[0008]

The technology of normalization at the largest value of the sample, described in PTL 2, is effective in a case where the low-band spectrum is sparse, i.e., in a case where the amplitude value of just part of the samples is large and the amplitude value of the other samples is almost zero. That is to say, the technology according to PTL 2 suppresses spectrums with extremely large amplitude from being generated even for sparse spectrums (homogenizing), and can yield normalized low-band spectrums with flat features (smoothing).

Citation List

Patent Literature

[0009]

PTL 1: Japanese Unexamined Patent Application Publication (Translation of PCT Application) No. 2001-521648

PTL 2: International Publication No. 2013/035257

Summary of Invention

[0010]

However, spectral holes readily occur when the pulse stream is sparse, and such spectral holes cause noise that is called musical noise. PTL 2 does not disclose any measures taken against musical noise due to spectral holes when normalizing the low-band spectrum by the largest amplitude of the sample.

[0011]

An embodiment of the present disclosure provides an decoding device and encoding device capable of decoding high-quality audio signals and so forth with suppressed musical noise, while reducing the overall bitrate.

An embodiment of the present invention relates to a ~~decoding device that decodes core encoded data where a low-band spectrum of a predetermined frequency or lower has been encoded, and extended band encoded data where a high-band spectrum of a predetermined frequency or higher has been encoded based on the core encoded data. This~~ decoding device includes: a separating unit that separates ~~the core~~first encoded data and ~~extended band~~second encoded data, where a spectrum including a low-band spectrum of audio signals has been encoded, and second encoded data where a high-band spectrum of a higher band than the low-band spectrum has been encoded, based on the first encoded data;

a ~~core~~ first decoding unit that decodes the ~~core~~ first encoded data and

generates a ~~core~~ first decoded spectrum;

a~~n~~ first amplitude ~~normalization unit~~normalizer that divides the amplitude of the first decoded spectrum into a plurality of sub-bands, normalizes the amplitude of ~~the core decoded spectrum~~each sub-band by the largest value of the amplitude of the first~~core~~ decoded

spectrum within each sub-band, and generates a normalized spectrum;

~~a noise generating unit that generates a noise spectrum;~~

an ~~first~~ addition unit that adds ~~the~~ noise spectrum to the normalized spectrum and generates a noise-added normalized spectrum;

a~~n extended band~~ second decoding unit that decodes the ~~extended band~~second encoded data using the noise-added normalized spectrum, and generates a second noise-added ~~extended band~~ spectrum; and

a ~~time-frequency~~ converter that ~~couples the core decoded spectrum and the noise-added extended band spectrum and also~~ performs time-frequency conversion regarding a spectrum coupled based on the first decoded spectrum and the second noise-added spectrum~~, and outputs output signals~~.

[0011a]

An embodiment of the present invention relates to an encoding unit including

a first encoding unit that encodes a spectrum including a low-band spectrum of audio signals and generates first encoded data,

an amplitude normalizer that divides the amplitude of the first decoded spectrum, obtained by decoding the first encoded data, into a plurality of sub-bands, normalizes the spectrum of each sub-band by the largest value of the amplitude of the first decoded spectrum within each sub-band, and generates a normalized spectrum,

a band search unit that searches for a particular band where correlation is greatest between the noise-added normalized spectrum obtained by adding the noise spectrum to the normalized spectrum, and a high-band spectrum of a higher band than the low-band spectrum, and

a multiplexer that multiplexes and outputs the first encoded data and encoded data including the particular band that has been searched for.

[0011b]

An embodiment of the present invention relates to a decoding method including

separating first encoded data, where a spectrum including a low-band spectrum of audio signals has been encoded, and second encoded data where a high-band spectrum of a higher band than the low-band spectrum has been encoded, based on the first encoded data,

decoding the first encoded data and generating a first decoded spectrum,

dividing the amplitude of the first decoded spectrum into a plurality of sub-bands, normalizing the spectrum of each sub-band by the largest value of the amplitude of the first decoded spectrum within each sub-band, and generating a normalized spectrum,

adding a noise spectrum to the normalized spectrum and generating a noise-added normalized spectrum;

decoding the second encoded data using the noise-added normalized spectrum, and generating a second noise-added spectrum; and

performing time-frequency conversion regarding a spectrum coupled based on the first decoded spectrum and the second noise-added spectrum.

