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(54) **VIDEO ENCODING APPLYING A REFRESH SCHEME**

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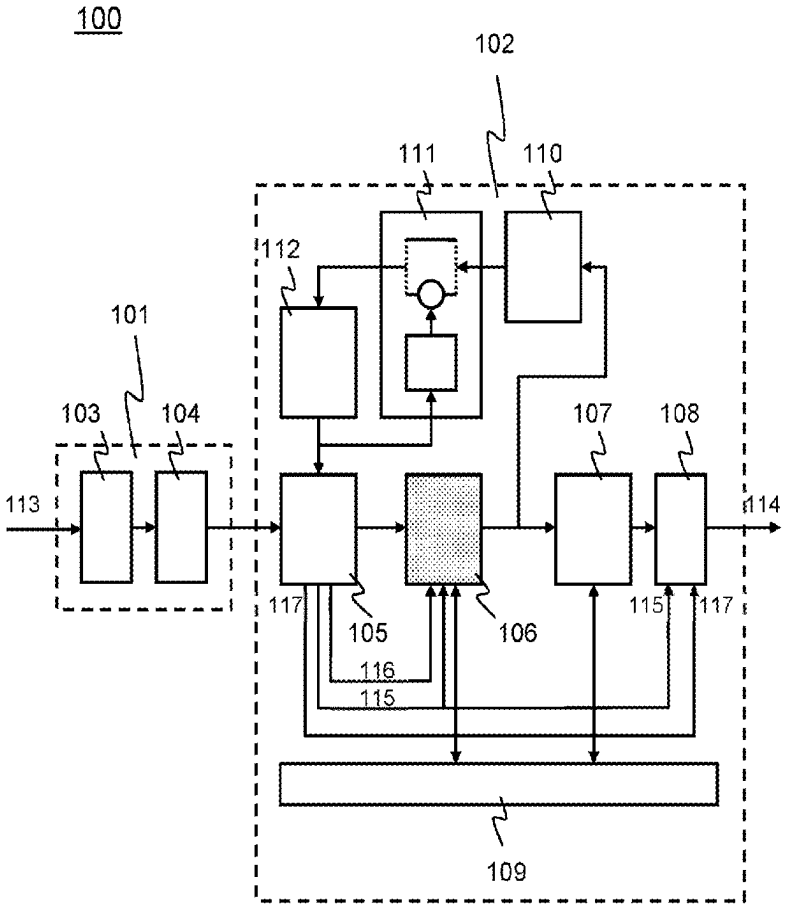
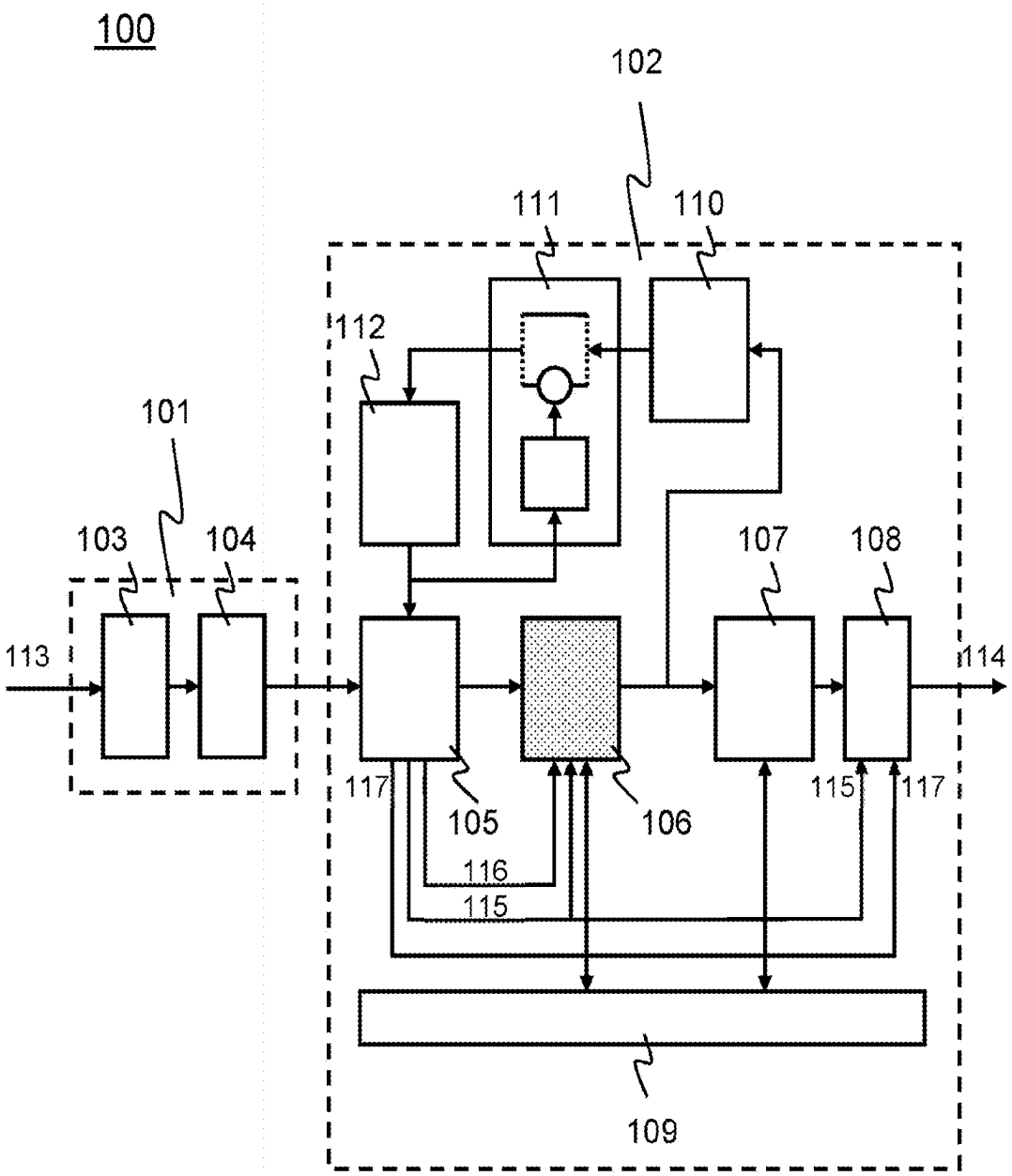
(57) **ABSTRACT**

A sequence of frames is encoded in the following manner. An evaluation on a frame-by-frame basis is made for at least a zone in a series of successive frames whether the zone should be encoded in an intra-mode or in an inter-mode. A refresh scheme is applied that frequently causes the zone to be forcibly encoded in the intra-mode for one out of several successive frames, irrespective of the evaluation made. The zone in the series of successive frames is quantized so that if, for a frame, the zone is forcibly encoded in the intra-mode and contrary to the evaluation that was made, the zone is quantized with a higher resolution than if the zone were encoded in accordance with the evaluation that was made in one of the following modes: the intra-mode and the inter-mode.




