Audio Encoder, Audio Decoder, Method for Encoding an Audio Signal and Method for Decoding an Encoded Audio Signal

Description

Embodiments relate to audio coding, in particular, to a method and apparatus for encoding an audio signal using predictive encoding and to a method and apparatus for decoding an encoded audio signal using predictive decoding. Preferred embodiments relate to methods and apparatuses for pitch-adaptive spectral prediction. Further preferred embodiments relate to perceptual coding of tonal audio signals by means of transform coding with spectral-domain inter-frame prediction tools.

To improve the quality of coded tonal signals especially at low bit-rates, modern audio transform coders employ very long transforms and/or long-term prediction or pre-/post-filtering. A long transform, however, implies a long algorithmic delay, which is undesirable for low-delay communication scenarios. Hence, predictors with very low delay based on the instantaneous fundamental pitch have gained popularity recently. The IETF (Internet Engineering Task Force) Opus codec utilizes pitch-adaptive pre- and postfiltering in its frequency-domain CELT (Constrained-Energy Lapped Transform) coding path [J. M. Valin, K. Vos, and T. Terriberry, "Definition of the Opus audio codec," 2012, IETF RFC 6716. http://tools.ietf.org/html/rfc67161.], and the 3GPP (3rd Generation Partnership Project) EVS (Enhanced Voice Services) codec provides a long-term harmonic post-filter for perceptual improvement of transform-decoded signals [3GPP TS 26.443, "Codec for Enhanced Voice Services (EVS)," Release 12, Dec. 2014.]. Both of these approaches operate in the time domain on the fully decoded signal waveform, making it difficult and/or computationally expensive to apply them frequency-selectively (both schemes only offer a simple low-pass filter for some frequency selectivity). A welcome alternative to time-domain long-term prediction (LTP) or pre-/post-filtering (PPF) is thus provided by frequency-domain prediction (FDP) like it is supported in MPEG-2 AAC [ISO/IEC 13818-7, "Information technology – Part 7: Advanced Audio Coding (AAC)," 2006.]. This method, although facilitating frequency selectivity, has its own disadvantages, as described hereafter.

The FDP method introduced above has two drawbacks over the other tools. First, the FDP method requires a high computational complexity. In detail, linear predictive coding of at least order two (i.e. from the last two frame's channel transform bins) is applied onto hundreds of spectral bins for each frame and channel in the worst case of prediction in all scale factor bands [ISO/IEC 13818-7, "Information technology – Part 7: Advanced Audio Coding (AAC)," 2006.]. Second, the FDP method comprises a limited overall prediction gain. More precisely, the efficiency of the prediction is limited because noisy components between predictable harmonic, tonal spectral parts are subjected to the prediction as well, introducing errors as these noisy parts are typically not predictable.

The high complexity is due to the backward adaptivity of the predictors. This means that the prediction coefficients for each bin have to be calculated based on previously transmitted bins. Therefore, numerical inaccuracies between encoder and decoder can lead to reconstruction errors due to diverging prediction coefficients. To overcome this problem, bit exact identical adaptation has to be guaranteed. Furthermore, even if groups of predictors are disabled in certain frames, the adaptation always has to be performed in order to keep the prediction coefficients up to date.

Therefore, it is the object of the present invention to provide a concept for encoding an audio signal and/or decoding an encoded audio signal that avoids at least one (e.g., both) of the aforementioned issues and leads to a more efficient and computationally cheap implementation.

This object is solved by the independent claims.

Advantageous implementations are addressed by the dependent claims.

Embodiments provide an encoder for encoding an audio signal. The encoder is configured to encode the audio signal in a transform domain or filter-bank domain, wherein the encoder is configured to determine spectral coefficients of the audio signal for a current frame and at least one previous frame, wherein the encoder is configured to selectively apply predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the encoder is configured to determine a spacing value, wherein the encoder is configured to select the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied based on the

spacing value which may be transmitted as side information with the encoded audio signal.

Further embodiments provide a decoder for decoding an encoded audio signal (e.g., encoded with the above described encoder). The decoder is configured to decode the encoded audio signal in a transform domain or filter-bank domain, wherein the decoder is configured to parse the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame, and wherein the decoder is configured to selectively apply predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the decoder may be configured to select the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied based on a transmitted spacing value.

According to the concept of the present invention, predictive encoding is (only) applied to selected spectral coefficients. The spectral coefficients to which predictive encoding is applied can be selected in dependence on signal characteristics. For example, by not applying predictive encoding to noisy signal components the aforementioned errors introduced by predicting non-predictable noisy signal components are avoided. At the same time computational complexity can be reduced since predictive encoding is only applied to selected spectral components.

For example, perceptual coding of tonal audio signals can be performed (e.g., by the encoder) by means of transform coding with guided / adaptive spectral-domain inter-frame prediction methods. The efficiency of frequency domain prediction (FDP) can be increased, and the computational complexity can be reduced, by applying the prediction only to spectral coefficients, for example, around harmonic signal components located at integer multiples of a fundamental frequency or pitch, which can be signaled in an appropriate bit-stream from an encoder to a decoder, e.g. as a spacing value. Embodiments of the present invention can be preferably implemented or integrated into the MPEG-H 3D audio codec, but are applicable to any audio transform coding system, such as, e.g., MPEG-2 AAC.

Further embodiments provide a method for encoding an audio signal in a transform domain or filter-bank domain, the method comprises:

- determining spectral coefficients of the audio signal for a current frame and at least one previous frame;
- determining a spacing value; and
- selectively applying predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied are selected based on the spacing value.

Further embodiments provide a method for decoding an encoded audio signal in a transform domain or filter-bank domain, the method comprises:

- parsing the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame;
- obtaining a spacing value; and
- selectively applying predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied are selected based on the spacing value.

Embodiments of the present invention are described herein making reference to the appended drawings, in which:

Fig. 1 shows a schematic block diagram of an encoder for encoding an audio signal, according to an embodiment;

Fig. 2 shows in a diagram an amplitude of an audio signal plotted over frequency for a current frame and corresponding selected spectral coefficients to which predictive encoding is applied, according to an embodiment;

Fig. 3 shows in a diagram an amplitude of an audio signal plotted over frequency for a current frame and corresponding spectral coefficients which are subjected to prediction according to MPEG-2 AAC;

Fig. 4 shows a schematic block diagram of a decoder for decoding an encoded audio signal, according to an embodiment;

Fig. 5 shows a flowchart of a method for encoding an audio signal, according to an embodiment; and

Fig. 6 shows a flowchart of a method for decoding an encoded audio signal, according to an embodiment.

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

In the following description, a plurality of details are set forth to provide a more thorough explanation of embodiments of the present invention. However, it will be apparent to one skilled in the art that embodiments of the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form rather than in detail in order to avoid obscuring embodiments of the present invention. In addition, features of the different embodiments described hereinafter may be combined with each other unless specifically noted otherwise.

Fig. 1 shows a schematic block diagram of an encoder 100 for encoding an audio signal 102, according to an embodiment. The encoder 100 is configured to encode the audio signal 102 in a transform domain or filter-bank domain 104 (e.g., frequency domain, or spectral domain), wherein the encoder 100 is configured to determine spectral coefficients 106_t0_f1 to 106_t0_f6 of the audio signal 102 for a current frame 108_t0 and spectral coefficients 106_t-1_f1 to 106_t-1_f6 of the audio signal for at least one previous frame 108_t-1. Further, the encoder 100 is configured to selectively apply predictive encoding to a plurality of individual spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5, wherein the encoder 100 is configured to determine a spacing value, wherein the encoder 100 is configured to select the plurality of individual spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 to which predictive encoding is applied based on the spacing value.

In other words, the encoder 100 is configured to selectively apply predictive encoding to a plurality of individual spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 selected based on a single spacing value transmitted as side information.

This spacing value may correspond to a frequency (e.g. a fundamental frequency of a harmonic tone (of the audio signal 102)), which defines together with its integer multiples the centers of all groups of spectral coefficients for which prediction is applied: The first group can be centered around this frequency, the second group can be centered around this frequency multiplied by two, the third group can be centered around this frequency multiplied by three, and so on. The knowledge of these center frequencies enables the calculation of prediction coefficients for predicting corresponding sinusoidal signal components (e.g. fundamental and overtones of harmonic signals). Thus, complicated and error prone backward adaptation of prediction coefficients is no longer needed.

In embodiments, the encoder 100 can be configured to determine one spacing value per frame.

In embodiments, the plurality of individual spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 can be separated by at least one spectral coefficient 106_t0_f3.

