Claims

[Claim 1] An encoding apparatus for enhancing a quantization efficiency in linear predictive encoding, the apparatus comprising:
a first converter to convert a linear predictive coding (LPC) coefficient of a mid-subframe of an input signal to one of a line spectral frequency (LSF) coefficient and an immitance spectral frequency (ISF) coefficient;
a weighting function determination unit to determine a weighting function associated with an importance of the LPC coefficient of the mid-subframe using the converted ISF coefficient or LSF coefficient;
a quantization unit to quantize the converted ISF coefficient or LSF coefficient using the determined weighting function; and
a second coefficient converter to convert the quantized ISF coefficient or LSF coefficient to a quantized LPC coefficient using at least one processor,
wherein the quantized LPC coefficient is output to an encoder of the encoding apparatus.

[Claim 2] The encoding apparatus of claim 1, wherein the weighting function determination unit determines a weighting function for quantizing the LPC coefficient of the mid-subframe by interpolating a parameter of a current frame and a parameter of a previous frame.

[Claim 3] The encoding apparatus of claim 2, wherein the weighting function determination unit determines the weighting function for quantizing the LPC coefficient of the mid-subframe by interpolating a first weighting function for quantizing an LPC coefficient of a frame-end of the previous frame and a second weighting function for quantizing an LPC coefficient of a frame-end of the current frame.

[Claim 4] The encoding apparatus of claim 2, wherein the weighting function determination unit performs an interpolation using at least one of a linear interpolation and a nonlinear interpolation, and performs one of a scheme of applying both the linear interpolation and the nonlinear interpolation to all orders of vectors, a scheme of differently applying the linear interpolation and the nonlinear interpolation for each sub-vector, and a scheme of differently applying the linear interpolation and the nonlinear interpolation depending on each LPC coefficient.

[Claim 5] The encoding apparatus of claim 1, wherein the weighting function determination unit determines a weighting function with respect to the

ISF coefficient or the LSF coefficient, based on an interpolated spectrum magnitude corresponding to a frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient.

[Claim 6] The encoding apparatus of claim 5, wherein the interpolated spectrum magnitude corresponds to a result obtained by interpolating a spectrum magnitude of a frame-end of a current frame and a spectrum magnitude of a frame-end of a previous frame.

[Claim 7] The encoding apparatus of claim 5, wherein the weighting function determination unit determines the weighting function with respect to the ISF coefficient or the LSF coefficient, based on a spectrum magnitude corresponding to a frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient and a neighboring frequency of the frequency.

[Claim 8] The encoding apparatus of claim 7, wherein the weighting function determination unit determines the weighting function based on a maximum value, a mean, or an intermediate value of the spectrum magnitude corresponding to the frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient and the neighboring frequency of the frequency.

[Claim 9] The encoding apparatus of claim 1, wherein the weighting function determination unit determines a weighting function with respect to the ISF coefficient or the LSF coefficient, based on an LPC spectrum magnitude corresponding to a frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient.

[Claim 10] The encoding apparatus of claim 9, wherein the LPC spectrum magnitude is determined based on an LPC spectrum that is frequency converted from the LPC coefficient of the mid-subframe.

[Claim 11] The encoding apparatus of claim 9, wherein the weighting function determination unit determines the weighting function with respect to the ISF coefficient or the LSF coefficient, based on a spectrum magnitude corresponding to a frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient and a neighboring frequency of the frequency.

[Claim 12] The encoding apparatus of claim 11, wherein the weighting function determination unit determines the weighting function based on a maximum value, a mean, or an intermediate value of the spectrum magnitude corresponding to the frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient and the

neighboring frequency of the frequency.

[Claim 13] The encoding apparatus of claim 1, wherein the weighting function determination unit determines a weighting function based on at least one of a frequency band of the mid-subframe, encoding mode information, and frequency analysis information.

[Claim 14] The encoding apparatus of claim 1, wherein the weighting function determination unit determines a final weighting function by combining a per-magnitude weighting function and per-frequency weighting function that are determined based on at least one of an LPC spectrum magnitude and an interpolated spectrum magnitude.

[Claim 15] The encoding apparatus of claim 14, wherein the per-frequency weighting function is a weighting function corresponding to a frequency of the ISF coefficient or the LSF coefficient that is converted from the LPC coefficient of the mid-subframe.

[Claim 16] The encoding apparatus of claim 14, wherein the per-frequency weighting function is expressed by a bark scale.