100
102
111
110
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101
103
104
107
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114
117
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116
115
109

FIG. 1

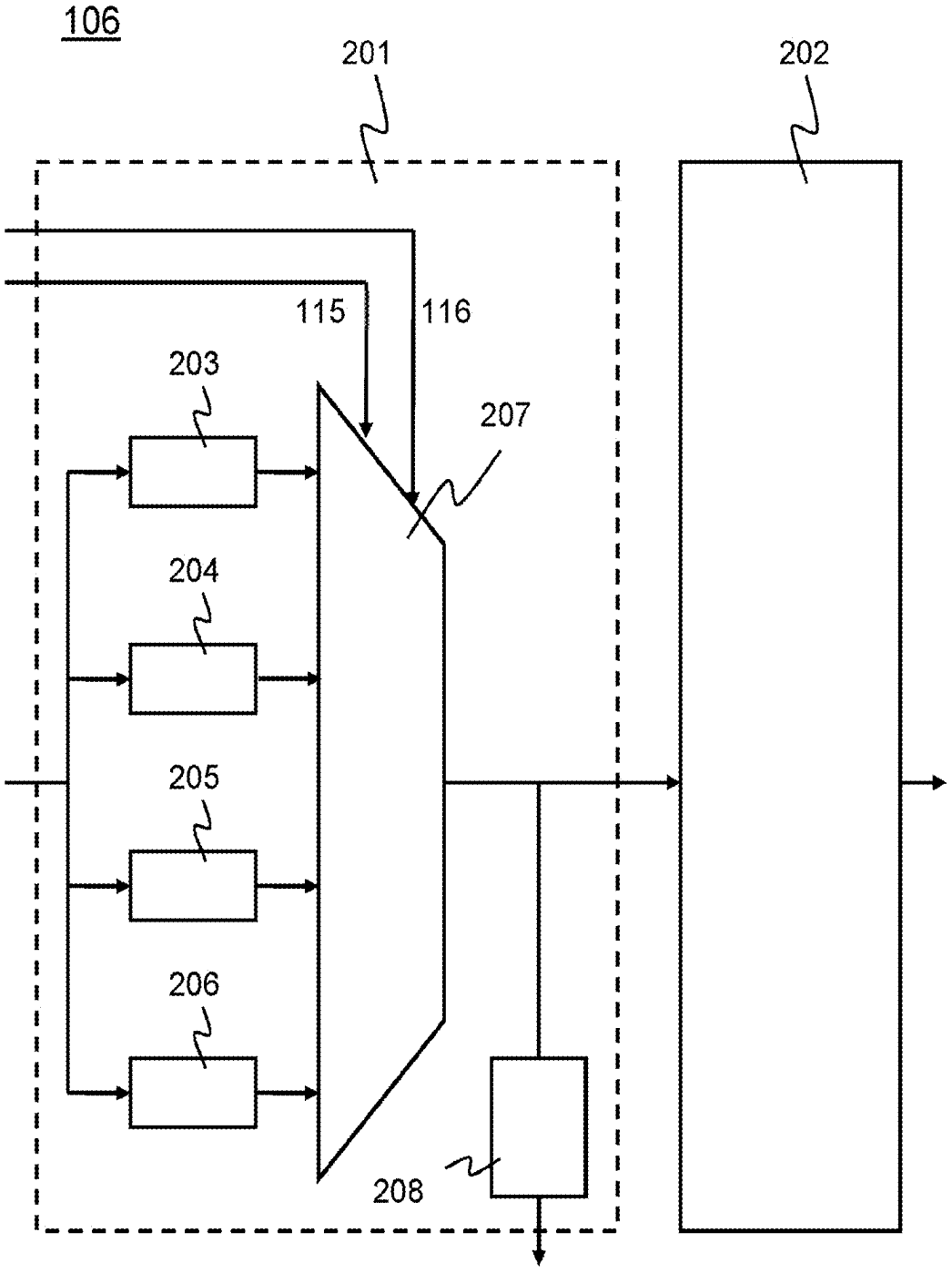


FIG. 2

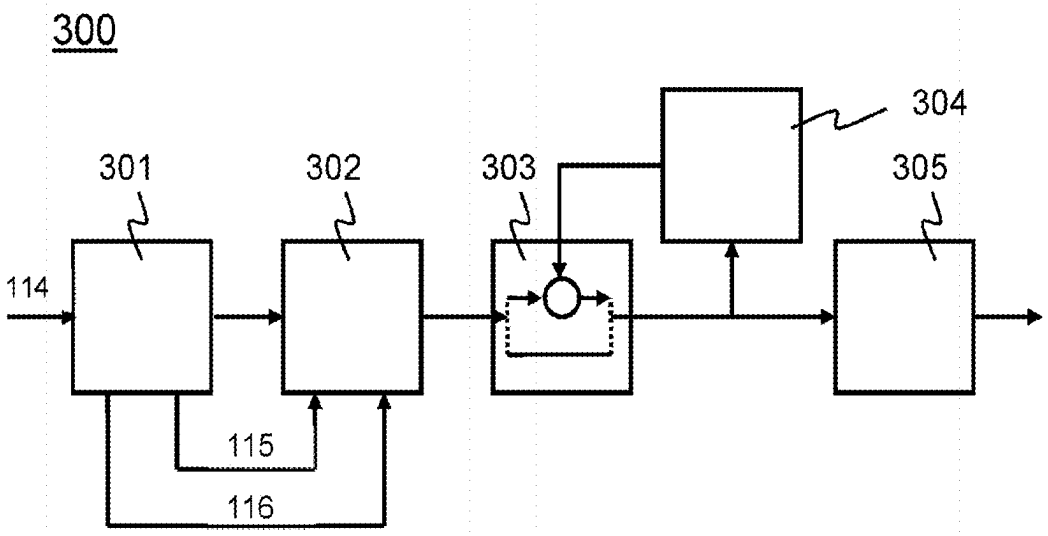


FIG. 3

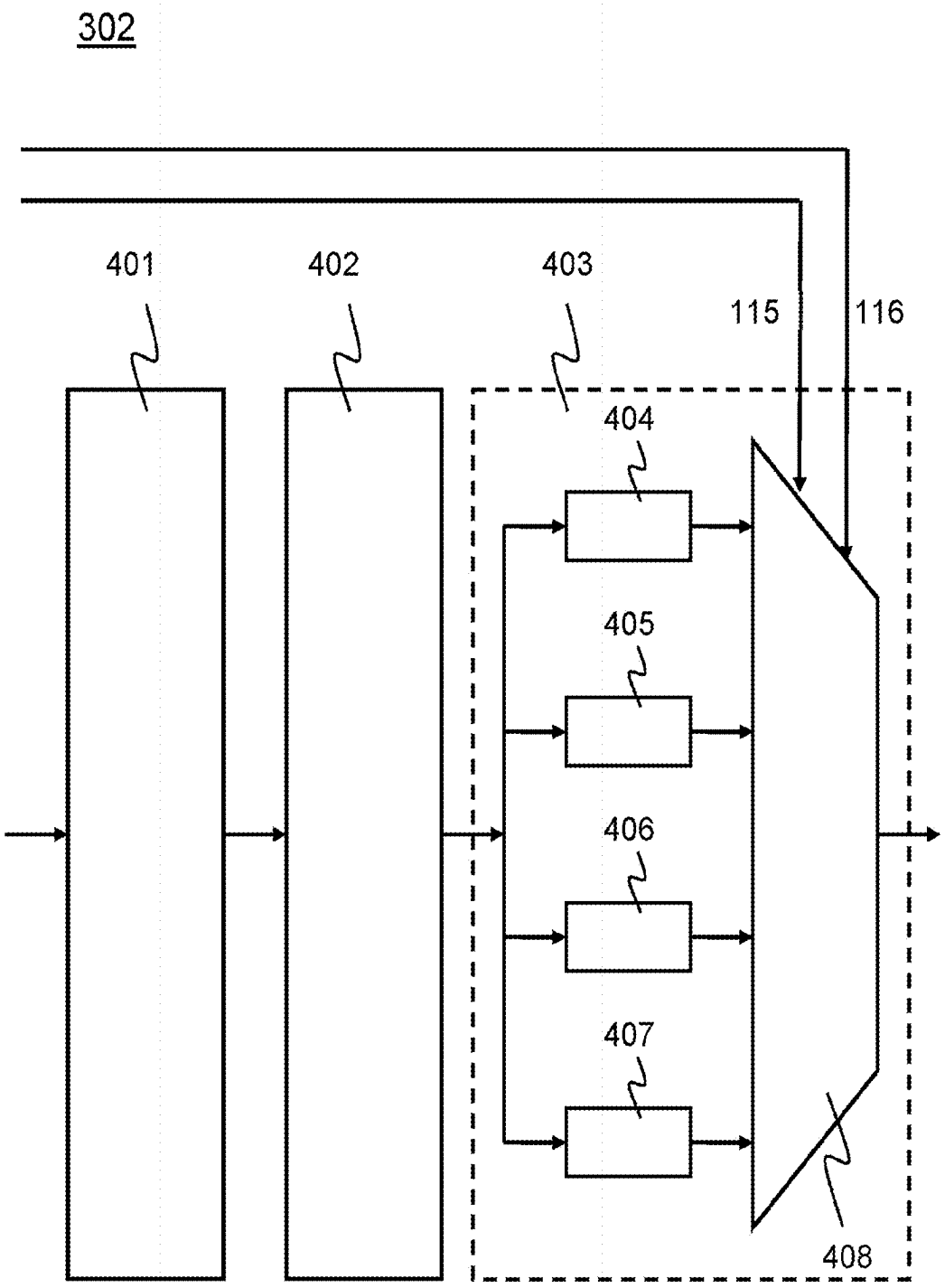


FIG. 4

# VIDEO ENCODING APPLYING A REFRESH SCHEME

## FIELD OF THE INVENTION

**[0001]** An aspect of the invention relates to a method of encoding a sequence of frames in which a refresh scheme is applied. The method may be used, for example, in a camera device for encoding a sequence of frames that has been captured. The camera device may then store the sequence of frames that has been encoded or may send this sequence, which constitutes a video, to another device, or both. Other aspects of the invention relate to a video encoder, a computer program for a video encoder, a data set comprising an encoded sequence of frames, and a video decoder.

## BACKGROUND ART

**[0002]** There are numerous video encoding techniques that apply intra-mode encoding and inter-mode encoding. A frame, or at least a zone therein, that is encoded in an intra-mode makes no reference to another frame. Accordingly, intra-mode encoding produces an encoded frame, or an encoded zone, that is self-contained. Conversely, a frame, or at least a zone therein, that is encoded in the inter-mode makes reference to one or more previously encoded frames. Generally, a differential representation of a zone to be encoded is generated. The differential representation corresponds with a difference between, on the one hand, the zone to be encoded and, on the other hand, a corresponding zone in a decoded version of a previously encoded frame. Accordingly, inter-mode encoding produces an encoded frame, or an encoded zone, that is intrinsically linked with one or more previously encoded frames.

**[0003]** Video encoding may involve making an evaluation whether a frame, or a zone therein, should be encoded in the intra-mode or in the inter-mode. This evaluation may be based on one or more criteria, which generally include a smallest amount of data produced by encoding as a criterion. In case the intra-mode is expected to produce the smallest amount of data, this mode may be applied. Conversely, in case the inter-mode is expected to produce the smallest amount of data, this mode may be applied. In general, the evaluation will retain the intra-mode as best if there are relatively large differences between the frame to be encoded, or the zone therein, and frames to which reference can be made. This will typically be the case, for example, if there is a change in scene, or a scene where many changes occur. The evaluation will retain the inter-mode as best if there are relatively small differences between the frame to be encoded, or the zone therein, and frames to which reference can be made. This will typically be the case, for example, in a quiet scene, akin to a still picture, or a static background in a scene.

**[0004]** In case the intra-mode or the inter-mode is applied in accordance with an evaluation as described hereinbefore, it may happen that there is a relatively long series of successive frames that are encoded in the inter-mode. This series of successive frames will thus not comprise any frame that is encoded in the intra-mode. The same applies with respect to a zone in a series of successive frames. If, for example, the zone is part of a static background, the zone will be encoded in the inter-mode throughout the series of successive frames.

**[0005]** The following decoding delay problem may present itself if there is a relatively long series of successive frames that are encoded in the inter-mode. A decoder that starts decoding during this relatively long series of successive frames will not be able to produce correctly decoded video as long as this series lasts. Namely, the decoder must first decode a frame that has been encoded in the intra-mode in order to have a valid reference, a valid decoding starting point. It may thus take a relatively long time before the decoder is able to produce correctly decoded video. This decoding delay problem also occurs if a zone in a relatively long series of successive frames is exclusively encoded in the inter-mode. There will be no frame in this series for which the zone is encoded in the intra-mode.