In embodiments, the encoder 100 can be configured to apply the predictive encoding to a plurality of individual spectral coefficients which are separated by at least one spectral coefficient, such as to two individual spectral coefficients which are separated by at least one spectral coefficient. Further, the encoder 100 can be configured to apply the predictive encoding to a plurality of groups of spectral coefficients (each of the groups comprising at least two spectral coefficients) which are separated by at least one spectral coefficient, such as to two groups of spectral coefficients which are separated by at least one spectral coefficient. Further, the encoder 100 can be configured to apply the predictive encoding to a plurality of individual spectral coefficients and/or groups of spectral coefficients which are separated by at least one spectral coefficient, such as to at least one individual spectral coefficient and at least one group of spectral coefficients which are separated by at least one spectral coefficient.

In the example shown in Fig. 1, the encoder 100 is configured to determine six spectral coefficients 106_t0_f1 to 106_t0_f6 for the current frame 108_t0 and six spectral coefficients 106_t-1_f1 to 106_t-1_f6 for the previous frame 108_t-1. Thereby, the encoder 100 is configured to selectively apply predictive encoding to the individual second spectral coefficient 106_t0_f2 of the current frame and to the group of spectral coefficients consisting of the fourth and fifth spectral coefficients 106_t0_f4 and 106_t0_f5 of the

current frame 108_t0. As can be seen, the individual second spectral coefficient 106_t0_f2 and the group of spectral coefficients consisting of the fourth and fifth spectral coefficients 106_t0_f4 and 106_t0_f5 are separated from each other by the third spectral coefficient 106_t0_f3.

Note that the term "selectively" as used herein refers to applying predictive encoding (only) to selected spectral coefficients. In other words, predictive encoding is not necessarily applied to all spectral coefficients, but rather only to selected individual spectral coefficients or groups of spectral coefficients, the selected individual spectral coefficients and/or groups of spectral coefficients which can be separated from each other by at least one spectral coefficient. In other words, predictive encoding can be disabled for at least one spectral coefficient by which the selected plurality of individual spectral coefficients or groups of spectral coefficients are separated.

In embodiments, the encoder 100 can be configured to selectively apply predictive encoding to a plurality of individual spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 of the current frame 108_t0 based on at least a corresponding plurality of individual spectral coefficients 106_t-1_f2 or groups of spectral coefficients 106_t-1_f4 and 106_t-1_f5 of the previous frame 108_t-1.

For example, the encoder 100 can be configured to predictively encode the plurality of individual spectral coefficients 106_t0_f2 or the groups of spectral coefficients 106_t0_f4 and 106_t0_f5 of the current frame 108_t0, by coding prediction errors between a plurality of predicted individual spectral coefficients 110_t0_f2 or groups of predicted spectral coefficients 110_t0_f4 and 110_t0_f5 of the current frame 108_t0 and the plurality of individual spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 of the current frame (or quantized versions thereof).

In Fig. 1, the encoder 100 encodes the individual spectral coefficient 106_t0_f2 and the group of spectral coefficients consisting of the spectral coefficients 106_t0_f4 and 106_t0_f5, by coding a prediction errors between the predicted individual spectral coefficient 110_t0_f2 of the current frame 108_t0 and the individual spectral coefficient 106_t0_f2 of the current frame 108_t0 and between the group of predicted spectral coefficients 110_t0_f4 and 110_t0_f5 of the current frame and the group of spectral coefficients 106_t0_f4 and 106_t0_f5 of the current frame.

In other words, the second spectral coefficient 106_t0_f2 is coded by coding the prediction error (or difference) between the predicted second spectral coefficient 110_t0_f2 and the (actual or determined) second spectral coefficient 106_t0_f2, wherein the fourth spectral coefficient 106_t0_f4 is coded by coding the prediction error (or difference) between the predicted fourth spectral coefficient 110_t0_f4 and the (actual or determined) fourth spectral coefficient 106_t0_f4, and wherein the fifth spectral coefficient 106_t0_f5 is coded by coding the prediction error (or difference) between the predicted fifth spectral coefficient 110_t0_f5 and the (actual or determined) fifth spectral coefficient 106_t0_f5.

In an embodiment, the encoder 100 can be configured to determine the plurality of predicted individual spectral coefficients 110_t0_f2 or groups of predicted spectral coefficients 110_t0_f4 and 110_t0_f5 for the current frame 108_t0 by means of corresponding actual versions of the plurality of individual spectral coefficients 106_t-1_f2 or of the groups of spectral coefficients 106_t-1_f4 and 106_t-1_f5 of the previous frame 108_t-1.

In other words, the encoder 100 may, in the above-described determination process, use directly the plurality of actual individual spectral coefficients 106_t-1_f2 or the groups of actual spectral coefficients 106_t-1_f4 and 106_t-1_f5 of the previous frame 108_t-1, where the 106_t-1_f2, 106_t-1_f4 and 106_t-1_f5 represent the original, not yet quantized spectral coefficients or groups of spectral coefficients, respectively, as they are obtained by the encoder 100 such that said encoder may operate in the transform domain or filter-bank domain 104.

For example, the encoder 100 can be configured to determine the second predicted spectral coefficient 110_t0_f2 of the current frame 108_t0 based on a corresponding not yet quantized version of the second spectral coefficient 106_t-1_f2 of the previous frame 10 108_t-1, the predicted fourth spectral coefficient 110_t0_f4 of the current frame 108_t0 based on a corresponding not yet quantized version of the fourth spectral coefficient 106_t-1_f4 of the previous frame 108_t-1, and the predicted fifth spectral coefficient 110_t0_f5 of the current frame 108_t0 based on a corresponding not yet quantized version of the fifth spectral coefficient 106_t-1_f5 of the previous frame.

By way of this approach, the predictive encoding and decoding scheme can exhibit a kind of harmonic shaping of the quantization noise, since a corresponding decoder, an embodiment of which is described later with respect to Fig. 4, can only employ, in the

above-noted determination step, the transmitted quantized versions of the plurality of individual spectral coefficients 106_t-1_f2 or of the plurality of groups of spectral coefficients 106_t-1_f4 and 106_t-1_f5 of the previous frame 108_t-1, for a predictive decoding.

While such harmonic noise shaping, as it is, for example, traditionally performed by long-term prediction (LTP) in the time domain, can be subjectively advantageous for predictive coding, in some cases it may be undesirable since it may lead to an unwanted, excessive amount of tonality introduced into a decoded audio signal. For this reason, an alternative predictive encoding scheme, which is fully synchronized with the corresponding decoding and, as such, only exploits any possible prediction gains but does not lead to quantization noise shaping, is described hereafter. According to this alternative encoding embodiment, the encoder 100 can be configured to determine the plurality of predicted individual spectral coefficients 110_t0_f2 or groups of predicted spectral coefficients 110_t0_f4 and 110_t0_f5 for the current frame 108_t0 using corresponding quantized versions of the plurality of individual spectral coefficients 106_t-1_f2 or the groups of spectral coefficients 106_t-1_f4 and 106_t-1_f5 of the previous frame 108_t-1.

For example, the encoder 100 can be configured to determine the second predicted spectral coefficient 110_t0_f2 of the current frame 108_t0 based on a corresponding quantized version of the second spectral coefficient 106_t-1_f2 of the previous frame 108_t-1, the predicted fourth spectral coefficient 110_t0_f4 of the current frame 108_t0 based on a corresponding quantized version of the fourth spectral coefficient 106_t-1_f4 of the previous frame 108_t-1, and the predicted fifth spectral coefficient 110_t0_f5 of the current frame 108_t0 based on a corresponding quantized version of the fifth spectral coefficient 106_t-1_f5 of the previous frame.

Further, the encoder 100 can be configured to derive prediction coefficients 112_f2, 114_f2, 112_f4, 114_f4, 112_f5 and 114_f5 from the spacing value, and to calculate the plurality of predicted individual spectral coefficients 110_t0_f2 or groups of predicted spectral coefficients 110_t0_f4 and 110_t0_f5 for the current frame 108_t0 using corresponding quantized versions of the plurality of individual spectral coefficients 106_t-1_f2 and 106_t-2_f2 or groups of spectral coefficients 106_t-1_f4, 106_t-2_f4, 106_t-1_f5, and 106_t-2_f5 of at least two previous frames 108_t-1 and 108_t-2 and using the derived prediction coefficients 112_f2, 114_f2, 112_f4, 114_f4, 112_f5 and 114_f5.

For example, the encoder 100 can be configured to derive prediction coefficients 112_f2 and 114_f2 for the second spectral coefficient 106_t0_f2 from the spacing value, to derive prediction coefficients 112_f4 and 114_f4 for the fourth spectral coefficient 106_t0_f4 from the spacing value, and to derive prediction coefficients 112_f5 and 114_f5 for the fifth spectral coefficient 106_t0_f5 from the spacing value.

For example, the derivation of prediction coefficients can be derived the following way: If the spacing value corresponds to a frequency f0 or a coded version thereof, the center frequency of the K-th group of spectral coefficients for which prediction is enabled is fc=K*f0. If the sampling frequency is fs and the transform hop size (shift between successive frames) is N, the ideal predictor coefficients in the K-th group assuming a sinusoidal signal with frequency fc are:

p1 = 2*cos(N*2*pi*fc/fs) and p2 = -1.

