In the thesis described in [7], a set of linear prediction coefficients are computed not only by considering the inter-frame prediction but also considering the prediction from one channel to another. The 2-dimensional set of coefficients calculated are then quantized and encoded using similar techniques as for single channel LP, but without considering quantization of the residual in the context of the thesis. However, implementation described comes with high delay and significant complexity and therefore, it is rather unsuitable for a real-time application that requires low delay, e.g. for communication systems.

In a stereo system like the MDCT-based system that is described in [8], preprocessing of the discrete L R channel signals is performed in order to scale the spectra using frequency domain noise-shaping to the “whitened domain”. Then, joint stereo processing is performed to quantize and code the whitened spectra in an optimal fashion.

The scaling parameters for the spectral noise shaping techniques described before are quantized encoded independently for each channel. This results in a double bitrate of side information needed to be sent to the decoder through the bitstream.

The publication Digital Enhanced Cordless Telecommunications (DECT); Low Complexity Communication Codec plus (LC3plus)", no. V1.1.3, (20200415), pages 1 - 151, ETSI DRAFT SPECIFICATION; 103 634, EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE (ETSI), 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS; FRANCE, discloses a two stage vector quantizer for SNS scale factors employing a first stage being a 10 bits split VQ and a second stage being a low complexity algorithmic Pyramide Vector Quantizer (PVQ).

It is an object of the present invention to provide an improved or more efficient coding/decoding concept.

This object is achieved by an audio quantizer of claim 1, and audio dequantizer of claim 15, a method of quantizing of claim 29, a method of dequantizing of claim 30, or a computer program of claim 31.

The present invention is based on the finding that bitrate savings can be obtained for cases, where the L, R signals or, generally, two or more channels of a multi-channel signal are correlated. In such a case, the extracted parameters for both channels are rather similar. Therefore, a joint quantization encoding of the parameters is applied which results in a

significant saving of bitrate. This saving of bitrate can be used in several different directions. One direction can be to spend the saved bitrate on the coding of the core signal so that the overall perceptual quality of the stereo or multichannel signal is improved. Another direction is to reach a lower overall bitrate in a case where the coding of the core signal and, therefore, the overall perceptual quality is not improved, but is left at the same quality.

In a preferred embodiment, in accordance with a first aspect, an audio encoder comprises a scale parameter calculator for calculating a first group of jointly encoded scale parameters

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.

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.

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 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.

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Claims

1. Audio quantizer for quantizing a plurality of audio information items, comprising:

a first stage vector quantizer for quantizing the plurality of audio information items to determine a first stage vector quantization result and a plurality of intermediate quantized items corresponding to the first stage vector quantization result;

a residual item determiner for calculating a plurality of residual items from the plurality of intermediate quantized items and the plurality of audio information items; and

a second stage vector quantizer for quantizing the plurality of residual items to obtain a second stage vector quantization result, wherein the first stage vector quantization result and the second stage vector quantization result are a quantized representation of the plurality of audio information items,

wherein the audio information items comprise, for a first frame of a multichannel audio signal, a first plurality of scale parameters for a first channel of the multichannel audio signal, and a second plurality of scale parameters for a second channel of the multichannel audio signal,

wherein the audio quantizer is configured to apply the first and the second stage vector quantizers to the first plurality and the second plurality of the first frame,

wherein the audio information items comprise, for a second frame of the multichannel audio signal, a third plurality of mid scale parameters and a fourth plurality of side scale parameters, and

wherein the audio quantizer is configured to apply the first and the second stage vector quantizers to the third plurality of mid scale parameters, and to apply the second vector quantizer stage to the fourth plurality of side scale parameters and to not apply the first stage vector quantizer to the fourth plurality of side scale parameters.

2. Audio quantizer of claim 1, wherein the residual item determiner is configured to calculate, for each residual item, a difference between a corresponding audio information item and a corresponding intermediate quantized item.

3. Audio quantizer of claim 1 or 2, wherein the residual item determiner is configured to amplify or weight, for each residual item, a difference between a corresponding audio information item and a corresponding intermediate quantized item so that the plurality of residual items are greater than the corresponding differences, or to amplify or weight the plurality of audio information items and/or the plurality of intermediate quantized items before calculating a difference between amplified items to obtain the residual items.

