained in at least one block or sub-block (80, 82, 84) of the picture (12).

21. The apparatus (20) according to claim 20,

wherein the block-related quantization parameter ($QP_C(B_K)$) for the chroma component is indicated in the data stream (14) by means of

a) a block-related quantization-parameter-offset-value ($O_c(B_K)$) only, or

b) a block-related quantization parameter index value ($QP\boldsymbol{index}(B_K)$) calculated from the block-related quantization parameter (QP_Y) for the luma component and the block-related quantization-parameter-offset-value ($O_c(B_K)$) of the chroma component according to equation:

$$QP\boldsymbol{index}(B_K) = QP_Y(B_K) \pm O_c(B_K),$$

wherein the quantization parameter offset value (O_c) is a block-related quantization parameter offset value ($O_c(B_K)$) indicating a block-wise calculated offset between the block-related quantization parameter ($QP_C(B_K)$) for the chroma component and the block-related quantization parameter ($QP_Y(B_K)$) for the luma component.

22. A method for encoding a picture (12), the method comprising steps of

computing a quantization parameter (QP_K) for a luma component in units of blocks (B_K) of the picture (12), using an activity measure of the luma component, and

computing a quantization parameter (QP_C) for a chroma component based on a ratio ($\frac{a_c}{a_Y}$) between an activity value (a_Y) of the luma component and an activity value (a_c) of the chroma component.

23. A method for decoding a picture (12), the method comprising steps of

deriving from a data stream (14)

a quantization parameter (QP_K) for a luma component of the picture, and

a quantization parameter (QP_C) for a chroma component of the picture, wherein the quantization parameter (QP_C) for the chroma component is calculated based on a ratio ($\frac{a_c}{a_Y}$) between an activity (a_Y) of the luma component and an activity (a_c) of the chroma component.

24. A data stream (14) being obtainable by a method according to claim 22 or 23.

25. A computer readable digital storage medium having stored thereon a computer program having a program code for performing, when running on a computer, a method according to claim 22 or 23.