If, for example, both spectral coefficients 106_t0_f4 and 106_t0_f5 are within this group, the prediction coefficients are:

112_f4 = 112_f5 = 2*cos(N*2*pi*fc/fs) and 114_f4 = 114_f5 = -1.

For stability reasons, a damping factor d can be introduced leading to modified prediction coefficients:

112_f4' = 112_f5' = d*2*cos(N*2*pi*fc/fs), 114_f4' = 114_f5' = d^2.

Since the spacing value is transmitted in the coded audio signal 120, the decoder can derive exactly the same prediction coefficients 212_f4 = 212_f5 = 2*cos(N*2*pi*fc/fs) and 114_f4 = 114_f5 = -1. If a damping factor is used, the coefficients can be modified accordingly.

As indicated in Fig. 1, the encoder 100 can be configured to provide an encoded audio signal 120. Thereby, the encoder 100 can be configured to include in the encoded audio signal 120 quantized versions of the prediction errors for the plurality of individual spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 to which predictive encoding is applied. Further, the encoder 100 can be configured to not include the prediction coefficients 112_f2 to 114_f5 in the encoded audio signal 120.

Thus, the encoder 100 may only use the prediction coefficients 112_f2 to 114_f5 for calculating the plurality of predicted individual spectral coefficients 110_t0_f2 or groups of predicted spectral coefficients 110_t0_f4 and 110_t0_f5 and therefrom the prediction errors between the predicted individual spectral coefficient 110_t0_f2 or group of predicted spectral coefficients 110_t0_f4 and 110_t0_f5 and the individual spectral coefficient 106_t0_f2 or group of predicted spectral coefficients 110_t0_f4 and 110_t0_f5 of the current frame, but will neither provide the individual spectral coefficients 106_t0_f4 (or a quantized version thereof) or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 (or quantized versions thereof) nor the prediction coefficients 112_f2 to 114_f5 in the encoded audio signal 120. Hence, a decoder, an embodiment of which is described later with respect to Fig. 4, may derive the prediction coefficients 112_f2 to 114_f5 for calculating the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame from the spacing value.

In other words, the encoder 100 can be configured to provide the encoded audio signal 120 including quantized versions of the prediction errors instead of quantized versions of the plurality of individual spectral coefficients 106_t0_f2 or of the groups of spectral coefficients 106_t0_f4 and 106_t0_f5 for the plurality of individual spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 to which predictive encoding is applied.

Further, the encoder 100 can be configured to provide the encoded audio signal 102 including quantized versions of the spectral coefficients 106_t0_f3 by which the plurality of individual spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 are separated, such that there is an alternation of spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 for which quantized versions of the prediction errors are included in the encoded audio signal 120 and spectral coefficients 106_t0_f3 or groups of spectral coefficients for which quantized versions are provided without using predictive encoding.

In embodiments, the encoder 100 can be further configured to entropy encode the quantized versions of the prediction errors and the quantized versions of the spectral coefficients 106_t0_f3 by which the plurality of individual spectral coefficients 106_t0_f2 or groups of spectral coefficients 106_t0_f4 and 106_t0_f5 are separated, and to include the

entropy encoded versions in the encoded audio signal 120 (instead of the non-entropy encoded versions thereof).

Fig. 2 shows in a diagram an amplitude of the audio signal 102 plotted over frequency for a current frame 108_t0. Further, in Fig. 2, the spectral coefficients in the transform domain or filter-bank domain determined by the encoder 100 for the current frame 108_t0 of the audio signal 102 are indicated.

As shown in Fig. 2, the encoder 100 can be configured to selectively apply prediction encoding to a plurality of groups 116_1 to 116_6 of spectral coefficients which are separated by at least one spectral coefficient. In detail, in the embodiment shown in Fig. 2, the encoder 100 selectively applies prediction encoding to six groups 116_1 to 116_6 of spectral coefficients, wherein each of the first five groups 116_1 to 116_5 of spectral coefficients includes three spectral coefficients (e.g., the second group 116_2 includes the spectral coefficients 106_t0_f8, 106_t0_f9 and 106_t0_f10), wherein the sixth group 116_6 of spectral coefficients includes two spectral coefficients. Thereby, the six groups 116_1 to 116_6 of spectral coefficients are separated by (five) groups 118_1 to 118_5 of spectral coefficients to which prediction encoding is not applied.

In other words, as indicated in Fig. 2, the encoder 100 can be configured to selectively apply prediction encoding to groups 116_1 to 110_6 of spectral coefficients, such that there is an alternation of groups 116_1 to 116_6 of spectral coefficients to which prediction encoding is applied and groups 118_1 to 118_5 of spectral coefficients to which prediction encoding is not applied.

In embodiments, the encoder 100 can be configured to determine a spacing value (indicated in Fig. 2 by the arrows 122_1 and 122_2), wherein the encoder 100 can be configured to select the plurality of groups 116_1 to 116_6 of spectral coefficients (or the plurality of individual spectral coefficients) to which predictive encoding is applied based on the spacing value.

The spacing value can be, for example, a spacing (or distance) between two characteristic frequencies of the audio signal 102, such as the peaks 124_1 and 124_2 of the audio signal. Further, the spacing value can be a an integer number of spectral coefficients (or indices of spectral coefficients) approximating the spacing between the two characteristic frequencies of the audio signal. Naturally, the spacing value can also be a real number or

a fraction or multiple of the integer number of spectral coefficients describing the spacing between the two characteristic frequencies of the audio signal.

In embodiments, the encoder 100 can be configured to determine an instantaneous fundamental frequency of the audio signal (102) and to derive the spacing value from the instantaneous fundamental frequency or a fraction or a multiple thereof.

For example, the first peak 124_1 of the audio signal 102 can be an instantaneous fundamental frequency (or pitch, or first harmonic) of the audio signal 102. Therefore, the encoder 100 can be configured to determine the instantaneous fundamental frequency of the audio signal 102 and to derive the spacing value from the instantaneous fundamental frequency or a fraction or a multiple thereof. In that case, the spacing value can be an integer number (or a fraction, or a multiple thereof) of spectral coefficients approximating the spacing between the instantaneous fundamental frequency 124_1 and a second harmonic 124_2 of the audio signal 102.

Naturally, the audio signal 102 may comprise more than two harmonics. For example, the audio signal 102 shown in Fig. 2 comprises six harmonics 124_1 to 124_6 spectrally distributed such that the audio signal 102 comprises at every integer multiple of the instantaneous fundamental frequency a harmonic. Naturally, it also possible that the audio signal 102 does not comprise all but only some of the harmonics, such as the first, third and fifth harmonic.

In embodiments, the encoder 100 can be configured to select groups 116_1 to 116_6 of spectral coefficients (or individual spectral coefficients) spectrally arranged according to a harmonic grid defined by the spacing value for a predictive encoding. Thereby, the harmonic grid defined by the spacing value describes the periodic spectral distribution (equidistant spacing) of harmonics in the audio signal 102. In other words, the harmonic grid defined by the spacing value can be a sequence of spacing values describing the equidistant spacing of harmonics of the audio signal.

Further, the encoder 100 can be configured to select spectral coefficients (e.g. only those spectral coefficients), spectral indices of which are equal to or lie within a range (e.g. predetermined or variable) around a plurality of spectral indices derived on the basis of the spacing value, for a predictive encoding.

From the spacing value the indices (or numbers) of the spectral coefficients which represent the harmonics of the audio signal 102 can be derived. For example, assuming that a fourth spectral coefficient 106_t0_f4 represents the instantaneous fundamental frequency of the audio signal 102 and assuming that the spacing value is five, the spectral coefficient having the index nine can be derived on the basis of the spacing value. As can be seen in Fig. 2, the so derived spectral coefficient having the index nine, i.e. the ninth spectral coefficient 106_t0_f9, represents the second harmonic. Similarly, the spectral coefficients having the indices 14, 19, 24 and 29 can be derived, representing the third to sixth harmonics 124_3 to 124_6. However, not only spectral coefficients having the indices which are equal to the plurality of spectral indices derived on the basis of the spacing value may be predictively encoded, but also spectral coefficients having indices within a given range around the plurality of spectral indices derived on the basis of the spacing value. For instance, as shown in Fig. 2, the range can be three, such that not a plurality of individual spectral coefficients are selected for prediction encoding, but rather a plurality of groups of spectral coefficients.