[0011c]

An embodiment of the present invention relates to an encoding method including

encoding a spectrum including a low-band spectrum of audio signals and generates first encoded data,

dividing the amplitude of the first decoded spectrum, obtained by decoding the first encoded data, into a plurality of sub-bands, normalizing the spectrum of each sub-band by the largest value of the amplitude of the first decoded spectrum within each sub-band, and generating a normalized spectrum,

generating a noise spectrum,

adding the noise spectrum to the normalized spectrum and generating a noise-added normalized spectrum;

searching for a particular band where correlation is greatest between the noise-added normalized spectrum, and a high-band spectrum of a higher band than the low-band spectrum; and

multiplexing the first encoded data and encoded data including the particular band that has been searched for.

[0012]

It should be noted that these general or specific embodiments may be implemented as a system, a device, a method, an integrated circuit, a computer program, and a storage medium, or may be implemented as any selective combination of a system, a method, an integrated circuit, a computer program, and a storage medium.

[0013]

According to a decoding device of an embodiment of the present disclosure, high-quality audio signals and so forth can be decoded with suppressed musical noise.

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 is a configuration diagram of a decoding device according to a first embodiment of the present disclosure.

[Fig. 2] Fig. 2 is a configuration diagram of a decoding device according to a second embodiment of the present disclosure.

[Fig. 3] Fig. 3 is a configuration diagram of another decoding device according to the second embodiment of the present disclosure.

[Fig. 4] Fig. 4 is a configuration diagram of a decoding device according to a third embodiment of the present disclosure.

[Fig. 5] Fig. 5 is an explanatory diagram of a noise generating unit according to the third embodiment of the present disclosure.

[Fig. 6] Fig. 6 is a configuration diagram of a decoding device according to a fourth embodiment of the present disclosure.

CLAIMS

[Claim 1]

(Currently Amended) A decoding device that decodes core encoded data where a low-band spectrum of a predetermined frequency or lower has been encoded, and extended band encoded data where a high-band spectrum of a predetermined frequency or higher has been encoded based on the core encoded data, the decoding device comprising:

a separating unit that separates the core encoded data and extended band encoded data;

a core decoding unit that decodes the core encoded data and generates a core decoded spectrum;

an amplitude normalization unit that normalizes the amplitude of the core decoded spectrum by the largest value of the amplitude of the core decoded spectrum and generates a normalized spectrum; a first addition unit that adds a noise spectrum to the normalized spectrum and generates a noise-added normalized spectrum;

an extended band decoding unit that decodes the extended band encoded data using the noise-added normalized spectrum and generates a noise-added extended band spectrum; and

a time-frequency converter that performs time-frequency conversion regarding signals obtained by coupling the core decoded spectrum and the noise-added extended band spectrum, and outputs output signals.

[Claim 2]

(Currently Amended) The decoding device according to Claim 1, further comprising:

a second addition unit that adds the noise spectrum to the core decoded spectrum and generates a noise-added core decoded spectrum,

wherein the time-frequency converter performs time-frequency conversion regarding signals obtained by coupling the noise-added core decoded spectrum and the noise-added extended band spectrum, and outputs output signals.

[Claim 3]

(Currently Amended) The decoding device according to either Claim 1 or 2,

wherein the amplitude of the noise spectrum is decided in accordance with sparse information of the core decoded spectrum.

[Claim 4]

(Currently Amended) The decoding device according either Claim 1 or 2, further comprising:

a noise amplitude normalization unit that normalizes the noise spectrum and outputs a normalized noise spectrum; and

an amplitude adjustment unit that adjusts the amplitude of the normalized noise spectrum in accordance with at least one of sparse information of the core decoded spectrum and sparse information of the normalized spectrum,

wherein the first addition unit adds the normalized noise spectrum of which the amplitude has been adjusted, to the normalized spectrum, and generates a noise-added normalized spectrum.