4. Audio quantizer of one of the preceding claims,

wherein the residual item determiner is configured to divide corresponding differences between the plurality of intermediate quantized items and the audio information items by a predetermined factor being lower than 1 or to multiply corresponding differences between the plurality of intermediate quantized items and the audio information items by a predetermined factor being greater than 1.

5. Audio quantizer of one of the preceding claims,

wherein the first stage vector quantizer is configured to perform the quantization with a first quantization precision, wherein the second stage vector quantizer is configured to perform the quantization with a second quantization precision, and wherein the second quantization precision is lower or higher than the first quantization precision, or

wherein the first stage vector quantizer is configured to perform a fixed rate quantization and wherein the second stage vector quantizer is configured to perform a variable rate quantization.

6. Audio quantizer of one of the preceding claims, wherein the first stage vector quantizer is configured to use a first stage codebook having a first number of entries, wherein the second stage vector quantizer is configured to use a second stage codebook having a second number of entries, and wherein the second number of entries is lower or higher than the first number of entries.

7. Audio quantizer of one of the preceding claims,

wherein the audio information items are the scale parameters for a frame of the multichannel audio signal usable for scaling time domain audio samples of the multichannel audio signal in a time domain or usable for scaling spectral domain audio samples of the multichannel audio signal in a spectral domain, wherein each scale parameter is usable for scaling at least two time domain or spectral domain audio samples, wherein the frame comprises a first number of scale parameters,

wherein the first stage vector quantizer is configured to perform a split of the first number of scale parameters into two or more sets of scale parameters, and wherein the first stage vector quantizer is configured to determine a quantization index for each set of scale parameters to obtain a plurality of quantization indices representing the first quantization result.

8. Audio quantizer of claim 7, wherein the first stage vector quantizer is configured to combine a first quantization index for the first set and a secondquantization index for the second set to obtain a single index as the first quantization result.

9. Audio quantizer of claim 8,

wherein the first stage vector quantizer is configured to multiply one of the first and the second index by a number corresponding to the number of bits of the first and the second index and to add a multiplied index and a non-multiplied index to obtain the single index.

10. Audio quantizer of one of the preceding claims,

wherein the second stage vector quantizer is an algebraic vector quantizer, wherein each index comprises a base codebook index and a Voronoi extension index.

11. Audio quantizer of one of the preceding claims,

wherein the first stage vector quantizer is configured to perform a first split of the plurality of audio information items,

wherein the second stage vector quantizer is configured to perform a second split of the plurality of residual items,

wherein the first split results in a first number of subsets of audio information items and the second split results in a second number of subsets of residual items, wherein the first number of subsets is equal to the second number of subsets.

12. Audio quantizer of one of the preceding claims,

wherein the first vector quantizer is configured to output, from a first codebook search, a first index having a first number of bits,

wherein the second vector quantizer is configured to output, for a second codebook search, a second index having a second number of bits, the second number of bits being lower or higher than the first number of bits.

13. Audio quantizer of claim 12,

wherein the first number of bits is a number of bits between 4 and 7, and wherein the second number of bits is a number of bits between 3 and 6.

14. Audio quantizer of claim 1,

wherein the residual item determiner is configured to amplify or weight, for the second frame, the fourth plurality of side scale parameters, and wherein the second stage vector quantizer is configured to process amplified or weighted side scale parameters for the second frame of the multichannel audio signal.