Further, the encoder 100 can be configured to select the groups 116_1 to 116_6 of spectral coefficients (or plurality of individual spectral coefficients) to which predictive encoding is applied such that there is a periodic alternation, periodic with a tolerance of +/- 1 spectral coefficient, between groups 116_1 to 116_6 of spectral coefficients (or the plurality of individual spectral coefficients) to which predictive encoding is applied and the spectral coefficients by which groups of spectral coefficients (or the plurality of individual spectral coefficients) to which predictive encoding is applied are separated. The tolerance of +/- 1 spectral coefficient may be required when a distance between two harmonics of the audio signal 102 is not equal to an integer spacing value (integer with respect to indices or numbers of spectral coefficients) but rather to a fraction or multiple thereof. This can also be seen in Fig. 2 since the arrows 122_1 to 122_6 do not always point exactly to the center or middle of the corresponding spectral coefficients.

In other words, the audio signal 102 can comprise at least two harmonic signal components 124_1 to 124_6, wherein the encoder 100 can be configured to selectively apply predictive encoding to those plurality of groups 116_1 to 116_6 of spectral coefficients (or individual spectral coefficients) which represent the at least two harmonic signal components 124_1 to 124_6 or spectral environments around the at least two harmonic signal components 124_1 to 124_6 of the audio signal 102. The spectral

environments around the at least two harmonic signal components 124_1 to 124_6 can be, for example, +/- 1, 2, 3, 4 or 5 spectral components.

Thereby, the encoder 100 can be configured to not apply predictive encoding to those groups 118_1 to 118_5 of spectral coefficients (or plurality of individual spectral coefficients) which do not represent the at least two harmonic signal components 124_1 to 124_6 or spectral environments of the at least two harmonic signal components 124_1 to 124_6 of the audio signal 102. In other words, the encoder 100 can be configured to not apply predictive encoding to those plurality of groups 118_1 to 118_5 of spectral coefficients (or individual spectral coefficients) which belong to a non-tonal background noise between signal harmonics 124_1 to 124_6.

Further, the encoder 100 can be configured to determine a harmonic spacing value indicating a spectral spacing between the at least two harmonic signal components 124_1 to 124_6 of the audio signal 102, the harmonic spacing value indicating those plurality of individual spectral coefficients or groups of spectral coefficients which represent the at least two harmonic signal components 124_1 to 124_6 of the audio signal 102.

Furthermore, the encoder 100 can be configured to provide the encoded audio signal 120 such that the encoded audio signal 120 includes the spacing value (e.g., one spacing value per frame) or (alternatively) a parameter from which the spacing value can be directly derived.

Embodiments of the present invention address the abovementioned two issues of the FDP method by introducing a harmonic spacing value into the FDP process, signaled from the encoder (transmitter) 100 to a respective decoder (receiver) such that both can operate in a fully synchronized fashion. Said harmonic spacing value may serve as an indicator of an instantaneous fundamental frequency (or pitch) of one or more spectra associated with a frame to be coded and identifies which spectral bins (spectral coefficients) shall be predicted. More specifically, only those spectral coefficients around harmonic signal components located (in terms of their indexing) at integer multiples of the fundamental pitch (as defined by the harmonic spacing value) shall be subjected to the prediction. Figs. 2 and 3 illustrate this pitch-adaptive prediction approach by means of a simple example, wherein Fig. 3 shows the operation of the state-of-the-art predictor in MPEG-2 AAC, which does not predict only around a harmonic grid but subjects every spectral bin below a certain stop frequency to prediction, and wherein Fig. 2 depicts the

same predictor with a modification according to an embodiment integrated to perform the prediction only on those "tonal" bins which are close to the harmonic spacing grid.

Comparing Figs. 2 and 3 reveals two advantages of the modification according to an embodiment, namely (1) much fewer spectral bins are included in the prediction process, reducing complexity (in the given example by roughly 40% since only three fifths of the bins are predicted), and (2) the bins belonging to the non-tonal background noise between the signals harmonics are not affected by prediction, which should increase the efficiency of the prediction.

Note that the harmonic spacing value does not necessarily need to correspond to the actual instantaneous pitch of the input signal but that it could represent a fraction or multiple of the true pitch if this yields an overall improvement of the efficiency of the prediction process. In addition, it must be emphasized that the harmonic spacing value does not have to reflect an integer multiple of the bin indexing or bandwidth unit but may include a fraction of said units.

Subsequently, a preferred implementation into an MPEG-style audio coder is described.

The pitch-adaptive prediction is preferably integrated into the MPEG-2 AAC [ISO/IEC 13818-7, "Information technology – Part 7: Advanced Audio Coding (AAC)," 2006.] or, utilizing a similar predictor as in AAC, into the MPEG-H 3D audio codec [ISO/IEC 23008-3, "Information technology – High efficiency coding, part 3: 3D audio," 2015.]. In particular, a one-bit flag can be written to, and read from, a respective bit-stream for each frame and channel which is not independently coded (for independent frame channels, the flag may not be transmitted since prediction can be disabled to ensure the independence). If the flag is set to one, another 8 bits can be written and read. These 8 bits represent a quantized version of (e.g. an index to) the harmonic spacing value for the given frame and channel. Employing the harmonic spacing value derived from the quantized version using either a linear or non-linear mapping function, the prediction process can be carried out in the manner according to an embodiment shown in Fig. 2. Preferably, only bins located within a maximal distance of 1.5 bins around the harmonic grid are subjected to the prediction. For example, if the harmonic spacing value indicates a harmonic line at bin index 47.11, then only the bins at indices 46, 47 and 48 are predicted. Said maximal distance, however, could be specified differently, either fixed a-priori for all channels and frames or separately for each frame and channel based on the harmonic spacing value.

Fig. 4 shows a schematic block diagram of a decoder 200 for decoding an encoded signal 120. The decoder 200 is configured to decode the encoded audio signal 120 in a transform domain or filter-bank domain 204, wherein the decoder 200 is configured to parse the encoded audio signal 120 to obtain encoded spectral coefficients 206_t0_f1 to 206_t0_f6 of the audio signal for a current frame 208_t0 and encoded spectral coefficients 206_t-1_f0 to 206_t-1_f6 for at least one previous frame 208_t-1, and wherein the decoder 200 is configured to selectively apply predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which are separated by at least one encoded spectral coefficient.

In embodiments, the decoder 200 can be configured to apply the predictive decoding to a plurality of individual encoded spectral coefficients which are separated by at least one encoded spectral coefficient, such as to two individual encoded spectral coefficients which are separated by at least one encoded spectral coefficient. Further, the decoder 200 can be configured to apply the predictive decoding to a plurality of groups of encoded spectral coefficients (each of the groups comprising at least two encoded spectral coefficients) which are separated by at least one encoded spectral coefficients, such as to two groups of encoded spectral coefficients which are separated by at least one encoded spectral coefficient. Further, the decoder 200 can be configured to apply the predictive decoding to a plurality of individual encoded spectral coefficients and/or groups of encoded spectral coefficients which are separated by at least one encoded spectral coefficient, such as to at least one individual encoded spectral coefficient and at least one group of encoded spectral coefficients which are separated by at least one encoded spectral coefficient.

In the example shown in Fig. 4, the decoder 200 is configured to determine six encoded spectral coefficients 206_t0_f1 to 206_t0_f6 for the current frame 208_t0 and six encoded spectral coefficients 206_t-1_f1 to 206_t-1_f6 for the previous frame 208_t-1. Thereby, the decoder 200 is configured to selectively apply predictive decoding to the individual second encoded spectral coefficient 206_t0_f2 of the current frame and to the group of encoded spectral coefficients consisting of the fourth and fifth encoded spectral coefficients 206_t0_f4 and 206_t0_f5 of the current frame 208_t0. As can be seen, the individual second encoded spectral coefficient 206_t0_f2 and the group of encoded spectral coefficients consisting of the fourth and fifth encoded spectral coefficients 206_t0_f4 and 206_t0_f5 are separated from each other by the third encoded spectral coefficient 206_t0_f3.

Note that the term "selectively" as used herein refers to applying predictive decoding (only) to selected encoded spectral coefficients. In other words, predictive decoding is not applied to all encoded spectral coefficients, but rather only to selected individual encoded spectral coefficients or groups of encoded spectral coefficients, the selected individual encoded spectral coefficients and/or groups of encoded spectral coefficients being separated from each other by at least one encoded spectral coefficient. In other words, predictive decoding is not applied to the at least one encoded spectral coefficient by which the selected plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients are separated.

In embodiments the decoder 200 can be configured to not apply the predictive decoding to the at least one encoded spectral coefficient 206_t0_f3 by which the individual encoded spectral coefficients 206_t0_f2 or the group of spectral coefficients 206_t0_f4 and 206_t0_f5 are separated.