[Claim 5]

(Currently Amended) An encoding unit, comprising:

a core encoding unit that encodes a low-band spectrum of a predetermined frequency or lower in input signals and generates core encoded data;

an amplitude normalization unit that normalizes an amplitude of a core decoded spectrum obtained by decoding the core encoded data, using a largest value of amplitude of the core decoded spectrum, and generates a normalized spectrum;

a noise generating unit that generates a noise spectrum;

a first addition unit that adds the noise spectrum to the normalized spectrum and generates a noise-added normalized spectrum;

a band search unit that searches for a particular band where correlation is greatest between the noise-added normalized spectrum and a high-band spectrum of a predetermined frequency or higher in the input signals;

a gain calculating unit that calculates gain between the noise-added normalized spectrum and the high-band spectrum, in a particular band;

an extended band encoding unit that encodes the particular band and the gain and generates extended band encoded data; and

a multiplexer that multiplexes and outputs the core encoded data and the extended band encoded data.

[Claim 6]

A terminal device comprising:

an antenna that receives the core encoded data and the extended band

encoded data and outputs to the separating unit;

and the decoding device according to either of Claim 1 or 2.

[Claim 7]

A base station device comprising:

an antenna that receives the core encoded data and the extended band encoded data and outputs to the separating unit;

and the decoding device according to either of Claim 1 or 2.

[Claim 8]

A terminal device comprising:

the encoding device according to Claim 5; and

an antenna that transmits the core encoded data and the extended band encoded data input from the multiplexer.

[Claim 9]

A base station device comprising:

the encoding device according to Claim 5; and

an antenna that transmits the core encoded data and the extended band encoded data input from the multiplexer.

[Claim 10]

(Currently Amended) A decoding method of decoding, by a processor, core encoded data where a low-band spectrum of a predetermined frequency or lower has been encoded, and extended band encoded data where a high-band spectrum of a predetermined frequency or higher has been encoded based on the core encoded data, the method comprising:

separating the core encoded data and extended band encoded data;

decoding the core encoded data and generating a core decoded spectrum;

normalizing the amplitude of the core decoded spectrum by the largest value of the amplitude of the core decoded spectrum and generating a normalized spectrum;

adding a noise spectrum to the normalized spectrum and generating a noise-added normalized spectrum;

decoding the extended band encoded data using the noise-added normalized spectrum and generating a noise-added extended band spectrum; and

performing time-frequency conversion regarding signals obtained by coupling the core decoded spectrum and the noise-added extended band

spectrum, and outputting output signals.

[Claim 11]

An encoding method of encoding input signals by a processor, the method comprising:

encoding a low-band spectrum of a predetermined frequency or lower in input signals and generating core encoded data;

normalizing an amplitude of a core decoded spectrum obtained by decoding the core encoded data, using a largest value of amplitude of the core decoded spectrum, and generating a normalized spectrum;

generating a noise spectrum;

adding the noise spectrum to the normalized spectrum and generating a noise-added normalized spectrum;

searching for a particular band where correlation is greatest between the noise-added normalized spectrum and a high-band spectrum of a predetermined frequency or higher in the input signals;

calculating gain between the noise-added normalized spectrum and the high-band spectrum, in a particular band;

encoding the particular band and the gain and generates extended band encoded data; and

multiplexing and outputting the core encoded data and the extended band encoded data.

[Claim 12]

A program that executes, by a processor, the decoding method in Claim 10.

[Claim 13]

A program that executes, by a processor, the encoding method in Claim 11.

[Claim 14]

(Currently Amended) The decoding device according to either Claim 1 or 2, further comprising:

a noise amplitude normalization unit that normalizes the noise spectrum and outputs a normalized noise spectrum;

a threshold value calculating unit that calculates a threshold value of spectral intensity, to separate between noise component and non-noise component, using sparse information of the normalized spectrum or the core decoded spectrum;

a noise spectrum amplitude adjustment unit that adjusts the amplitude of the normalized noise spectrum so that the largest value of the normalized noise spectrum is equal to the threshold value or lower; and

a core decoded spectrum amplitude adjustment unit that adjusts the amplitude of the normalized spectrum so that the non-zero component of the normalized spectrum is larger than the threshold value.

[Claim 15]

The decoding device according to Claim 14,

wherein the threshold value calculating unit further calculates a zeroing threshold value, to separate between zero component and non-zero component of the normalized spectrum, using the threshold value,

and wherein the zero component of the normalized spectrum is zeroed based on the zeroing threshold value.

[Claim 16]

The decoding device according to Claim 15,

wherein the noise spectrum is added to a position of the zero component that has been zeroed.