15. Audio dequantizer for dequantizing a quantized plurality of audio information items, comprising:

a first stage vector dequantizer for dequantizing a first stage vector quantization result included in the quantized plurality of audio information items to obtain a plurality of intermediate quantized audio information items;

a second stage vector dequantizer for dequantizing a second stage vector quantization result included in the quantized plurality of audio information items to obtain a plurality of residual items; and

a combiner for combining the plurality of intermediate quantized information items and the plurality of residual items to obtain a dequantized plurality of audio information items,

wherein the quantized plurality of audio information items comprise, for a first frame of a multichannel audio signal, a first plurality of scale parameters for a first channel of the multichannel audio signal and a second plurality of scale parameters for a second channel of the multichannel audio signal,

wherein the audio dequantizer is configured to apply the first stage vector dequantizer and the second stage vector dequantizer to the first plurality and the second plurality of the first frame,

wherein the quantized plurality of audio information items comprises, for a second frame of the multichannel audio signal, a third plurality of mid scale parameters and a fourth plurality of side scale parameters, and

wherein the audio dequantizer is configured to apply the first stage vector dequantizer and the second stage vector dequantizer to the third plurality of mid scale parameters and to apply the second stage vector dequantizer to the fourth plurality of side scale parameters and to not apply the first stage vector dequantizer to the fourth plurality of side scale parameters.

16. Audio dequantizer of claim 15, wherein the combiner is configured to calculate, for each dequantized information item, a sum between a corresponding intermediate quantized audio information item and a corresponding residual item.

17. Audio dequantizer of one of claims 15 or 16,

wherein the combiner is configured to attenuate or weight the plurality of residual items, so that attenuated residual items are lower than corresponding residual items before performing the attenuation, and wherein the combiner is configured to add the attenuated residual items to the corresponding intermediate quantized audio information items,

or

wherein the combiner is configured to use an attenuation or weighting value lower than 1 to attenuate the plurality of residual items or jointly encoded scaling

parameters before performing a combination, wherein the combination is performed using attenuated residual values, and/or

wherein, exemplarily, the weighting or attenuation value is used to multiply a scaling parameter by the weighting or amplification value, wherein the weighting value is preferably between 0.1 and 0.9, or more preferably between 0.2 and 0.6 or even more preferably between 0.25 and 0.4, and/or

wherein the same attenuation or weighting value is used for all scaling parameters of the plurality of residual items or any jointly encoded scaling parameters.

18. Audio dequantizer of claim 17, wherein the combiner is configured to multiply a corresponding residual item by a weighting factor being lower than one or to divide a corresponding residual item by a weighting factor being greater than one.

19. Audio dequantizer of one of claims 15 to 18,

wherein the first stage dequantizer is configured to perform the dequantization with a first precision,

wherein the second stage dequantizer is configured to perform the dequantization with a second precision, wherein the second precision is lower or higher than the first precision.

20. Audio dequantizer of one of claims 15 to 19,

wherein the first stage dequantizer is configured to use a first stage codebook having a first number of entries, wherein the second stage dequantizer is configured to use a second stage codebook having a second number of entries, and wherein the second number of entries is lower than or higher than the first number of entries, or

wherein the first stage dequantizer is configured to receive, for a first codebook retrieval, a first index having a first number of bits,

wherein the second stage vector dequantizer is configured to receive, for a second codebook retrieval, a second index having a second number of bits, the second number of bits being lower or higher than the first number of bits, or wherein, exemplarily, the first number of bits is a number of bits between 4 and 7, and

wherein, exemplarily, the second number of bits is a number of bits between 3 and 6.

21. Audio dequantizer of one of claims 15 to 20,

wherein the dequantized plurality of audio information items the scale parameters for a frame of the multichannel audio signal usable for scaling time domain audio samples of the multichannel audio signal in a time domain or usable for scaling spectral domain audio samples of the multichannel audio signal in a spectral domain, wherein each scale parameter is usable for scaling at least two time domain or spectral domain audio samples, wherein the frame comprises a first number of scale parameters,

wherein the first stage dequantizer is configured to determine, from two or more result indices for the first stage vector quantization result, a first set and a second set of scale parameters, and

wherein the first stage vector dequantizer or the combiner is configured to put together the first set of scale parameters and the second set of scale parameters into a vector to obtain the first number of intermediate quantized scale parameters.

22. Audio dequantizer of claim 21,
wherein the first stage vector dequantizer s configured to retrieve, as the first stage dequantization result, a single combined index and to process the single combined index to obtain the two or more result indices.