**[0006]** A refresh scheme may be applied to address the decoding delay problem described hereinbefore. Basically, the refresh scheme frequently causes a frame, or at least a zone therein, to be forcibly encoded in the intra-mode for one out of several successive frames. That is, this one frame, or the zone therein, is encoded in the intra-mode although the evaluation was made that the frame, or the zone therein, should be encoded in the inter-mode. The refresh scheme thus ensures that references occur frequently in a series of successive frames. Accordingly, this prevents a too long delay in obtaining correctly decoded video.

**[0007]** Patent publication WO2020249790A1 describes certain aspects discussed hereinbefore. Specifically, this patent publication describes an encoding assembly that evaluates for a portion of a linearly transformed frame whether the following condition applies, or not. When the portion of the linearly transformed frame is encoded in the inter mode, an encoded version of the portion of the linearly transformed frame is obtained that comprises a smaller amount of data than an encoded version that is obtained by encoding the portion of the linearly transformed frame in the intra mode. The encoding assembly encodes the portion of the linearly transformed frame in the inter mode if this condition applies. If not, the portion of the linearly transformed frame is encoded in the intra mode.

**[0008]** Patent publication WO2020249790A1 further describes that the encoding assembly periodically encodes respective linearly transformed frame portions in the intra mode. This can be regarded as a refresh mechanism, which allows quickly achieving relatively good image quality at a decoding end. A video decoder can quickly lock in, as it were, on an encoded video stream provided by a video encoder that incorporates the encoding assembly. What is more, this also allows more robust video transmission. In case a portion of the encoded video stream gets lost due to, for example errors, an impacted zone of a frame can relatively quickly be restored.

## SUMMARY OF THE INVENTION

**[0009]** There is a need for a video encoding technique that allows an improvement in video quality.

**[0010]** The invention takes the following into consideration. A refresh scheme as described hereinbefore may give rise to visual artifacts. Let it be assumed that there is a series of successive frames that have been encoded in the inter-mode without applying a refresh scheme. As mentioned hereinbefore, the series of successive frames may represent a quiet scene, or even a static scene. In the series of successive frames, each frame that is encoded in the inter-

mode may provide a refinement making that image quality gradually increases or, at least, is maintained at a relatively high level.

**[0011]** Let it now be assumed that a refresh scheme is applied making that a frame in the aforementioned series of successive frames is forcibly encoded in the intra-mode. This encoding in the intra-mode potentially produces a relatively large amount of data. Generally, a frame, or a zone therein, is encoded so that an amount of data is produced that is within a budget for the amount of data. In order to keep the amount of data produced by the encoding in the intra-mode within the budget, the frame that is forcibly encoded in the intra-mode may need to be quantized with a relatively low resolution. Consequently, a decoded version of that frame may have a relatively poor quality. As a result, image quality may suddenly drop at a certain point in a scene, which may be a relatively quiet scene or an almost static scene. This may constitute a visual artifact, in particular because of the unexpected nature of the quality drop in the scene.

**[0012]** The aforementioned visual artifacts need not occur when a frame is encoded in the intra-mode in accordance with an evaluation that this mode should indeed be applied. The frame then generally differs to a large extent from one or more preceding frames because, for example, there is quite some change in a scene, or there is a change of scene. In that case, quantization with a relatively low resolution is generally significantly less noticeable than the case described hereinbefore in which a frame is forcibly encoded in the intra-mode whereas the frame would otherwise have been encoded in the inter-mode.