The decoder 200 can be configured to entropy decode the encoded spectral coefficients, to obtain quantized prediction errors for the spectral coefficients 206_t0_f2, 2016_t0_f4 and 206_t0_f5 to which predictive decoding is to be applied and quantized spectral coefficients 206_t0_f3 for the at least one spectral coefficient to which predictive decoding is not to be applied. Thereby, the decoder 200 can be configured to apply the quantized prediction errors to a plurality of predicted individual spectral coefficients 210_t0_f2 or groups of predicted spectral coefficients 210_t0_f4 and 210_t0_f5, to obtain, for the current frame 208_t0, decoded spectral coefficients associated with the encoded spectral coefficients 206_t0_f2, 206_t0_f4 and 206_t0_f5 to which predictive decoding is applied.

For example, the decoder 200 can be configured to obtain a second quantized prediction error for a second quantized spectral coefficient 206_t0_f2 and to apply the second quantized prediction error to the predicted second spectral coefficient 210_t0_f2, to obtain a second decoded spectral coefficient associated with the second encoded spectral coefficient 206_t0_f2, wherein the decoder 200 can be configured to obtain a fourth quantized prediction error for a fourth quantized spectral coefficient 206_t0_f4 and to apply the fourth quantized prediction error to the predicted fourth spectral coefficient 210_t0_f4, to obtain a fourth decoded spectral coefficient associated with the fourth encoded spectral coefficient 206_t0_f4, and wherein the decoder 200 can be configured to obtain a fifth quantized prediction error for a fifth quantized spectral coefficient

206_t0_f5 and to apply the fifth quantized prediction error to the predicted fifth spectral coefficient 210_t0_f5, to obtain a fifth decoded spectral coefficient associated with the fifth encoded spectral coefficient 206_t0_f5.

Further, the decoder 200 can be configured to determine the plurality of predicted individual spectral coefficients 210_t0_f2 or groups of predicted spectral coefficients 210_t0_f4 and 210_t0_f5 for the current frame 208_t0 based on a corresponding plurality of the individual encoded spectral coefficients 206_t-1_f2 (e.g., using a plurality of previously decoded spectral coefficients associated with the plurality of the individual encoded spectral coefficients 206_t-1_f2) or groups of encoded spectral coefficients 206_t-1_f4 and 206_t-1_f5 (e.g., using groups of previously decoded spectral coefficients associated with the groups of encoded spectral coefficients 206_t-1_f4 and 206_t-1_f5) of the previous frame 208_t-1.

For example, the decoder 200 can be configured to determine the second predicted spectral coefficient 210_t0_f2 of the current frame 208_t0 using a previously decoded (quantized) second spectral coefficient associated with the second encoded spectral coefficient 206_t-1_f2 of the previous frame 208_t-1, the fourth predicted spectral coefficient 210_t0_f4 of the current frame 208_t0 using a previously decoded (quantized) fourth spectral coefficient associated with the fourth encoded spectral coefficient 206_t-1_f4 of the previous frame 208_t-1, and the fifth predicted spectral coefficient 210_t0_f5 of the current frame 208_t0 using a previously decoded (quantized) fifth spectral coefficient associated with the fifth encoded spectral coefficient 206_t-1_f5 of the previous frame 208_t-1.

Furthermore, the decoder 200 can be configured to derive prediction coefficients from the spacing value, and wherein the decoder 200 can be configured to calculate the plurality of predicted individual spectral coefficients 210_t0_f2 or groups of predicted spectral coefficients 210_t0_f4 and 210_t0_f5 for the current frame 208_t0 using a corresponding plurality of previously decoded individual spectral coefficients or groups of previously decoded spectral coefficients of at least two previous frames 208_t-1 and 208_t-2 and using the derived prediction coefficients.

For example, the decoder 200 can be configured to derive prediction coefficients 212_f2 and 214_f2 for the second encoded spectral coefficient 206_t0_f2 from the spacing value, to derive prediction coefficients 212_f4 and 214_f4 for the fourth encoded spectral

coefficient 206_t0_f4 from the spacing value , and to derive prediction coefficients 212_f5 and 214_f5 for the fifth encoded spectral coefficient 206_t0_f5 from the spacing value.

Note that the decoder 200 can be configured to decode the encoded audio signal 120 in order to obtain quantized prediction errors instead of a plurality of individual quantized spectral coefficients or groups of quantized spectral coefficients for the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied.

Further, the decoder 200 can be configured to decode the encoded audio signal 120 in order to obtain quantized spectral coefficients by which the plurality of individual spectral coefficients or groups of spectral coefficients are separated, such that there is an alternation of encoded spectral coefficients 206_t0_f2 or groups of encoded spectral coefficients 206_t0_f4 and 206_t0_f5 for which quantized prediction errors are obtained and encoded spectral coefficients 206_t0_f3 or groups of encoded spectral coefficients for which quantized spectral coefficients are obtained.

The decoder 200 can be configured to provide a decoded audio signal 220 using the decoded spectral coefficients associated with the encoded spectral coefficients 206_t0_f2, 206_t0_f4 and 206_t0_f5 to which predictive decoding is applied, and using entropy decoded spectral coefficients associated with the encoded spectral coefficients 206_t0_f1, 206_t0_f3 and 206_t0_f6 to which predictive decoding is not applied.

In embodiments, the decoder 200 can be configured to obtain a spacing value, wherein the decoder 200 can be configured to select the plurality of individual encoded spectral coefficients 206_t0_f2 or groups of encoded spectral coefficients 206_t0_f4 and 206_t0_f5 to which predictive decoding is applied based on the spacing value.

As already mentioned above with respect to the description of the corresponding encoder 100, the spacing value can be, for example, a spacing (or distance) between two characteristic frequencies of the audio signal. Further, the spacing value can be a an integer number of spectral coefficients (or indices of spectral coefficients) approximating the spacing between the two characteristic frequencies of the audio signal. Naturally, the spacing value can also be a fraction or multiple of the integer number of spectral coefficients describing the spacing between the two characteristic frequencies of the audio signal.

The decoder 200 can be configured to select individual spectral coefficients or groups of spectral coefficients spectrally arranged according to a harmonic grid defined by the spacing value for a predictive decoding. The harmonic grid defined by the spacing value may describe the periodic spectral distribution (equidistant spacing) of harmonics in the audio signal 102. In other words, the harmonic grid defined by the spacing value can be a sequence of spacing values describing the equidistant spacing of harmonics of the audio signal 102.

Furthermore, the decoder 200 can be configured to select spectral coefficients (e.g. only those spectral coefficients), spectral indices of which are equal to or lie within a range (e.g. predetermined or variable range) around a plurality of spectral indices derived on the basis of the spacing value, for a predictive decoding. Thereby, the decoder 200 can be configured to set a width of the range in dependence on the spacing value.

In embodiments, the encoded audio signal can comprise the spacing value or an encoded version thereof (e.g., a parameter from which the spacing value can be directly derived), wherein the decoder 200 can be configured to extract the spacing value or the encoded version thereof from the encoded audio signal to obtain the spacing value.

Alternatively, the decoder 200 can be configured to determine the spacing value by itself, i.e. the encoded audio signal does not include the spacing value. In that case, the decoder 200 can be configured to determine an instantaneous fundamental frequency (of the encoded audio signal 120 representing the audio signal 102) and to derive the spacing value from the instantaneous fundamental frequency or a fraction or a multiple thereof.

In embodiments, the decoder 200 can be configured to select the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive decoding is applied such that there is a periodic alternation, periodic with a tolerance of +/-1 spectral coefficient, between the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive decoding is applied and the spectral coefficients by which the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive decoding is applied are separated.

In embodiments, the audio signal 102 represented by the encoded audio signal 120 comprises at least two harmonic signal components, wherein the decoder 200 is

configured to selectively apply predictive decoding to those plurality of individual encoded spectral coefficients 206_t0_f2 or groups of encoded spectral coefficients 206_t0_f4 and 206_t0_f5 which represent the at least two harmonic signal components or spectral environments around the at least two harmonic signal components of the audio signal 102. The spectral environments around the at least two harmonic signal components can be, for example, +/- 1, 2, 3, 4 or 5 spectral components.

Thereby, the decoder 200 can be configured to identify the at least two harmonic signal components, and to selectively apply predictive decoding to those plurality of individual encoded spectral coefficients 206_t0_f2 or groups of encoded spectral coefficients 206_t0_f4 and 206_t0_f5 which are associated with the identified harmonic signal components, e.g., which represent the identified harmonic signal components or which surround the identified harmonic signal components).

Alternatively, the encoded audio signal 120 may comprise an information (e.g., the spacing value) identifying the at least two harmonic signal components. In that case, the decoder 200 can be configured to selectively apply predictive decoding to those plurality of individual encoded spectral coefficients 206_t0_f2 or groups of encoded spectral coefficients 206_t0_f4 and 206_t0_f5 which are associated with the identified harmonic signal components, e.g., which represent the identified harmonic signal components or which surround the identified harmonic signal components).