23. Audio dequantizer of claim 22,

wherein the first stage dequantizer is configured to retrieve the first result index by determining a remainder from a division and to retrieve the second result index by determining an integer result from the division.

24. Audio dequantizer of one of claims 15 to 23, wherein the second stage vector dequantizer is an algebraic vector dequantizer, wherein each index comprises a base codebook index and a Voronoi extension index.

25. Audio dequantizer of one of claims 15 to 24,

wherein the first stage vector dequantizer or the combiner is configured to put together a first set of the scale parameters and a second set of the scale parameters from a quantization split in a frame of the multichannel audio signal,

wherein the second stage vector dequantizer is configured to put together a first set of residual parameters and a second set of residual parameters from a split of residual parameters, and

wherein a number of splits addressed by the first vector dequantizer and another number of splits addressed by the second stage vector dequantizer are the same.

26. Audio dequantizer of one of claims 15 to 25,

wherein the first stage vector dequantizer is configured to use a first index having a first number of bits to generate the plurality of intermediate quantized audio information items, and

wherein the second stage vector dequantizer is configured to use, as an index, a second index having a second number of bits to obtain the plurality of residual items, wherein the second number of bits is lower than or higher than the first number of bits.

27. Audio dequantizer of claim 26, wherein the first number of bits is between four and seven, and the second number of bits is between three and six.

28. Audio dequantizer of claim 15,

wherein the combiner is configured to attenuate, for the second frame, the fourth plurality of side scale parameters before further using or further processing the fourth plurality of side scale parameters.

29. A method of quantizing a plurality of audio information items, comprising:

first stage vector quantizing the plurality of audio information items to determine a first stage vector quantization result and a plurality of intermediate quantized items corresponding to the first stage vector quantization result;

calculating a plurality of residual items from the plurality of intermediate quantized items and the plurality of audio information items; and

second stage vector quantizing the plurality of residual items to obtain a second stage vector quantization result, wherein the first stage vector quantization result and the second stage vector quantization result are a quantized representation of the plurality of audio information items,

wherein the audio information items comprise, for a first frame of a multichannel audio signal, a first plurality of scale parameters for a first channel of the multichannel audio signal, and a second plurality of scale parameters for a second channel of the multichannel audio signal,

wherein the audio quantizer is configured to apply the first and the second stage vector quantizers to the first plurality and the second plurality of the first frame,

wherein the audio information items comprise, for a second frame of the multichannel audio signal, a third plurality of mid scale parameters and a fourth plurality of side scale parameters, and

wherein the audio quantizer is configured to apply the first and the second stage vector quantizers to the third plurality of mid scale parameters, and to apply the second vector quantizer stage to the fourth plurality of side scale parameters and to not apply the first stage vector quantizer to the fourth plurality of side scale parameters.

30. A method of dequantizing a quantized plurality of audio information items, comprising:

first stage vector dequantizing a first stage vector quantization result included in the quantized plurality of audio information items to obtain a plurality of intermediate quantized audio information items;

second stage vector dequantizing a second stage vector quantization result included in the quantized plurality of audio information items to obtain a plurality of residual items; and

combining the plurality of intermediate quantized information items and the plurality of residual items to obtain a dequantized plurality of audio information items,

wherein the quantized plurality of audio information items comprise, for a first frame of a multichannel audio signal, a first plurality of scale parameters for a first channel of the multichannel audio signal and a second plurality of scale parameters for a second channel of the multichannel audio signal,

wherein the audio dequantizer is configured to apply the first stage vector dequantizer and the second stage vector dequantizer to the first plurality and the second plurality of the first frame,

wherein the quantized plurality of audio information items comprises, for a second frame of the multichannel audio signal, a third plurality of mid scale parameters and a fourth plurality of side scale parameters, and

wherein the audio dequantizer is configured to apply the first stage vector dequantizer and the second stage vector dequantizer to the third plurality of mid scale parameters and to apply the second stage vector dequantizer to the fourth plurality of side scale parameters and to not apply the first stage vector dequantizer to the fourth plurality of side scale parameters.

31. Computer program for performing, when running on a computer or a processor, the method of claim 29 or the method of claim 30.