[Claim 17] An encoding method for enhancing a quantization efficiency in linear predictive encoding, the method comprising:
converting a linear predictive coding (LPC) coefficient of a mid-subframe of an input signal to one of a line spectral frequency (LSF) coefficient and an immitance spectral frequency (ISF) coefficient;
determining a weighting function associated with an importance of the LPC coefficient of the mid-subframe using the converted ISF coefficient or LSF coefficient;
quantizing the converted ISF coefficient or LSF coefficient using the determined weighting function; and
converting the quantized ISF coefficient or LSF coefficient to a quantized LPC coefficient using at least one processor,
wherein the quantized LPC coefficient is output to an encoder.

[Claim 18] The encoding method of claim 17, wherein the determining comprises determining a weighting function for quantizing the LPC coefficient of the mid-subframe by interpolating a parameter of a current frame and a parameter of a previous frame.

[Claim 19] The encoding method of claim 18, wherein the determining comprises determining the weighting function for quantizing the LPC coefficient of the mid-subframe by interpolating a first weighting function for quantizing an LPC coefficient of a frame-end of the previous frame and a second weighting function for quantizing an LPC coefficient of a

frame-end of the current frame.

[Claim 20] The encoding method of claim 18, wherein the determining comprises performing an interpolation using at least one of a linear interpolation and a nonlinear interpolation, and performing one of a scheme of applying both the linear interpolation and the nonlinear interpolation to all orders of vectors, a scheme of differently applying the linear interpolation and the nonlinear interpolation for each sub-vector, and a scheme of differently applying the linear interpolation and the nonlinear interpolation depending on each LPC coefficient.

[Claim 21] The encoding method of claim 17, wherein the determining comprises determining a weighting function with respect to the ISF coefficient or the LSF coefficient, based on an interpolated spectrum magnitude corresponding to a frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient.

[Claim 22] The encoding method of claim 21, wherein the interpolated spectrum magnitude corresponds to a result obtained by interpolating a spectrum magnitude of a frame-end of a current frame and a spectrum magnitude of a frame-end of a previous frame.

[Claim 23] The encoding method of claim 21, wherein the determining comprises determining the weighting function with respect to the ISF coefficient or the LSF coefficient, based on a spectrum magnitude corresponding to a frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient and a neighboring frequency of the frequency.

[Claim 24] The encoding method of claim 23, wherein the determining comprises determining the weighting function based on a maximum value, a mean, or an intermediate value of the spectrum magnitude corresponding to the frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient and the neighboring frequency of the frequency.

[Claim 25] The encoding method of claim 17, wherein the determining comprises determining a weighting function with respect to the ISF coefficient or the LSF coefficient, based on an LPC spectrum magnitude corresponding to a frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient.

[Claim 26] The encoding method of claim 25, wherein the LPC spectrum magnitude is determined based on an LPC spectrum that is frequency converted from the LPC coefficient of the mid-subframe.

[Claim 27] The encoding method of claim 25, wherein the determining comprises

determining the weighting function with respect to the ISF coefficient or the LSF coefficient, based on a spectrum magnitude corresponding to a frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient and a neighboring frequency of the frequency.

[Claim 28] The encoding method of claim 27, wherein the determining comprises determining the weighting function based on a maximum value, a mean, or an intermediate value of the spectrum magnitude corresponding to the frequency of the ISF coefficient or the LSF coefficient converted from the LPC coefficient and the neighboring frequency of the frequency.

[Claim 29] The encoding method of claim 17, wherein the determining comprises determining a weighting function based on at least one of a frequency band of the mid-subframe, encoding mode information, and frequency analysis information.

[Claim 30] The encoding method of claim 17, wherein the determining comprises determining a final weighting function by combining a per-magnitude weighting function and per-frequency weighting function that are determined based on at least one of an LPC spectrum magnitude and an interpolated spectrum magnitude.

[Claim 31] The encoding method of claim 30, wherein the per-frequency weighting function is a weighting function corresponding to a frequency of the ISF coefficient or the LSF coefficient that is converted from the LPC coefficient of the mid-subframe.

[Claim 32] The encoding method of claim 30, wherein the per-frequency weighting function is expressed by a bark scale.

[Claim 33] A non-transitory computer-readable medium storing computer readable instructions to control at least one processor to implement the method of claim 17.

[Claim 34] An encoding apparatus for enhancing a quantization efficiency in linear predictive encoding, the apparatus comprising:
a weighting function determination unit to determine a weighting function associated with an importance of a linear predictive coding (LPC) coefficient of a mid-subframe of an input signal using an immitance spectral frequency (ISF) coefficient or a line spectral frequency (LSF) coefficient corresponding to the LPC coefficient;
a quantization unit to quantize the ISF coefficient or the LSF coefficient using the determined weighting function; and
a coefficient converter to convert the quantized ISF coefficient or LSF

coefficient to a quantized LPC coefficient using at least one processor, wherein the quantized LPC coefficient is output to an encoder of the encoding apparatus.