**[0013]** The aforementioned equally applies to a zone in a series of successive frames. The zone may be part of, for example, a static background. Then, for each frame, an evaluation will indicate that the zone should be encoded in the inter-mode. The inter-mode will indeed be applied except for one or more frames that are forcibly encoded in the intra-mode due to a refresh scheme being applied. Here too, this will generally make that, for these frame, the zone is then quantized with a relatively low resolution in order to respect a budget for an amount of data. Accordingly, a sudden drop in image quality may occur, which may constitute local visual artifacts in this case.

**[0014]** An aspect of the invention as defined in claim **1** provides for a method of encoding a sequence of frames so as to obtain an encoded sequence of frames, the method comprising:

**[0015]** making an evaluation on a frame-by-frame basis for at least a zone in a series of successive frames whether the zone should be encoded in an intra-mode or in an inter-mode;

**[0016]** applying a refresh scheme that frequently causes the zone to be forcibly encoded in the intra-mode for one out of several successive frames, irrespective of the evaluation made; and

**[0017]** quantizing the zone in the series of successive frames so that if, for a frame, the zone is forcibly encoded in the intra-mode and contrary to the evaluation that was made, the zone is quantized with a higher resolution than if the zone were encoded in accordance with the evaluation that was made in one of the following modes: the intra-mode and the inter-mode.

**[0018]** A further aspect of the invention as defined in claim **12**, provides for a video encoder adapted to encode a sequence of frames so as to obtain an encoded sequence of frames, the video encoder comprising:

**[0019]** a coding-mode application assembly comprising:

**[0020]** a coding-mode evaluation module adapted to make an evaluation on a frame-by-frame basis for at least a zone in a series of successive frames whether the zone should be encoded in an intra-mode or in an inter-mode; and

**[0021]** a refresh scheme application module adapted to frequently cause the zone to be forcibly encoded in the intra-mode for one out of several successive frames, irrespective of the evaluation made; and

**[0022]** a quantization assembly adapted to quantize the zone in the series of successive frames so that if, for a frame, the zone is forcibly encoded in the intra-mode and contrary to the evaluation was made, the zone is quantized with a higher resolution than if the zone were encoded in accordance with the evaluation that was made in one of the following modes: the intra-mode and the inter-mode.

**[0023]** A yet further aspect of the invention as defined in claim **13**, provides for a computer program for a video encoder, the computer program comprising a set of instructions that enables the video encoder to carry out the method defined hereinbefore.

**[0024]** In each of these aspects, a frame, or a zone in a frame, that is forcibly encoded in the intra-mode, whereas the frame, or the zone, would otherwise have been encoded in the inter-mode, is quantized with a relatively high resolution. In a manner of speaking, such a frame, or such a zone, gets a preferential treatment in quantization. This contributes to preventing that the frame, or the zone, has a significantly lower image quality than preceding frames, or the zone in the preceding frames. Accordingly, a sudden significant drop in image quality may be prevented, which thus prevents aforementioned visual artifacts, or at least mitigates such artifacts. The invention thus allows an improvement in the video quality.

**[0025]** There are various ways of giving the aforementioned preferential treatment in quantization. One basic option is to adapt a quantization control scheme based on achieving a target amount of data. The preferential treatment may be integrated, as it were, in such a quantization control scheme. Another basic option is to pre-quantize a frame, or a zone therein, with a resolution that depends on whether, or not, the frame, or the zone therein, is forcibly encoded in the intra-mode whereas, otherwise, the inter-mode would have been applied. The resolution is then higher for a frame, or a zone therein, that is forcibly intra-encoded instead of inter than for other frames, or other zones. The frame, or the zone therein, that is forcibly intra-encoded instead of inter may also not undergo any quantization, whereas the other frames, or the other zones, are subject to a quantization. Such a selective pre-quantization also provides the preferential treatment.

**[0026]** An additional aspect of the invention as defined in claim **14**, provides for a data set comprising:

**[0027]** an encoded sequence of frames obtained by a method as defined hereinbefore; and

**[0028]** an indication on whether, or not, a zone in a frame was forcibly encoded in the intra-mode although an evaluation was made that the zone should be encoded in the inter-mode.

**[0029]** A further additional aspect of the invention as defined in claim **15**, provides for a video decoder adapted to decode a sequence of encoded frames obtained by a method as defined hereinbefore, wherein the sequence of encoded frames is comprised in a data set that includes an indication on whether, or not, a zone in a frame was forcibly encoded in the intra-mode although an evaluation was made that the zone should be encoded in the inter-mode, the video decoder comprising:

**[0030]** a dequantization assembly adapted to dequantize the zone depending on the indication on whether, or not, the zone was forcibly encoded in the intra-mode although an evaluation was made that the zone should be encoded in the inter-mode.

**[0031]** These additional aspects allow cost-efficient implementations of giving the preferential treatment mentioned hereinbefore. Moreover, these additional aspects may also allow implementing the preferential treatment in existing coding techniques in an efficient manner, in particular in terms of efficient use of data. JPEG XS is an example of an existing coding technique to which this applies. JPEG XS is defined in ISO document ISO/IEC 21122-1:2022—Information technology—JPEG XS low-latency lightweight image coding system—Part 1: Core coding system. JPEG XS incorporates an efficient technique for specifying data quantization that a video encoder has applied. A relatively small amount of data may specify the data quantization that has been applied, which enables a video decoder to correctly apply dequantization. The aforementioned indication on whether or not a zone was forcibly intra-encoded instead of inter, may require an additional flag. However, this indication allows maintaining the efficient technique for specifying data quantization in JPEG-XS.

**[0032]** For the purpose of illustration, some embodiments of the invention are described in detail with reference to accompanying drawings. In this description, additional features will be presented, some of which are defined in the dependent claims, and advantages will be apparent.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0033]** FIG. **1** is a schematic block diagram of a video encoder.

**[0034]** FIG. **2** is a schematic block diagram of a quantization assembly in the video encoder.

**[0035]** FIG. **3** is a schematic block diagram of a video decoder.

**[0036]** FIG. **4** is a schematic block diagram of an entropy decoding and dequantization assembly in the video decoder.

## DESCRIPTION OF SOME EMBODIMENTS

**[0037]** FIG. **1** schematically illustrates a video encoder **100**. FIG. **1** provides a schematic block diagram of the video encoder **100**. The video encoder **100** may be, for example, comprised in a communication device that can capture a video, or that can store a video, or both, such as, for example, a smart phone. The video encoder **100** may enable the communication device to efficiently transfer a video to another communication device via a communication channel that may be provided by a network.

**[0038]** The video encoder **100** illustrated in FIG. **1** is an innovatively improved version of a video encoder **100** presented in patent publication WO2020249790A1 mentioned hereinbefore as background art. The latter video encoder **100** will be referred to hereinafter as prior art video encoder for the sake of convenience. The video encoder **100** illustrated in FIG. **1** of the present patent application comprises a similar set of functional entities. These functional entities include a linear transform assembly **101** and an encoding assembly **102**. The linear transform assembly **101** may comprise a reversible color transform module **103** and a wavelet transform module **104**. The encoding assembly **102** may comprise coding-mode selection assembly **105**, a quantization assembly **106**, an entropy coding module **107**, a data packaging module **108**, a rate allocation module **109**, a dequantization module **110**, a reconstruction module **111**, and a reference frame buffer assembly **112**.