In both of the aforementioned alternatives, the decoder 200 can be configured to not apply predictive decoding to those plurality of individual encoded spectral coefficients 206_t0_f3, 206_t0_f1 and 206_t0_f6 or groups of encoded spectral coefficients which do not represent the at least two harmonic signal components or spectral environments of the at least two harmonic signal components of the audio signal 102.

In other words, the decoder 200 can be configured to not apply predictive decoding to those plurality of individual encoded spectral coefficients 206_t0_f3, 206_t0_f1, 206_t0_f6 or groups of encoded spectral coefficients which belong to a non-tonal background noise between signal harmonics of the audio signal 102.

Fig. 5 shows a flowchart of a method 300 for encoding an audio signal, according to an embodiment. The method 300 comprises a step 302 of determining spectral coefficients of the audio signal for a current frame and at least one previous frame, and a step 304 of

selectively applying predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients which are separated by at least one spectral coefficient.

Fig. 6 shows a flowchart of a method 400 for decoding an encoded audio signal, according to an embodiment. The method 400 comprises a step 402 of parsing the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame, and a step 404 of selectively applying predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which are separated by at least one encoded spectral coefficient.

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.

The inventive encoded audio signal can be stored on a digital storage medium or can be transmitted on a transmission medium such as a wireless transmission medium or a wired transmission medium such as the Internet.

Depending on certain implementation requirements, embodiments of the invention can be implemented in hardware or 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–transitionary.

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.

The above described embodiments are merely illustrative for the principles of the present invention. It is understood that modifications and variations of the arrangements and the details described herein will be apparent to others skilled in the art. It is the intent, therefore, to be limited only by the scope of the impending patent claims and not by the specific details presented by way of description and explanation of the embodiments herein.

Claims

1. An encoder for encoding an audio signal, wherein the encoder is configured to encode the audio signal in a transform domain or filter-bank domain, wherein the encoder is configured to determine spectral coefficients of the audio signal for a current frame and at least one previous frame, wherein the encoder is configured to selectively apply predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the encoder is configured to determine a spacing value, wherein the encoder is configured to select the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied based on the spacing value;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

2. The encoder according to claim 1, wherein the plurality of individual spectral coefficients or groups of spectral coefficients are separated by at least one spectral coefficient.

3. The encoder according to claim 2, wherein the predictive encoding is not applied to the at least one spectral coefficient by which the individual spectral coefficients or the groups of spectral coefficients are separated.

4. The encoder according to one of the claims 1 to 3, wherein the encoder is configured to predictively encode the plurality of individual spectral coefficients or the groups of spectral coefficients of the current frame, by coding prediction errors between a plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients of the current frame and the plurality of individual spectral coefficients or groups of spectral coefficients of the current frame.

5. The encoder according to claim 4, wherein the encoder is configured to derive prediction coefficients from the spacing value, and wherein the encoder is configured to calculate the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using a corresponding plurality of individual spectral coefficients or corresponding groups of spectral coefficients of at least two previous frames and using the derived prediction coefficients.

6. The encoder according to claim 4, wherein the encoder is configured to determine the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using corresponding quantized versions of the plurality of individual spectral coefficients or the groups of spectral coefficients of the previous frame.

7. The encoder according to claim 6, wherein the encoder is configured to derive prediction coefficients from the spacing value, and wherein the encoder is configured to calculate the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using corresponding quantized versions of the plurality of individual spectral coefficients or the groups of spectral coefficients of at least two previous frames and using the derived prediction coefficients.

8. The encoder according to one of the claims 5 or 7, wherein the encoder is configured to provide an encoded audio signal, the encoded audio signal not including the prediction coefficients or encoded versions thereof.

9. The encoder according to one of the claims 4 to 8, wherein the encoder is configured to provide an encoded audio signal, the encoded audio signal including quantized versions of the prediction errors instead of quantized versions of the plurality of individual spectral coefficients or of the groups of spectral coefficients for the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied.

10. The encoder according to claim 9, wherein the encoded audio signal includes quantized versions of the spectral coefficients to which predictive encoding is not applied, such that there is an alternation of spectral coefficients or groups of spectral coefficients for which quantized versions of the prediction errors are included in the encoded audio signal and spectral coefficients or groups of spectral coefficients for which quantized versions are provided without using predictive encoding.

11. The encoder according to one of the claims 1 to 10, wherein the encoder is configured to determine an instantaneous fundamental frequency of the audio

signal and to derive the spacing value from the instantaneous fundamental frequency or a fraction or a multiple thereof.

12. The encoder according to one of the claims 1 to 11, wherein the encoder is configured to select individual spectral coefficients or groups of spectral coefficients spectrally arranged according to a harmonic grid defined by the spacing value for a predictive encoding.

13. The encoder according to one of claims 1 to 11, wherein the encoder is configured to select spectral coefficients, spectral indices of which are equal to or lie within a range around a plurality of spectral indices derived on the basis of the spacing value, for a predictive encoding.

14. The encoder according to claim 13, wherein the encoder is configured to set a width of the range in dependence on the spacing value.

15. The encoder according to one of the claims 1 to 14, wherein the encoder is configured to select the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied such that there is a periodic alternation, periodic with a tolerance of +/-1 spectral coefficient, between the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied and the spectral coefficients or groups of spectral coefficients to which predictive encoding is not applied

16. The encoder according to one of the claims 1 to 15, wherein the audio signal comprises at least two harmonic signal components, wherein the encoder is configured to selectively apply predictive encoding to those plurality of individual spectral coefficients or groups of spectral coefficients which represent the at least two harmonic signal components or spectral environments around the at least two harmonic signal components, wherein the spectral environments comprise +/- 1, 2, 3, 4 or 5 spectral components around the at least two harmonic signal components of the audio signal.

17. The encoder according to claim 16, wherein the encoder is configured to not apply predictive encoding to those plurality of individual spectral coefficients or groups of

spectral coefficients which do not represent the at least two harmonic signal components or spectral environments of the at least two harmonic signal components of the audio signal.

18. The encoder according to one of the claims 16 or 17, wherein the encoder is configured to not apply predictive encoding to those plurality of individual spectral coefficients or groups of spectral coefficients which belong to a non-tonal background noise between signal harmonics.

19. The encoder according to one of the claims 16 to 18, wherein the spacing value is a harmonic spacing value indicating a spectral spacing between the at least two harmonic signal components of the audio signal, the harmonic spacing value indicating those plurality of individual spectral coefficients or groups of spectral coefficients which represent the at least two harmonic signal components of the audio signal.

20. The encoder according to one of the claims 1 to 19, wherein the encoder is configured to provide an encoded audio signal, wherein the encoder is configured to include in the encoded audio signal the spacing value or an encoded version thereof.

21. The encoder according to one of the claims 1 to 20, wherein the spectral coefficients are spectral bins.

22. A decoder for decoding an encoded audio signal, wherein the decoder is configured to decode the encoded audio signal in a transform domain or filter-bank domain, wherein the decoder is configured to parse the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame, and wherein the decoder is configured to selectively apply predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the decoder is configured to obtain a spacing value, wherein the decoder is configured to select the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied based on the spacing value;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

23. The decoder according to claim 22, wherein the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients are separated by at least one encoded spectral coefficient.

24. The decoder according to claim 23, wherein the predictive decoding is not applied to the at least one spectral coefficient by which the individual spectral coefficients or the group of spectral coefficients are separated.

25. The decoder according to one of the claims 22 to 24, wherein the decoder is configured to entropy decode the encoded spectral coefficients, to obtain quantized prediction errors for the spectral coefficients to which predictive decoding is to be applied and quantized spectral coefficients for spectral coefficients to which predictive decoding is not to be applied; and

wherein the decoder is configured to apply the quantized prediction errors to a plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients, to obtain, for the current frame, decoded spectral coefficients associated with the encoded spectral coefficients to which predictive decoding is applied.

26. The decoder according to claim 25, wherein the decoder is configured to determine the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame based on a corresponding plurality of the individual encoded spectral coefficients or groups of encoded spectral coefficients of the previous frame.

27. The decoder according to claim 26, wherein the decoder is configured to derive prediction coefficients from the spacing value, and wherein the decoder is configured to calculate the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using a corresponding plurality of previously decoded individual spectral coefficients or groups of previously decoded spectral coefficients of at least two previous frames and using the derived prediction coefficients.

28. The decoder according to one of the claims 22 to 27, wherein the decoder is configured to decode the encoded audio signal in order to obtain quantized prediction errors instead of a plurality of individual quantized spectral coefficients or groups of quantized spectral coefficients for the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied.

29. The decoder according to claim 28, wherein the decoder is configured to decode the encoded audio signal in order to obtain quantized spectral coefficients for encoded spectral coefficients to which predictive decoding is not applied, such that there is an alternation of encoded spectral coefficients or groups of encoded spectral coefficients for which quantized prediction errors are obtained and encoded spectral coefficients or groups of encoded spectral coefficients for which quantized spectral coefficients are obtained.