[Claim 35] An encoding method for enhancing a quantization efficiency in linear predictive encoding, the method comprising:
determining a weighting function associated with an importance of a linear predictive coding (LPC) coefficient of a mid-subframe of an input signal using an immitance spectral frequency (ISF) coefficient or a line spectral frequency (LSF) coefficient corresponding to the LPC coefficient;
quantizing the ISF coefficient or LSF coefficient using the determined weighting function; and
converting the quantized ISF coefficient or LSF coefficient to a quantized LPC coefficient using at least one processor,
wherein the quantized LPC coefficient is output to an encoder.

[Claim 36] A non-transitory computer-readable medium storing computer readable instructions to control at least one processor to implement the method of claim 35.

Claims

1. An encoding apparatus for enhancing a quantization efficiency in linear predictive encoding, the apparatus comprising:

a converter configured to convert a linear predictive coding (LPC) coefficient of a mid-subframe of an input signal to a line spectral frequency (LSF) coefficient of the mid-subframe or an immittance spectral frequency (ISF) coefficient of the mid-subframe;

a weighting function determination unit configured to determine a weighting function based on a spectral magnitude corresponding to the ISF coefficient or the LSF coefficient; and

a quantization unit configured to quantize the ISF coefficient or the LSF coefficient using the determined weighting function.

2. The encoding apparatus of claim 1, wherein the weighting function of the ISF or the LSF coefficient of the mid-subframe is obtained by interpolating a parameter of a current frame and a parameter of a previous frame.

3. The encoding apparatus of claim 2, wherein the weighting function of the ISF or LSF coefficient of the mid-subframe is obtained by interpolating a first weighting function of an ISF or LSF coefficient of a frame-end of the previous frame and a second weighting function of an ISF or LSF coefficient of a frame-end of the current frame.

4. The encoding apparatus of claim 1, wherein the weighting function of the ISF coefficient or the LSF coefficient is based on an interpolated spectral magnitude corresponding to the ISF coefficient or the LSF coefficient.

5. The encoding apparatus of claim 4, wherein the interpolated spectral magnitude is obtained by interpolating a spectral magnitude of a frame-end of a current frame and a spectral magnitude of a frame-end of a previous frame.

6. The encoding apparatus of claim 4, wherein the weighting function of the ISF coefficient or the LSF coefficient is based on the spectral magnitude corresponding to the ISF coefficient or the LSF coefficient and at least one neighboring spectral magnitude.

8. The encoding apparatus of claim 6, wherein the weighting function of the ISF coefficient or the LSF coefficient is based on a maximum value, a mean value, or an intermediate value of the spectral magnitude corresponding to the ISF coefficient or the LSF coefficientand the neighboring spectral magnitude.

9. The encoding apparatus of claim 1, wherein the weighting function of the ISF coefficient or the LSF coefficient is based on the spectral magnitude corresponding to the ISF coefficient or the LSF coefficient and at least one neighboring spectral magnitude.

10. The encoding apparatus of claim 9, wherein the weighting function is based on a maximum value, a mean value, or an intermediate value of the spectral magnitude corresponding to the ISF coefficient or the LSF coefficient and the neighboring spectral magnitude.

11. The encoding apparatus of claim 1, wherein the weighting function is based on at least one of a bandwidth, encoding mode information, and frequency analysis information of the input signal.

12. The encoding apparatus of claim 1, wherein the weighting function determination unit is further configured to determine a frequency weighting function of the LSF coefficient or the ISF coefficient of the mid-subframe based on frequency information about the ISF coefficient or the LSF coefficient, and

wherein the quantization unit is further configured to quantize the ISF coefficient or the LSF coefficient based on the frequency weighting function and the weighting function.

13. The encoding apparatus of claim 12, wherein the frequency weighting function is based on a perceptual model of the ISF coefficient or the LSF coefficient.

14. The encoding apparatus of claim 13, wherein the perceptual model is based on a bark scale.

15. The encoding apparatus of claim 12, wherein the frequency weighting function is based on an encoding mode of the input signal.

16. The encoding apparatus of claim 12, wherein the frequency weighting function is based on a formant information corresponding to an encoding mode of the input signal, the encoding mode being determined on a basis of signal characteristics.

17. The encoding apparatus of claim 12, wherein the frequency weighting function is based on a bandwidth of the input signal.

18. The encoding apparatus of claim 1, wherein the weighting function is based on a spectral envelope of the input signal.