**[0039]** Basically, the video encoder **100** may encode a sequence of frames **113**, which may constitute a video, so as to obtain an encoded sequence of frames **114**. The encoded sequence of frames **114** may thus constitute an encoded video comprising a smaller amount of data than the video in its original form. The video encoder **100** basically operates in a manner similar to that of the prior art video encoder. The description of the prior art video encoder in patent publication WO2020249790A1 therefore equally applies to the video encoder **100** illustrated in FIG. **1**, unless indicated otherwise.

**[0040]** In the video encoder **100** illustrated in FIG. **1**, the encoding mode selection assembly **105** replaces the encoding mode selection module in the prior art video encoder. Nonetheless, the encoding mode selection assembly **105** may substantially operate in a similar manner. That is, for a series of successive linearly transformed frames, the encoding mode selection assembly **105** makes an evaluation on a frame-by-frame basis for a subband frame portion having a particular position in a linearly transformed frame. The evaluation concerns whether, for the linearly transformed frame concerned, the subband frame portion should be encoded in an intra-mode or in an inter-mode. Like in the prior art video decoder, the evaluation may be based on comparing an intra-mode GCLI sum value with an inter-mode GCLI sum value. The encoding mode selection assembly **105** may thus comprise an encoding mode evaluation module that is similar to that in the prior art video encoder. However, the encoding mode selection assembly **105** need not provide GCLI coding values as an output.

**[0041]** The encoding mode selection assembly **105** may further apply a refresh scheme that frequently causes a subband frame portion having a particular position in a linearly transformed frame to be forcibly encoded in the intra-mode for one out of several successive linearly transformed frames, irrespective of the evaluation made. This aspect has also been described in great detail in patent publication WO2020249790A1. The encoding mode assembly may thus comprise a specific refresh scheme application module.

**[0042]** The encoding mode selection assembly **105** provides an evaluation flag **115** and a refresh flag **116** in association with a subband frame portion. The evaluation flag **115** indicates the evaluation that has been made: whether the subband frame portion should be encoded in the intra-mode or in the inter-mode. The refresh flag **116** indicates whether the subband frame portion has been forcibly encoded in the intra-mode, or not.

**[0043]** A first innovative improvement of the video encoder **100** illustrated in FIG. **1** concerns the quantization assembly **106**, which replaces the quantization module in the

prior art video encoder. Like the quantization module in the prior art video encoder, the quantization assembly **106** may receive a subband frame portion or a differential representation of a subband frame portion, depending on whether the intra-mode or the inter-mode has been applied, respectively. The quantization module further receives the evaluation flag **115** and refresh flag **116** from the encoding mode selection assembly **105**.

**[0044]** FIG. **2** schematically illustrates the quantization assembly **106**. The quantization assembly **106** comprises a pre-quantization module **201** and a controlled quantization module **202**. In this embodiment, the pre-quantization module **201** comprises a set of bit shifters **203-206**, a multiplexer **207**, and a GCLI extractor **208**. The set of bit shifters **203-206** comprises a first bit shifter **203**, a second bit shifter **204**, a third bit shifter **205**, and a fourth bit shifter **206**.

**[0045]** The pre-quantization module **201** basically operates as follows. The set of bit shifters **203-206** receives samples comprised in the subband frame portion in or the differential representation thereof, whichever is provided by the encoding mode selection assembly **105**. The first bit shifter **203** does not shift the samples. The second bit shifter **204** shifts the samples two positions to the right. This is equivalent to truncating two least significant bits. The third and the fourth bit shifters **205**, **206** shift the samples three positions to the right. This is equivalent to truncating three least significant bits.

**[0046]** The multiplexer **207** selects one of the bit shifters in dependence on the evaluation flag **115** and the refresh flag **116** provided by the encoding mode selection assembly **105**. The multiplexer **207** selects the first bit shifter **203** in case the evaluation flag **115** indicates that it has been evaluated that the inter-mode should apply and the refresh flag **116** indicates that the subband frame portion is forcibly encoded in the intra-mode. In that case, the pre-quantization module **201** does not truncate the samples of the subband frame portion.

**[0047]** The multiplexer **207** selects the second bit shifter **204** in case the evaluation flag **115** indicates that it has been evaluated that the inter-mode should apply and the refresh flag **116** indicates there is no forcible encoding in the intra-mode. In that case, the pre-quantization module **201** truncates the two least significant bits of the samples of the subband frame portion.

**[0048]** The multiplexer **207** selects the third bit shifter **205** in case the evaluation flag **115** indicates that it has been evaluated that the intra-mode should apply and the refresh flag **116** indicates that forcible encoding in the intra-mode applies. In that case, the pre-quantization module **201** truncates the three least significant bits of the samples of the subband frame portion.

**[0049]** The multiplexer **207** selects the fourth bit shifter **206** in case the evaluation flag **115** indicates that it has been evaluated that the intra-mode should apply and the refresh flag **116** indicates there is no forcible encoding in the intra-mode. In that case, the pre-quantization module **201** also truncates the three least significant bits of the samples of the subband frame portion.

**[0050]** The following table illustrates the operation of the pre-quantization module **201**:

| Evaluation flag 115 (1 for inter) | Refresh flag 116 (1 for refresh) | Pre-quantization "Gain" (implemented as right shift) |
|---|---|---|
| 1 | 1 | 1 (i.e. >> 0) |
| 1 | 0 | ¼ (i.e. >> 2) |
| 0 | 1 | ⅛ (i.e. >> 3) |
| 0 | 0 | ⅛ (i.e. >> 3) |

**[0051]** The table comprises four lines representing four encoding conditions. Each one of these four lines uniquely represents one of the four encoding conditions. The table comprises a right-hand column representing a quantization setting that applies in an encoding condition. In this example, there are three different quantization settings.

**[0052]** A first one of the four lines represents a first encoding condition. In the first encoding condition, a subband frame portion is forcibly encoded in the intra-mode, although it was evaluated that the inter-mode should apply. Since it is the refresh scheme that dictates this forced encoding in the intra-mode, the first encoding condition may be referred to as inter-refreshed encoding condition. The evaluation flag **115** and the refresh flag **116** jointly signal the inter-refreshed encoding condition by both being set to true (1) in this example. A first quantization setting applies in the inter-refreshed encoding condition according to which the subband frame portion is not quantized.

**[0053]** A second one of the four lines represents a second encoding condition. In the second encoding condition, a subband frame portion is encoded in the inter-mode in accordance with the evaluation that was made. Thus, in this encoding condition, the refresh scheme does not dictate forced encoding in the intra-mode. The second encoding condition may thus be simply referred to as inter-encoding condition. The evaluation flag **115** and the refresh flag **116** jointly signal the inter-encoding condition by being set to true (1) and false (0), respectively, in this example. A second quantization setting applies in the inter-encoding condition according to which the subband frame portion is quantized by an effective factor equal to four (4). Accordingly, the pre-quantization module **201** applies a quantization with a four (4) times lower resolution in the inter-encoding condition with respect to the inter-refreshed encoding condition discussed hereinbefore.

**[0054]** A third one of the four lines represents a third encoding condition. In the third encoding condition, a subband portion is encoded in the intra-mode in accordance with the evaluation that was made, while the refresh scheme dictates forced encoding in the intra-mode. In this encoding condition, the evaluation is thus in line with what the refresh scheme dictates. The third encoding condition may be referred to as intra-refreshed encoding condition. The evaluation flag **115** and refresh flag **116** jointly signal the intra-refreshed encoding condition by being set to false (0) and true (1), respectively, in this example. A third quantization setting applies in the intra-refreshed encoding condition according to which the subband frame portion is quantized by an effective factor equal to eight (8). Accordingly, the pre-quantization module **201** applies a quantization with an eight (8) times lower resolution in the intra-refreshed encoding condition with respect to the inter-refreshed encoding

condition discussed hereinbefore, and with a two times (2) lower resolution with respect to the inter-encoding condition discussed hereinbefore.