[Claim 17]

(Currently Amended) The decoding device according to any one of Claim 1 Claim 2, and Claim 14, further comprising:

an amplitude readjustment unit that adjusts the amplitude of the noise component of the noise-added extended band spectrum.

[Claim 18]

The decoding device according to Claim 17,

the amplitude readjustment unit including

a noise energy calculating unit that detects noise component of the noise-added extended band spectrum with the threshold value as a standard, and also calculates the energy of the noise component,

an inter-frame smoothing unit that smoothens energy change between frames of the noise-added extended band spectrum using the energy of the noise component, and calculates a scaling coefficient representing the ratio between the noise component energy and energy of the noise component after smoothing, and

an amplitude adjustment unit that adjusts the amplitude of noise

component of the noise-added extended band spectrum using the scaling coefficient.

CLAIMS

1. A decoding device comprising:

a separating unit that separates first encoded data, where a spectrum including a low-band spectrum of audio signals has been encoded, and second encoded data where a high-band spectrum of a higher band than the low-band spectrum has been encoded, based on the first encoded data;

a first decoding unit that decodes the first encoded data and generates a first decoded spectrum;

a first amplitude normalizer that divides the amplitude of the first decoded spectrum into a plurality of sub-bands, normalizes the spectrum of each sub-band by the largest value of the amplitude of the first decoded spectrum within each sub-band, and generates a normalized spectrum;

an addition unit that adds noise spectrum to the normalized spectrum and generates a noise-added normalized spectrum;

a second decoding unit that decodes the second encoded data using the noise-added normalized spectrum, and generates a second noise-added spectrum; and

a converter that performs time-frequency conversion regarding a spectrum coupled based on the first decoded spectrum and the second noise-added spectrum.

2. The decoding device according to Claim 1,

wherein the converter performs time-frequency conversion regarding a spectrum coupled based on a first noise-added decoded spectrum obtained by adding the noise spectrum to the first decoded spectrum, and the second noise-added spectrum.

3. The decoding device according to Claim 1,

wherein the amplitude of the noise spectrum is based on at least one of bit allocation information of the first decoded spectrum, and sparse information of the first decoded spectrum.

4. The decoding device according to Claim 1, further comprising:

a second amplitude adjustment unit that adjusts the amplitude of the normalized noise spectrum obtained by normalizing the noise spectrum, in accordance with at least one of bit allocation information of the first decoded spectrum, sparse information of the first decoded spectrum, and sparse information of the normalized spectrum,

wherein the addition unit further adds the adjusted normalized noise spectrum.

5. The decoding device according to Claim 4,

wherein the second amplitude adjusting unit performs adjustment based on a threshold value of spectral intensity that separates the largest value of the normalized noise spectrum into noise component and non-noise component, the threshold value being calculated using the normalized spectrum or sparse information of the first decoded spectrum.

6. The decoding device according to Claim 5,

wherein a first adjusting unit adjusts the amplitude of the normalized spectrum so that the largest value of the normalized noise spectrum is equal to or smaller than the threshold value,

and wherein the second amplitude adjusting unit adjusts the amplitude of the normalized noise spectrum regarding a non-zero content of the normalized spectrum by removing the non-zero content smaller than the threshold value.

7. The decoding device according to Claim 6,

wherein the first amplitude normalizer zeroes the zero content of the normalized spectrum based on a zeroing threshold value to separate the zero content and non-zero content of the normalized spectrum, the zeroing threshold value being calculated using the threshold value.

8. The decoding device according to Claim 7, further comprising:

a noise adding unit that adds the noise spectrum to a position of the zero content that has been zeroed.

9. The decoding device according to Claim 1, further comprising:

an amplitude readjustment unit that adjusts the amplitude of the noise component of the second noise-added spectrum.

10. The decoding device according to Claim 9,

wherein the amplitude readjustment unit

smoothens energy change between frames of the first noise-added spectrum using the energy of the noise component of the second noise-added spectrum calculated based on the threshold value, and

adjusts the amplitude of noise component of the second noise-added spectrum using a scaling coefficient representing the ratio between the noise component energy and energy of the noise component after smoothing.