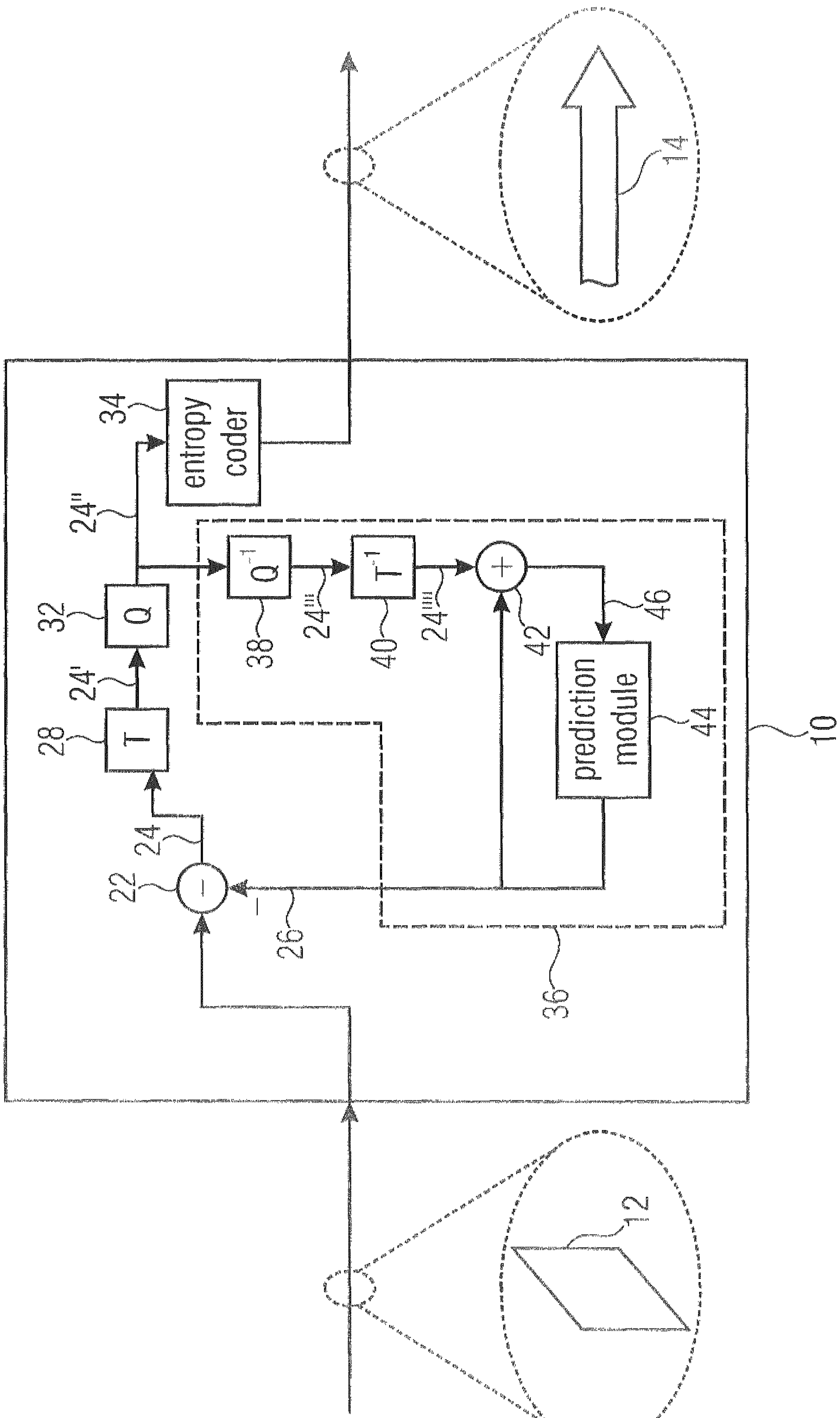
entropy coder
prediction module
T
Q
Q⁻¹
T⁻¹
10
12
14
22
24
24'
24''
24'''
24''''
26
28
32
34
36
38
40
42
44
46