**[0055]** A last, fourth one of the four lines represents a fourth encoding condition. In the fourth encoding condition, a subband portion is encoded in the intra-mode in accordance with the evaluation that was made, while the refresh scheme does not dictate forced encoding in the intra-mode. The fourth encoding condition may thus be simply referred to as intra-encoding condition. The evaluation flag **115** and refresh flag **116** jointly signal the intra-encoding condition by both being set to false (0) in this example. The third quantization setting equally applies in the intra-encoding condition. Indeed, there is no need for quantizing a subband frame portion differently depending on whether the evaluation that the subband frame portion should be encoded in the intra-mode is in line with what the refresh scheme dictates, or not. Thus, any subband frame portion that is encoded in the intra-mode is quantized by an effective factor equal to eight (8).

**[0056]** Thus, the pre-quantization module **201** does not quantize a subband frame portion in the inter-refreshed encoding condition, in which the subband frame portion is forcibly encoded in the intra-mode, although it is evaluated that the inter-mode should apply. In the other encoding conditions, where encoding is in accordance with the evaluation that was made, the pre-quantization module **201** quantizes the subband frame with a given resolution. Thus, a subband frame portion that is forcibly encoded in the intra-mode and contrary to the evaluation that was made, is quantized with a higher resolution than if the subband frame portion were encoded in accordance with the evaluation that was made, whereby the evaluation is one of the following: the intra-mode and the inter-mode.

**[0057]** The pre-quantization module **201** quantizes a subband frame portion with a resolution that is somewhat higher in the inter-encoding condition than in the intra-refreshed and intra-encoding conditions. That is, if encoding is in accordance with the evaluation that was made, the resolution is somewhat higher for encoding in the inter-mode than for encoding in the intra-mode. As discussed hereinbefore, the evaluation will generally indicate that the inter-mode should be applied for encoding a rather static zone, where few changes occur, or even no changes occur. Correspondingly, the evaluation will generally indicate that the intra-mode should be applied for encoding a rather dynamic zone, where many changes occur. Quantizing a rather dynamic zone, where many changes occur, with a relatively low resolution need not significantly affect perceived image quality. Conversely, quantizing a rather static zone, where few or even no changes occur, with a higher resolution than a rather dynamic zone, where many changes occur, may enhance perceived image quality. Thus, quantizing a zone that is encoded in the inter-mode in accordance with the evaluation made with a higher resolution than a zone that is encoded in the intra-mode in accordance with the evaluation made, will generally contribute to an improved perceived image quality.

**[0058]** The controlled quantization module **202** in the quantization assembly **106** may operate in a manner similar to that of the quantization module in the prior art video encoder. Basically, the controlled quantization module **202** quantizes a pre-quantized subband frame portion, or the differential representation thereof, with a resolution that is set by the rate allocation module **109**. The rate allocation module **109** applies a control scheme ensuring that encoding the frame, or a portion thereof, produces an amount of data that is within a budget. Accordingly, the resolution of quantization depends on the control scheme.

**[0059]** The pre-quantization module **201** and the controlled quantization module **202** jointly carry out an overall quantization. The pre-quantization module **201** makes that a subband frame portion that is forcibly encoded in the intra-mode, although it was evaluated that inter-mode should apply, gets a preferential treatment in the overall quantization. Namely, in the overall quantization, the resolution may be at least two times (2) higher in the inter-refreshed encoding condition compared with the other encoding conditions. Specifically, in the example discussed hereinbefore, the resolution in the inter-refreshed encoding condition may be about four times (4) higher than in the inter-encoding condition, and about eight (8) times higher than in the intra-refreshed and intra-encoding conditions. As explained hereinbefore, such a preferential treatment allows preventing visual artifacts that may otherwise occur if no preferential treatment is given. However, it should be noted that the embodiment presented here is only one of numerous possible embodiments for giving preferential treatment in quantization.

**[0060]** A second innovative improvement of the video encoder **100** illustrated in FIG. **1** concerns providing, in association with the encoded sequence of frames **114**, a specification **117** of the refresh scheme that is applied by the video encoder **100**. In this embodiment, the data packaging module **108** receives this specification from the encoding mode selection assembly **105**. The data packaging module **108** embeds the specification **117** of the refresh scheme in an output video stream, which includes the encoded sequence of frames **114**. This output video stream may be regarded as a data set. For example, the video output stream may be stored in the memory and then takes the form of a video file, which may also be regarded as a data set.

**[0061]** In an embodiment, the specification **117** of the refresh scheme may be comprised in a frame header, which may also be referred to as picture header. The specification may comprise several fields. One field may specify a refresh rate, which may be an integer corresponding to a periodicity in terms of number of frames with which a refresh should be carried out. The other field may define a frame index, which may be an integer too corresponding to a unique serial number identifying a frame's position in the sequence of frames. This specification **117** of the refresh scheme may be complemented with respective refresh offset values for respective types of subbands. These refresh offset values may be comprised in a table having an entry for each type of subband and containing a refresh offset value for the type of subband. This table may be predefined and stored in a memory, or another type of circuit, within the video encoder **100**, as well as within a complementary video decoder.

**[0062]** For a given type of subband, the aforementioned parameters, the refresh rate, the frame index, and the refresh offset value, may determine whether a subband frame portion is to be forcibly encoded in the intra-mode, or not. A subband frame portion may have a group index defining the subband frame portion's position within a subband frame. The following rule may then be applied. If {([group index]+[frame index]+[refresh offset value]) modulo [refresh rate]}

is equal to 0, then the subband frame portion must be forcibly encoded in the intra-mode, otherwise not.

**[0063]** In another embodiment, the specification **117** of the refresh scheme may be comprised in a marker following a frame header. Such a marker thus occurs only once every frame, like the frame header. The marker may comprise several fields. One field may comprise a table specifying respective refresh offset values for respective types of subbands. Another field may comprise a table specifying respective refresh rates for respective types of subbands. These two tables thus specify the following two parameters for each type of subband: a refresh offset value and a refresh rate.

**[0064]** For a given type of subband, the aforementioned parameters, the refresh offset value, the refresh rate, may determine whether a subband frame portion is to be forcibly encoded in the intra-mode, or not. The following rule may then be applied. If {([group index]−[refresh offset value]) modulo [1<<refresh rate]} is equal to 0, then the subband frame portion must be forcibly encoded in the intra-mode, otherwise not. As mentioned hereinbefore, the group index defines the subband frame portion's position within the subband frame. The notation [1<<refresh rate] means that binary number one (1) is shifted to the left by a number of positions corresponding to the refresh rate. Thus, [1<<refresh_rate] is equivalent to [2 to the power refresh_rate] if refresh rate is a positive integer.

**[0065]** A general advantage of the specification **117** of the refresh scheme being provided with the encoded sequence of frames **114** is that there is no need for providing an encoding mode flag with each encoded subband frame portion. Namely, the specification **117** of the refresh scheme indicates subband frame portions that are forcibly encoded in the intra-mode. Specifically, the specification **117** of the refresh scheme comprises a set of parameters that applies generally to many respective encoded subband frame portions, which may cover multiple encoded frames, indicating for each encoded subband frame portion whether the encoded subband frame portion has forcibly been encoded in the intra-mode, or not. Thus, there is no need for providing an encoding mode flag for the encoded subband frame portions that have been forcibly encoded in the intra-mode. This may constitute an economy in signaling data, allowing more room for other data, in particular encoded subband frame portions. In turn, this may contribute to a better ratio of video quality to data bandwidth.