30. The decoder according to one of the claims 22 to 29, wherein the decoder is configured to select individual spectral coefficients or groups of spectral coefficients spectrally arranged according to a harmonic grid defined by the spacing value for a predictive decoding.

31. The decoder according to one of claims 22 to 30, wherein the decoder is configured to select spectral coefficients, spectral indices of which are equal to or lie within a range around a plurality of spectral indices derived on the basis of the spacing value, for a predictive decoding.

32. The decoder according to claim 31, wherein the decoder is configured to set a width of the range in dependence on the spacing value.

33. The decoder according to one of the claims 22 to 32, wherein the encoded audio signal comprises the spacing value or an encoded version thereof, wherein the decoder is configured to extract the spacing value or the encoded version thereof from the encoded audio signal to obtain the spacing value.

34. The decoder according to one of the claims 22 to 32, wherein the decoder is configured to determine the spacing value.

35. The decoder according to claim 34, wherein the decoder is configured to determine an instantaneous fundamental frequency and to derive the spacing value from the instantaneous fundamental frequency or a fraction or a multiple thereof.

36. The decoder according to one of the claims 22 to 35, wherein the audio signal represented by the encoded audio signal comprises at least two harmonic signal components, wherein the decoder is configured to selectively apply predictive decoding to those plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which represent the at least two harmonic signal components or spectral environments around the at least two harmonic signal components, wherein the spectral environments comprise +/- 1, 2, 3, 4 or 5 spectral components around the at least two harmonic signal components of the audio signal.

37. The decoder according to claim 36, wherein the decoder is configured to identify the at least two harmonic signal components, and to selectively apply predictive decoding to those plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which are associated with the identified harmonic signal components.

38. The decoder according to claim 36, wherein the encoded audio signal comprises the spacing value or an encoded version thereof, wherein the spacing value identifies the at least two harmonic signal components, wherein the decoder is configured to selectively apply predictive decoding to those plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which are associated with the identified harmonic signal components.

39. The decoder according to one of the claim 36 to 38, wherein the decoder is configured to not apply predictive decoding to those plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which do not represent the at least two harmonic signal components or spectral environments of the at least two harmonic signal components of the audio signal.

40. The decoder according to one of the claims 36 to 39, wherein the decoder is configured to not apply predictive decoding to those plurality of individual encoded

spectral coefficients or groups of encoded spectral coefficients which belong to a non-tonal background noise between signal harmonics of the audio signal.

41. The decoder according to one of the claims 22 to 40, wherein the encoded audio signal includes the spacing value or an encoded version thereof, wherein the spacing value is a harmonic spacing value, the harmonic spacing value indicating those plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which represent at least two harmonic signal components of the audio signal.

42. The decoder according to one of the claims 22 to 41, wherein the spectral coefficients are spectral bins.

43. An encoder for encoding an audio signal, wherein the encoder is configured to encode the audio signal in a transform domain or filter-bank domain, wherein the encoder is configured to determine spectral coefficients of the audio signal for a current frame and at least one previous frame, wherein the encoder is configured to selectively apply predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the encoder is configured to determine a spacing value, wherein the encoder is configured to select the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied based on the spacing value;

wherein the encoder is configured to predictively encode the plurality of individual spectral coefficients or the groups of spectral coefficients of the current frame, by coding prediction errors between a plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients of the current frame and the plurality of individual spectral coefficients or groups of spectral coefficients of the current frame;

wherein the encoder is configured to derive prediction coefficients from the spacing value, and wherein the encoder is configured to calculate the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using a corresponding plurality of individual spectral coefficients or corresponding groups of spectral coefficients of at least two previous frames and using the derived prediction coefficients; and

wherein the encoder is configured to select spectral coefficients, spectral indices of which are equal to or lie within a range around a plurality of spectral indices derived on the basis of the spacing value, for a predictive encoding;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

44. An encoder for encoding an audio signal, wherein the encoder is configured to encode the audio signal in a transform domain or filter-bank domain, wherein the encoder is configured to determine spectral coefficients of the audio signal for a current frame and at least one previous frame, wherein the encoder is configured to selectively apply predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the encoder is configured to determine a spacing value, wherein the encoder is configured to select the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied based on the spacing value;

wherein the encoder is configured to predictively encode the plurality of individual spectral coefficients or the groups of spectral coefficients of the current frame, by coding prediction errors between a plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients of the current frame and the plurality of individual spectral coefficients or groups of spectral coefficients of the current frame;

wherein the encoder is configured to determine the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using corresponding quantized versions of the plurality of individual spectral coefficients or the groups of spectral coefficients of the previous frame;

wherein the encoder is configured to derive prediction coefficients from the spacing value, and wherein the encoder is configured to calculate the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using corresponding quantized versions of the plurality of individual spectral coefficients or the groups of spectral coefficients of at least two previous frames and using the derived prediction coefficients; and

wherein the encoder is configured to select spectral coefficients, spectral indices of which are equal to or lie within a range around a plurality of spectral indices derived on the basis of the spacing value, for a predictive encoding;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

45. An encoder for encoding an audio signal, wherein the encoder is configured to encode the audio signal in a transform domain or filter-bank domain, wherein the encoder is configured to determine spectral coefficients of the audio signal for a current frame and at least one previous frame, wherein the encoder is configured to selectively apply predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the encoder is configured to determine a spacing value, wherein the encoder is configured to select the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied based on the spacing value;

wherein the encoder is configured to determine an instantaneous fundamental frequency of the audio signal and to derive the spacing value from the instantaneous fundamental frequency or a fraction or a multiple thereof;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

46. An encoder for encoding an audio signal, wherein the encoder is configured to encode the audio signal in a transform domain or filter-bank domain, wherein the encoder is configured to determine spectral coefficients of the audio signal for a current frame and at least one previous frame, wherein the encoder is configured to selectively apply predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the encoder is configured to determine a spacing value, wherein the encoder is configured to select the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied based on the spacing value;

wherein the encoder is configured to select individual spectral coefficients or groups of spectral coefficients spectrally arranged according to a harmonic grid defined by the spacing value for a predictive encoding;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

47. An encoder for encoding an audio signal, wherein the encoder is configured to encode the audio signal in a transform domain or filter-bank domain, wherein the encoder is configured to determine spectral coefficients of the audio signal for a current frame and at least one previous frame, wherein the encoder is configured to selectively apply predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the encoder is configured to determine a spacing value, wherein the encoder is configured to select the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied based on the spacing value;

wherein the audio signal comprises at least two harmonic signal components, wherein the encoder is configured to apply predictive encoding only to those plurality of individual spectral coefficients or groups of spectral coefficients which represent the at least two harmonic signal components or spectral environments around the at least two harmonic signal components, wherein the spectral environments comprise +/- 1, 2, 3, 4 or 5 spectral components around the at least two harmonic signal components of the audio signal;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

48. A decoder for decoding an encoded audio signal, wherein the decoder is configured to decode the encoded audio signal in a transform domain or filter-bank domain, wherein the decoder is configured to parse the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame, and wherein the decoder is configured to selectively apply predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the decoder is configured to obtain a spacing value, wherein the decoder is configured to select the plurality of

individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied based on the spacing value;

wherein the decoder is configured to entropy decode the encoded spectral coefficients, to obtain quantized prediction errors for the spectral coefficients to which predictive decoding is to be applied and quantized spectral coefficients for spectral coefficients to which predictive decoding is not to be applied;

wherein the decoder is configured to apply the quantized prediction errors to a plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients, to obtain, for the current frame, decoded spectral coefficients associated with the encoded spectral coefficients to which predictive decoding is applied;

wherein the decoder is configured to determine the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame based on a corresponding plurality of the individual encoded spectral coefficients or groups of encoded spectral coefficients of the previous frame;

wherein the decoder is configured to derive prediction coefficients from the spacing value, and wherein the decoder is configured to calculate the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using a corresponding plurality of previously decoded individual spectral coefficients or groups of previously decoded spectral coefficients of at least two previous frames and using the derived prediction coefficients;

wherein the decoder is configured to select spectral coefficients, spectral indices of which are equal to or lie within a range around a plurality of spectral indices derived on the basis of the spacing value, for a predictive decoding;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

49. A decoder for decoding an encoded audio signal, wherein the decoder is configured to decode the encoded audio signal in a transform domain or filter-bank domain, wherein the decoder is configured to parse the encoded audio signal to

obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame, and wherein the decoder is configured to selectively apply predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the decoder is configured to obtain a spacing value, wherein the decoder is configured to select the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied based on the spacing value;

wherein the decoder is configured to select individual spectral coefficients or groups of spectral coefficients spectrally arranged according to a harmonic grid defined by the spacing value for a predictive decoding;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