Fig. 1

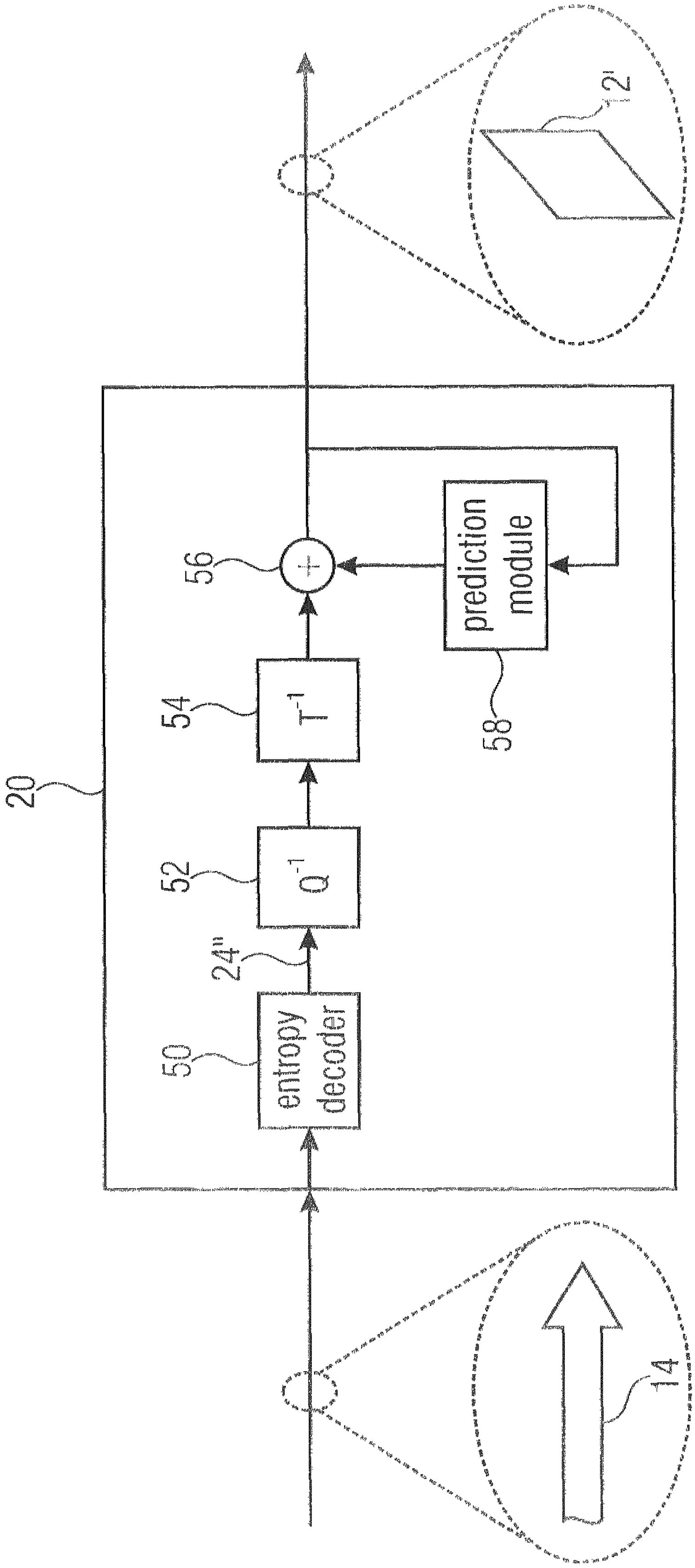
20
50
entropy decoder
24"
52
Q-1
54
T-1
56
58
prediction module
12'
14