**[0066]** The data packaging module **108** may further include the evaluation flag **115** in the data set mentioned hereinbefore, in association with the subband frame portion to which the evaluation flag **115** belongs. In combination with the specification **117** of the refresh scheme, an indication is thus provided on whether, or not, the subband frame portion concerned was forcibly encoded in the intra-mode, although the evaluation was made that the inter-mode should apply. As explained hereinbefore, this indication allows cost-efficient implementations of giving the preferential treatment mentioned hereinbefore. The embodiment presented here is an example of such a cost-efficient implementation. Moreover, the aforementioned indication may also allow implementing the aforementioned preferential treatment in existing coding techniques in an efficient manner, in particular in terms of efficient use of data.

**[0067]** FIG. **3** schematically illustrates a video decoder **300**, which is complementary with the video decoder **300** described hereinbefore with reference to FIGS. **1** and **2**. FIG. **3** provides a schematic block diagram of the video decoder **300**. The video decoder **300** illustrated in FIG. **3** is an innovatively improved version of a video decoder **300** presented in patent publication WO2020249790A1 mentioned hereinbefore. The latter video decoder **300** will be referred to hereinafter as prior art video decoder for the sake of convenience. The video decoder **300** illustrated in FIG. **3** of the present patent application comprises a similar set of functional entities. These functional entities include an unpacking module **301**, an entropy decoding and dequantization assembly **302**, a decoding reconstruction module **303**, a decoding buffer memory **304**, an inverse wavelet and color transform module **305**.

**[0068]** Basically, the video decoder **300** may receive and decode the encoded sequence of frames **114** produced by the video encoder **100** illustrated in FIG. **1**. The video encoder **100** basically operates in a manner similar to that of the prior art video decoder. The description of the prior art video decoder in patent publication WO2020249790A1 therefore equally applies to the video decoder **300** illustrated in FIG. **3**, unless indicated otherwise.

**[0069]** The video decoder **300** basically operates as follows. The unpacking module **301** carries out operations inverse to those carried out by the packing module described hereinbefore. Accordingly, the unpacking module **301** retrieves various types of data, which includes encoded subband frame portions, the specification **117** of the refresh scheme, and respective evaluation flags **115** associated with respective encoded subband frame portions. The unpacking module **301** may further derive respective refresh flags **116** associated with respective encoded subband frame portions on the basis of the specification **117** of the refresh scheme.

**[0070]** FIG. **4** schematically illustrates the entropy decoding and dequantization assembly **302**, which is different from the entropy decoding and dequantization module in the prior art video decoder. FIG. **4** provides a schematic block diagram of the entropy decoding and dequantization assembly **302**. The entropy decoding and dequantization assembly **302** comprises an entropy decoding module **401**, a primary dequantization module **402**, and a post dequantization module **403**. The post dequantization module **403** comprises a set of bit shifters **404-407** and a multiplexer **408**. The set of bit shifters **404-407** comprises a first bit shifter **404**, a second bit shifter **405**, a third bit shifter **406**, and a fourth bit shifter **407**.

**[0071]** The entropy decoding module **401** and the primary dequantization module **402** may operate in a manner similar to that of the entropy decoding and dequantization module in the prior art video decoder. The primary dequantization module **402** provides respective partially dequantized subband frame portions, if encoded in the intra-mode, and partially dequantized differential representations of subband frame portions, if encoded in the inter-mode. These will jointly be referred to as partially dequantized frame portions for the sake of convenience.

**[0072]** The post dequantization module **403** basically operates as follows. The set of bit shifters **404-407** receives samples comprised in a partially dequantized frame portion. The first bit shifter **404** does not shift the samples. The second bit shifter **405** shifts the samples two positions to the left. In effect, this provides substitutes for two least significant bits that have been truncated. The third and the fourth bit shifters **406**, **407** shift the samples three positions to the

left. In effect, this provides substitutes for three least significant bits that have been truncated.

**[0073]** The multiplexer **408** selects one of the bit shifters in dependence on an evaluation flag **115** and a refresh flag **116**. These flags belong to the partially dequantized frame portion of which the samples are applied to the set of bit shifters **404-407**. The multiplexer **408** selects the first bit shifter **404** in case the evaluation flag **115** indicates that the inter-mode should have been applied to the subband frame portion concerned and the refresh flag **116** indicates that the subband frame portion has been forcibly encoded in the intra-mode. In that case, the post dequantization module **403** does not alter the samples of the partially dequantized frame portions.

**[0074]** The multiplexer **408** selects the second bit shifter **405** in case the evaluation flag **115** indicates that the inter-mode should have been applied to the subband frame portion concerned and the refresh flag **116** indicates there has been no forcible encoding in the intra-mode. In that case, the post dequantization module **403** provides zeroes as substitutes for the two least significant bits that have been truncated.

**[0075]** The multiplexer **408** selects the third bit shifter **406** in case the evaluation flag **115** indicates that the intra-mode should have been applied and the refresh flag **116** indicates that forcible encoding in the intra-mode has applied for the subband frame portion concerned. In that case, the post dequantization module **403** provides zeroes as substitutes for the three least significant bits that have been truncated.

**[0076]** The multiplexer **408** selects the fourth bit shifter **407** in case the evaluation flag **115** indicates that the intra-mode should have been applied and the refresh flag **116** indicates there has been no forcible encoding in the intra-mode. In that case, the post dequantization module **403** provides zeroes as substitutes for the three least significant bits that have been truncated.

**[0077]** The following table illustrates the operation of the post dequantization module **403**:

| Evaluation flag 115 (1 for inter) | Refresh flag 116 (1 for refresh) | Post dequantization "Gain" (implemented as left shift) |
|---|---|---|
| 1 | 1 | 1 (i.e. << 0) |
| 1 | 0 | 4 (i.e. << 2) |
| 0 | 1 | 8 (i.e. << 3) |
| 0 | 0 | 8 (i.e. << 3) |

**[0078]** In effect, the post dequantization module **403** thus inverses relative weights that the pre-quantization module **201** in the video encoder **100** has given with respect to quantization. In a certain sense, the pre-quantization module **201** in the video encoder **100** may be regarded as an equalizer boosting a zone in a frame that may cause visual artifacts if quantized in a conventional manner. Conversely, the post dequantization module **403** in the video decoder **300** may be regarded as an inverse equalizer, which neutralizes the aforementioned boosting in dequantization.

## Notes

**[0079]** The embodiments described hereinbefore with reference to the drawings are presented by way of illustration. The invention may be implemented in numerous different ways. In order to illustrate this, some alternatives are briefly indicated.

**[0080]** There are numerous different ways of implementing an encoding technique in accordance with the invention. In the embodiments presented hereinbefore, the encoding technique was applied to a video encoding scheme described in patent publication WO2020249790A1 in which inter-mode encoding is done in a transform domain. In this context, a zone in a frame corresponds with a subband frame portion having a particular position in each of a series of successive frames in the transform domain. The encoding technique may also be applied to a video encoding scheme in which inter-mode encoding is done in a purely spatial, pixel domain, In such a scheme, the linear transformation is done after inter-mode encoding, rather than before. In such a context, a zone in a frame corresponds with a portion of a frame having a particular position in each of a series of successive frames, such as, for example, an upper-left corner. Thus, an encoding technique in accordance with the invention may be applied in a context where an evaluation is made for respective zones in a frame whether a zone should be encoded in an intra-mode or in an inter-mode and where a refresh scheme is applied that causes a set of zones in the frame to be forcibly encoded in the intra-mode, irrespective of the evaluation made. Optionally, a specification of the refresh scheme may be provided that identifies the set of zones in the frame that are forcibly encoded in the intra-mode.