11. An encoding unit, comprising:

a first encoding unit that encodes a spectrum including a low-band spectrum of audio signals and generates first encoded data;

an amplitude normalizer that divides the amplitude of the first decoded spectrum, obtained by decoding the first encoded data, into a plurality of sub-bands, normalizes the spectrum of each sub-band by the largest value of the amplitude of the first decoded spectrum within each sub-band, and generates a normalized spectrum;

a band search unit that searches for a particular band where correlation is greatest between the noise-added normalized spectrum obtained by adding the noise spectrum to the normalized spectrum, and a high-band spectrum of a higher band than the low-band spectrum; and

a multiplexer that multiplexes and outputs the first encoded data and encoded data including the particular band that has been searched for.

12. A decoding method comprising:

separating first encoded data, where a spectrum including a low-band spectrum of audio signals has been encoded, and second encoded data where a high-band spectrum of a higher band than the low-band spectrum has been encoded, based on the first encoded data;

decoding the first encoded data and generating a first decoded spectrum;

dividing the amplitude of the first decoded spectrum into a plurality of sub-

bands, normalizing the spectrum of each sub-band by the largest value of the amplitude of the first decoded spectrum within each sub-band, and generating a normalized spectrum;

adding a noise spectrum to the normalized spectrum and generating a noise-added normalized spectrum;

decoding the second encoded data using the noise-added normalized spectrum, and generating a second noise-added spectrum; and

performing time-frequency conversion regarding a spectrum coupled based on the first decoded spectrum and the second noise-added spectrum.

13. The decoding method according to Claim 12,

wherein time-frequency conversion is performed regarding a spectrum coupled based on a first noise-added decoded spectrum obtained by adding the noise spectrum to the first decoded spectrum, and the second noise-added spectrum.

14. The decoding method according to Claim 12,

wherein the amplitude of the noise spectrum is based on at least one of bit allocation information of the first decoded spectrum, and sparse information of the first decoded spectrum.

15. The decoding method according to Claim 12, further comprising:

adjusting the amplitude of the normalized noise spectrum obtained by normalizing the noise spectrum, in accordance with at least one of bit allocation information of the first decoded spectrum, sparse information of the first decoded spectrum, and sparse information of the normalized spectrum,

wherein the adjusted normalized noise spectrum is further added.

16. The decoding method according to Claim 15,

wherein adjustment is performed based on a threshold value of spectral intensity that separates the largest value of the normalized noise spectrum into noise component and non-noise component, the threshold value being calculated using the normalized spectrum or sparse information of the first decoded spectrum.

17. The decoding method according to Claim 16,

wherein the amplitude of the normalized noise spectrum is adjusted so that the largest value of the normalized noise spectrum is equal to or smaller than the threshold value,

and wherein the amplitude of the normalized noise spectrum is adjusted regarding a non-zero content of the normalized spectrum by removing the non-zero content smaller than the threshold value.

18. The decoding method according to Claim 17,

wherein the zero content of the normalized spectrum is zeroed based on a zeroing threshold value to separate the zero content and non-zero content of the normalized spectrum, the zeroing threshold value being calculated using the threshold value.

19. The decoding method according to Claim 18, further comprising:

adding the noise spectrum to a position of the zero content that has been zeroed.

20. The decoding method according to Claim 12, further comprising:

adjusting the amplitude of the noise component of the second noise-added spectrum.

21. The decoding method according to Claim 20,

wherein energy change is smoothened between frames of the first noise-added spectrum using the energy of the noise component of the second noise-added spectrum calculated based on the threshold value, and

wherein the amplitude of noise component of the second noise-added spectrum is adjusted using a scaling coefficient representing the ratio between the noise component energy and energy of the noise component after smoothing.

22. An encoding method, comprising:

encoding a spectrum including a low-band spectrum of audio signals and generates first encoded data;

dividing the amplitude of the first decoded spectrum, obtained by decoding

the first encoded data, into a plurality of sub-bands, normalizing the spectrum of each sub-band by the largest value of the amplitude of the first decoded spectrum within each sub-band, and generating a normalized spectrum;

generating a noise spectrum;

adding the noise spectrum to the normalized spectrum and generating a noise-added normalized spectrum;

searching for a particular band where correlation is greatest between the noise-added normalized spectrum obtained by adding the noise spectrum to the normalized spectrum, and a high-band spectrum of a higher band than the low-band spectrum; and

multiplexing the first encoded data and encoded data including the particular band that has been searched for.