Fig. 2

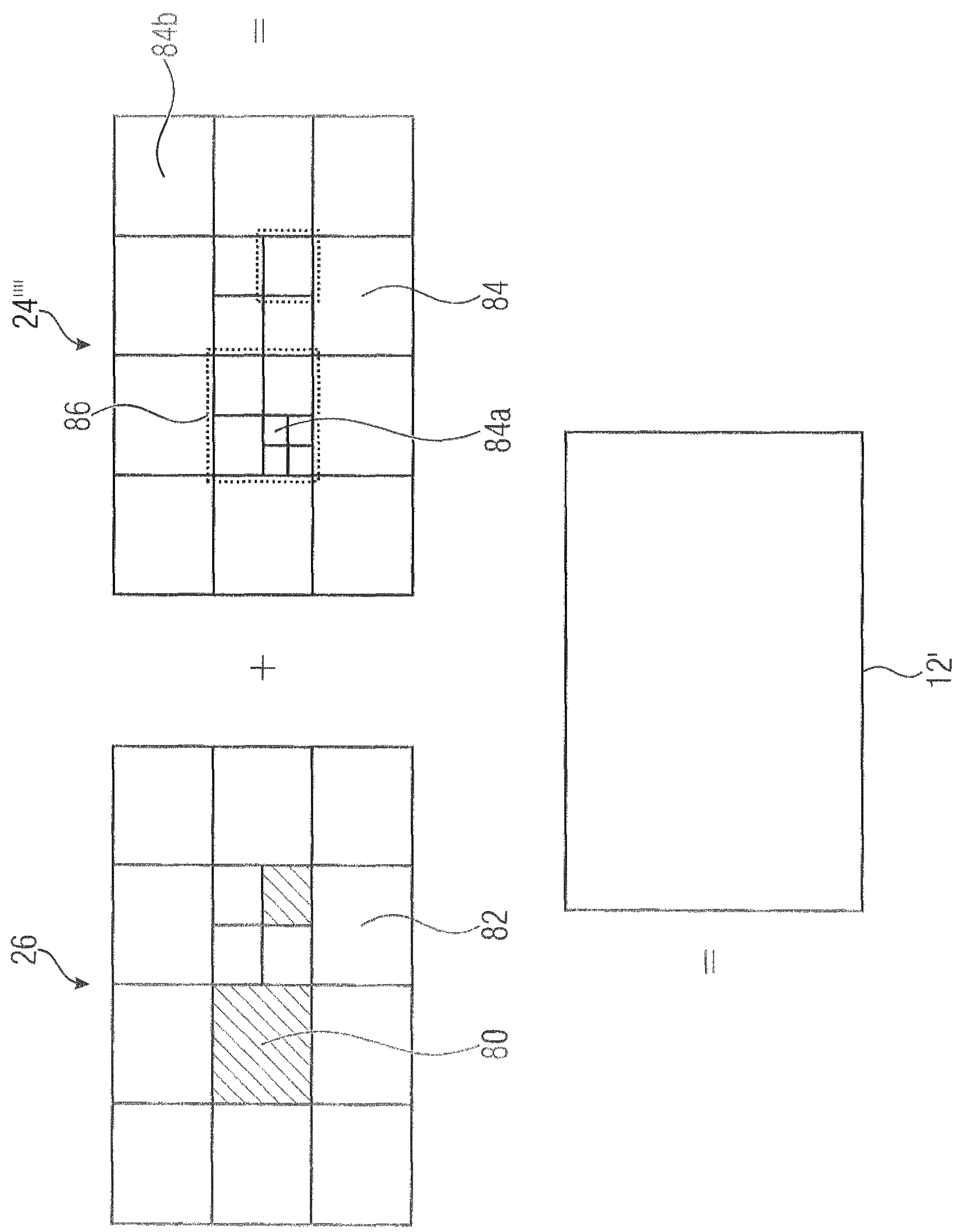

Fig. 3

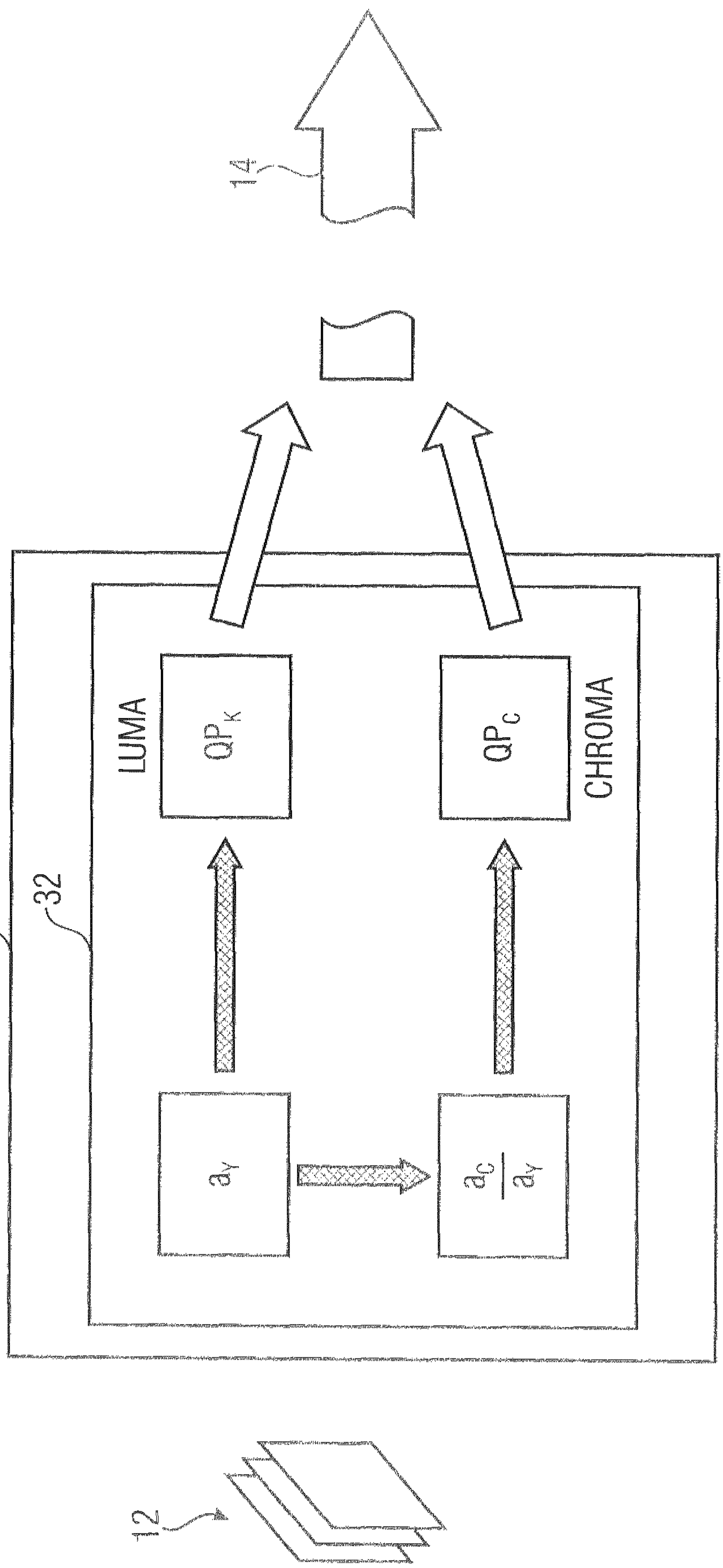

Fig. 4

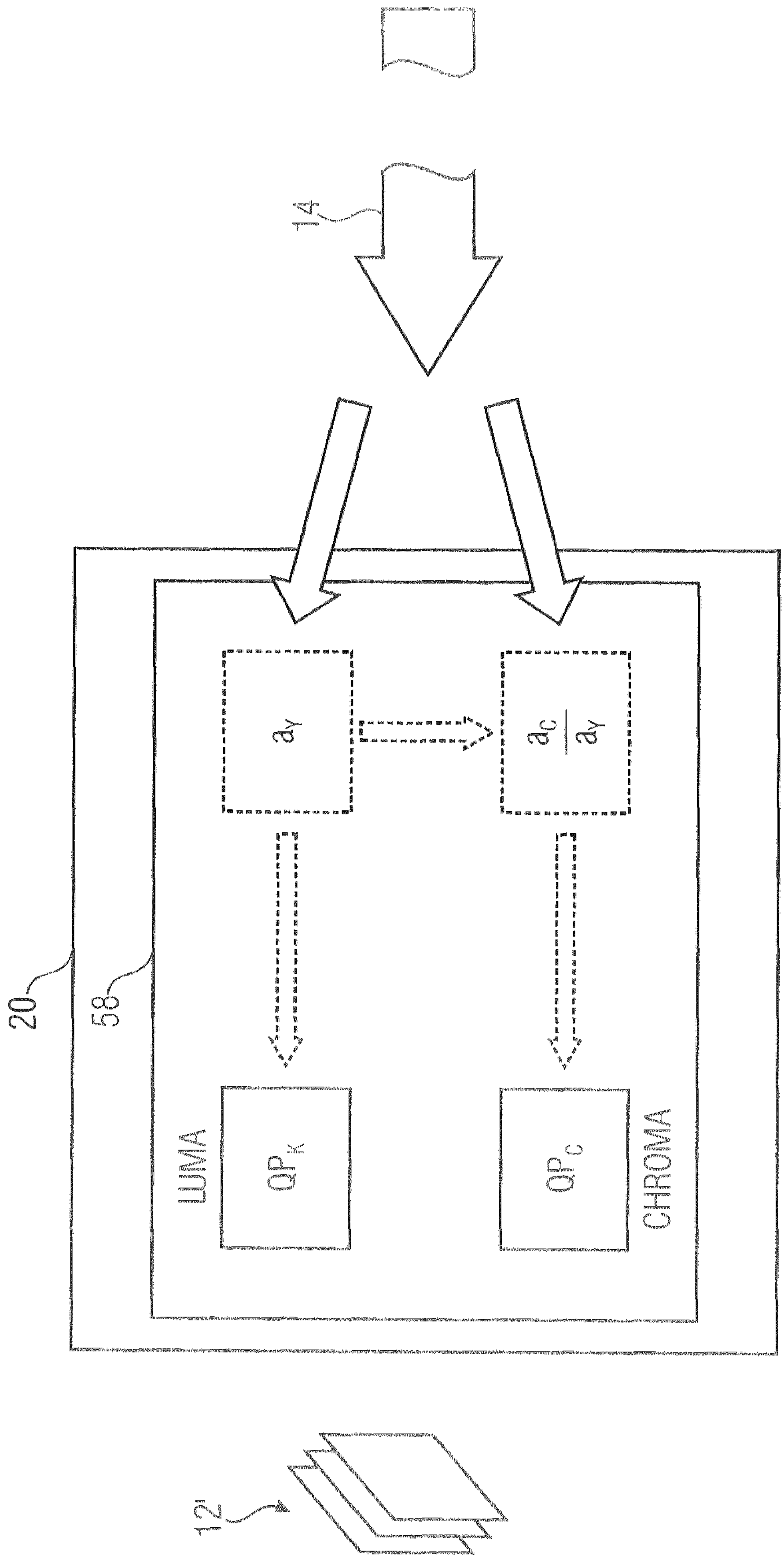

Fig. 5

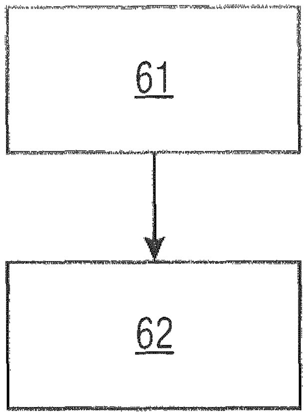

Fig. 6

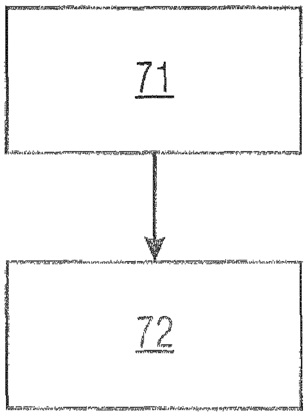

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/067678

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N19/124 H04N19/14 H04N19/176 H04N19/186
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.
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[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

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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
6 September 2019	16/09/2019

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	Hampson, Frances

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Section 2 Proposed Changes to the Perceptual QPA Method -----	
X	JP H08 102968 A (SONY CORP) 16 April 1996 (1996-04-16) abstract paragraph [0024] - paragraph [0037] figures 1-5 -----	1,14-16, 20-25
X	US 2009/296808 A1 (REGUNATHAN SHANKAR [US] ET AL) 3 December 2009 (2009-12-03) abstract paragraph [0078] - paragraph [0080] paragraph [0107] -----	14-21, 23-25
X A	US 2013/077676 A1 (SATO KAZUSHI [JP]) 28 March 2013 (2013-03-28) abstract paragraph [0159] - paragraph [0176] paragraph [0195] - paragraph [0203] paragraph [0259] - paragraph [0276] -----	14-21, 23-25 1-13,22
A	US 2007/092001 A1 (ARAKAWA HIROSHI [JP]) 26 April 2007 (2007-04-26) abstract paragraph [0042] - paragraph [0060] figures 3-8 -----	1-25
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1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/067678

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