**[0081]** There are numerous different ways of implementing video encoding in accordance with the invention, which involves giving a preferential treatment in quantizing. In the embodiments presented hereinbefore, the preferential treatment was given by means of pre-quantizing. In other embodiments, the preferential treatment may be integrated in a quantization control scheme for meeting a budget for an amount of data. In such embodiment, pre-quantization is not required. In the embodiments presented hereinbefore, pre-quantizing was done by means of bit shifting. In other embodiments, quantization techniques other than bit shifting may be used, such as, for example, a quantization technique that involves rounding to a nearest quantization value.

**[0082]** In general, there are numerous different ways of implementing video encoding and video decoding in accordance with the invention. Any of the modules in the presented embodiments may be implemented by means of an electrical circuit, which may be dedicated or programmable, or by means of a suitably programmed processor, or a combination thereof. A computer program may define one or more operations that have been described with reference to the presented embodiments. In this respect, the schematic block diagrams of FIGS. **1-4** may each also be regarded, at least partially, as representing a flow chart diagram of such a computer program, as well as representing a method that a processor may carry out when executing the computer program. For example, the pre-quantization module **201** in the block diagram of FIG. **2** may be regarded as representing a pre-quantization step. Similarly, other modules may be regarded as representing steps of a method.

**[0083]** Two innovative improvements have been presented. The first innovative improvement concerns giving preferential treatment in quantization when the intra-mode is enforced, whereas the inter-mode would have been used otherwise. This first innovative improvement is subject of

the appended claims. The second innovative improvement concerns including a specification of a refresh scheme in a data set together with an encoded sequence of frames to which the refresh scheme has been applied. The second innovative improvement does not require use of the first innovative improvement, and vice versa. That is, the two innovative improvements are independent from each other, although these may jointly be applied in as in the embodiments described hereinbefore. Also, the second innovative improvement may be applied to video encoding schemes different from that described in patent publication WO2020249790A1. The remarks made hereinbefore equally apply.

**[0084]** The remarks made hereinbefore demonstrate that the embodiments described with reference to the drawings illustrate the invention, rather than limit the invention. The invention can be implemented in numerous alternative ways that are within the scope of the appended claims. All changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope. Any reference sign in a claim should not be construed as limiting the claim. The verb "comprise" in a claim does not exclude the presence of other elements or other steps than those listed in the claim. The same applies to similar verbs such as "include" and "contain". The mention of an element in singular in a claim pertaining to a product, does not exclude that the product may comprise a plurality of such elements. Likewise, the mention of a step in singular in a claim pertaining to a method does not exclude that the method may comprise a plurality of such steps. The mere fact that respective dependent claims define respective additional features, does not exclude combinations of additional features other than those reflected in the claims.

**1**. A method of encoding a sequence of frames so as to obtain an encoded sequence of frames, the method comprising:

making an evaluation on a frame-by-frame basis for at least a zone in a series of successive frames whether the zone should be encoded in an intra-mode or in an inter-mode;

applying a refresh scheme that frequently causes the zone to be forcibly encoded in the intra-mode for one out of several successive frames, irrespective of the evaluation made; and

quantizing the zone in the series of successive frames so that if, for a frame, the zone is forcibly encoded in the intra-mode although the evaluation was made that the zone in the frame should be encoded in the inter-mode, the zone is quantized with a higher resolution than if the zone were encoded in accordance with the evaluation that was made.

**2**. A method of encoding a sequence of frames according to claim **1**, wherein the zone is quantized with a higher resolution if the zone is encoded in the inter-mode according to the evaluation that was made than if the zone is encoded in the intra-mode according to the evaluation that was made.

**3**. A method of encoding a sequence of frames according to any one of claims **1** and **2**, wherein quantizing the zone comprises:

fixedly quantizing the zone with a resolution that is higher if the zone is forcibly encoded in the intra-mode although the evaluation was made that the zone should be encoded in the inter-mode than if the zone were encoded in accordance with the evaluation that was made; and

controllably quantizing the zone with a resolution depending on a control scheme ensuring that encoding the frame, or a portion thereof, produces an amount of data that is within a budget.

**4**. A method of encoding a sequence of frames according to claim **3**, wherein fixedly quantizing the zone comprises quantizing the zone with:

a first predetermined resolution if the zone is forcibly encoded in the intra-mode although the evaluation was made that the zone should be encoded in the inter-mode;

a second predetermined resolution if the zone is encoded in the inter-mode according to the evaluation that was made; and

a third predetermined resolution if the zone is encoded in the intra-mode according to the evaluation that was made,

the first predetermined resolution being higher than the second predetermined resolution and higher than the third predetermined resolution.

**5**. A method of encoding a sequence of frames according to claim **4**, wherein the second predetermined resolution is higher than the third predetermined resolution.

**6**. A method of encoding a sequence of frames according to any of claims **4** and **5**, wherein the first predetermined resolution, the second first predetermined resolution, and the third predetermined resolution have ratios with respect to each other that are integer powers of two.

**7**. A method of encoding a sequence of frames according to any of claims **3** to **6**, wherein fixedly quantizing the zone comprises truncating samples belonging to the zone.

**8**. A method of encoding a sequence of frames according to claim **7**, wherein:

the samples are not truncated if the zone is forcibly encoded in the intra-mode although the evaluation was made that the zone should be encoded in the inter-mode;

two least significant bits are truncated if the zone is encoded in the inter-mode according to the evaluation that was made; and

three least significant bits are truncated if the zone is encoded in the intra-mode according to the evaluation that was made.

**9**. A method of encoding a sequence of frames according to any of claims **1** to **8**, the method comprising:

providing, for a frame that is encoded, an indication on whether, or not, the zone in the frame was forcibly encoded in the intra-mode although the evaluation was made that the zone should be encoded in the inter-mode.

**10**. A method of encoding a sequence of frames according to claim **9**, wherein the indication comprises:

a flag indicating whether, according to the evaluation, the zone should have been encoded in the intra-mode or in the inter-mode; and

a specification of the refresh scheme that is applied.

**11**. A method of encoding a sequence of frames according to claim **9**, wherein the indication comprises:

a first flag indicating whether, according to the evaluation, the zone should have been encoded in the intra-mode or in the inter-mode; and

a second flag indicating whether the zone was encoded in the intra-mode or in the inter-mode.

**12**. A video encoder adapted to encode a sequence of frames so as to obtain an encoded sequence of frames, the video encoder comprising:

a encoding-mode selection assembly comprising:

a encoding-mode evaluation module adapted to make an evaluation on a frame-by-frame basis for at least a zone in a series of successive frames whether the zone should be encoded in an intra-mode or in an inter-mode; and

a refresh scheme application module adapted to frequently cause the zone to be forcibly encoded in the intra-mode for one out of several successive frames, irrespective of the evaluation made; and

a quantization assembly adapted to quantize the zone in the series of successive frames so that if, for a frame, the zone is forcibly encoded in the intra-mode although the evaluation was made that the zone in the frame should be encoded in the inter-mode, the zone is quantized with a higher resolution than if the zone were encoded in accordance with the evaluation that was made.

**13**. A computer program for a video encoder, the computer program comprising a set of instructions that enables the video encoder to carry out the method according to any of claims **1** to **11**.

**14**. A data set comprising:

an encoded sequence of frames obtained by a method according to any of claims **1** to **11**;

an indication on whether, or not, a zone in a frame was forcibly encoded in the intra-mode although an evaluation was made that the zone should be encoded in the inter-mode.

**15**. A video decoder adapted to decode a sequence of encoded frames obtained by a method according to any of claims **1** to **11**, wherein the sequence of encoded frames is comprised in a data set that includes an indication on whether, or not, a zone in a frame was forcibly encoded in the intra-mode although an evaluation was made that the zone should be encoded in the inter-mode,

the video decoder comprising:

a dequantization assembly adapted to dequantize the zone depending on the indication on whether, or not, the zone was forcibly encoded in the intra-mode although an evaluation was made that the zone should be encoded in the inter-mode.

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