50. A decoder for decoding an encoded audio signal, wherein the decoder is configured to decode the encoded audio signal in a transform domain or filter-bank domain, wherein the decoder is configured to parse the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame, and wherein the decoder is configured to selectively apply predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the decoder is configured to obtain a spacing value, wherein the decoder is configured to select the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied based on the spacing value;

wherein the decoder is configured to determine the spacing value; and

wherein the decoder is configured to determine an instantaneous fundamental frequency and to derive the spacing value from the instantaneous fundamental frequency or a fraction or a multiple thereof;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

51. A decoder for decoding an encoded audio signal, wherein the decoder is configured to decode the encoded audio signal in a transform domain or filter-bank domain, wherein the decoder is configured to parse the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame, and wherein the decoder is configured to selectively apply predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the decoder is configured to obtain a spacing value, wherein the decoder is configured to select the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied based on the spacing value;

wherein the audio signal represented by the encoded audio signal comprises at least two harmonic signal components, wherein the decoder is configured to apply predictive decoding only to those plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which represent the at least two harmonic signal components or spectral environments around the at least two harmonic signal components, wherein the spectral environments comprise +/- 1, 2, 3, 4 or 5 spectral components around the at least two harmonic signal components of the audio signal;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

52. A decoder for decoding an encoded audio signal, wherein the decoder is configured to decode the encoded audio signal in a transform domain or filter-bank domain, wherein the decoder is configured to parse the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame, and wherein the decoder is configured to selectively apply predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the decoder is configured to obtain a spacing value, wherein the decoder is configured to select the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied based on the spacing value;

wherein the encoded audio signal includes the spacing value or an encoded version thereof, wherein the spacing value is a harmonic spacing value describing a spacing between harmonics, the harmonic spacing value indicating those

plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which represent at least two harmonic signal components of the audio signal;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

53. Method for encoding an audio signal in a transform domain or filter-bank domain, the method comprising:

determining spectral coefficients of the audio signal for a current frame and at least one previous frame;

determining a spacing value; and

selectively applying predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied are selected based on the spacing value;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

54. Method for encoding an audio signal in a transform domain or filter-bank domain, the method comprising:

determining spectral coefficients of the audio signal for a current frame and at least one previous frame;

determining a spacing value;

selectively applying predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied are selected based on the spacing value, wherein the plurality of individual spectral coefficients or the groups of spectral coefficients of the current

frame are predictively encoded, by coding prediction errors between a plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients of the current frame and the plurality of individual spectral coefficients or groups of spectral coefficients of the current frame;

deriving prediction coefficients from the spacing value;

calculating the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using a corresponding plurality of individual spectral coefficients or corresponding groups of spectral coefficients of at least two previous frames and using the derived prediction coefficients; and

selecting spectral coefficients, spectral indices of which are equal to or lie within a range around a plurality of spectral indices derived on the basis of the spacing value, for a predictive encoding;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

55. Method for encoding an audio signal in a transform domain or filter-bank domain, the method comprising:

determining spectral coefficients of the audio signal for a current frame and at least one previous frame;

determining a spacing value;

selectively applying predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied are selected based on the spacing value;

predictively encoding the plurality of individual spectral coefficients or the groups of spectral coefficients of the current frame, by coding prediction errors between a plurality of predicted individual spectral coefficients or groups of predicted spectral

coefficients of the current frame and the plurality of individual spectral coefficients or groups of spectral coefficients of the current frame;

determining the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using corresponding quantized versions of the plurality of individual spectral coefficients or the groups of spectral coefficients of the previous frame;

deriving prediction coefficients from the spacing value;

calculating the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using corresponding quantized versions of the plurality of individual spectral coefficients or the groups of spectral coefficients of at least two previous frames and using the derived prediction coefficients;

selecting spectral coefficients, spectral indices of which are equal to or lie within a range around a plurality of spectral indices derived on the basis of the spacing value, for a predictive encoding;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

56. Method for encoding an audio signal in a transform domain or filter-bank domain, the method comprising:

determining spectral coefficients of the audio signal for a current frame and at least one previous frame;

determining a spacing value;

selectively applying predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied are selected based on the spacing value;

determining an instantaneous fundamental frequency of the audio signal;

deriving the spacing value from the instantaneous fundamental frequency or a fraction or a multiple thereof;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

57. Method for encoding an audio signal in a transform domain or filter-bank domain, the method comprising:

determining spectral coefficients of the audio signal for a current frame and at least one previous frame;

determining a spacing value;

selectively applying predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied are selected based on the spacing value; and

selecting individual spectral coefficients or groups of spectral coefficients spectrally arranged according to a harmonic grid defined by the spacing value for a predictive encoding;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

58. Method for encoding an audio signal in a transform domain or filter-bank domain, the method comprising:

determining spectral coefficients of the audio signal for a current frame and at least one previous frame;

determining a spacing value;

selectively applying predictive encoding to a plurality of individual spectral coefficients or groups of spectral coefficients, wherein the plurality of individual spectral coefficients or groups of spectral coefficients to which predictive encoding is applied are selected based on the spacing value;

wherein the audio signal comprises at least two harmonic signal components;

applying predictive encoding only to those plurality of individual spectral coefficients or groups of spectral coefficients which represent the at least two harmonic signal components or spectral environments around the at least two harmonic signal components, wherein the spectral environments comprise +/- 1, 2, 3, 4 or 5 spectral components around the at least two harmonic signal components of the audio signal;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

59. Method for decoding an encoded audio signal in a transform domain or filter-bank domain, the method comprising:

parsing the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame;

obtaining a spacing value; and

selectively applying predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied are selected based on the spacing value;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

60. Method for decoding an encoded audio signal in a transform domain or filter-bank domain, the method comprising:

parsing the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame;

obtaining a spacing value; and

selectively applying predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied are selected based on the spacing value;

entropy decoding the encoded spectral coefficients, to obtain quantized prediction errors for the spectral coefficients to which predictive decoding is to be applied and quantized spectral coefficients for spectral coefficients to which predictive decoding is not to be applied;

applying the quantized prediction errors to a plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients, to obtain, for the current frame, decoded spectral coefficients associated with the encoded spectral coefficients to which predictive decoding is applied;

determining the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame based on a corresponding plurality of the individual encoded spectral coefficients or groups of encoded spectral coefficients of the previous frame:

deriving prediction coefficients from the spacing value;

calculating the plurality of predicted individual spectral coefficients or groups of predicted spectral coefficients for the current frame using a corresponding plurality of previously decoded individual spectral coefficients or groups of previously decoded spectral coefficients of at least two previous frames and using the derived prediction coefficients; and

selecting spectral coefficients, spectral indices of which are equal to or lie within a range around a plurality of spectral indices derived on the basis of the spacing value, for a predictive decoding;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

61. Method for decoding an encoded audio signal in a transform domain or filter-bank domain, the method comprising:

parsing the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame;

obtaining a spacing value; and

selectively applying predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied are selected based on the spacing value;

selecting individual spectral coefficients or groups of spectral coefficients spectrally arranged according to a harmonic grid defined by the spacing value for a predictive decoding;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

62. Method for decoding an encoded audio signal in a transform domain or filter-bank domain, the method comprising:

parsing the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame;

obtaining a spacing value; and

selectively applying predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied are selected based on the spacing value;

determining the spacing value;

determining an instantaneous fundamental frequency; and

deriving the spacing value from the instantaneous fundamental frequency or a fraction or a multiple thereof;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

63. Method for decoding an encoded audio signal in a transform domain or filter-bank domain, the method comprising:

parsing the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame;

obtaining a spacing value; and

selectively applying predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied are selected based on the spacing value;

wherein the audio signal represented by the encoded audio signal comprises at least two harmonic signal components;

applying predictive decoding only to those plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which represent the at least two harmonic signal components or spectral environments around the at least two harmonic signal components, wherein the spectral environments comprise +/- 1, 2, 3, 4 or 5 spectral components around the at least two harmonic signal components of the audio signal;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

64. Method for decoding an encoded audio signal in a transform domain or filter-bank domain, the method comprising:

parsing the encoded audio signal to obtain encoded spectral coefficients of the audio signal for a current frame and at least one previous frame;

obtaining a spacing value; and

selectively applying predictive decoding to a plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients, wherein the plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients to which predictive decoding is applied are selected based on the spacing value;

wherein the encoded audio signal includes the spacing value or an encoded version thereof, wherein the spacing value is a harmonic spacing value describing a spacing between harmonics, the harmonic spacing value indicating those plurality of individual encoded spectral coefficients or groups of encoded spectral coefficients which represent at least two harmonic signal components of the audio signal;

wherein the spacing value is a harmonic spacing value describing a spacing between harmonics.

65. Computer program for performing a method according to one of the claims 53 to 64.