

DESCRIPTION

Title of Invention

AUDIO SIGNAL ENCODING METHOD, AUDIO SIGNAL
DECODING METHOD, ENCODING DEVICE, DECODING
5 DEVICE, AUDIO SIGNAL PROCESSING SYSTEM, AUDIO
SIGNAL ENCODING PROGRAM, AND AUDIO SIGNAL
DECODING PROGRAM

Technical Field

[0001] The present invention relates to an audio signal encoding
10 method, an audio signal decoding method, an encoding device, a
decoding device, an audio signal processing system, an audio signal
encoding program, and an audio signal decoding program.

Background Art

[0002] A coding technique for compressing speech/music signals (audio
15 signals) at low bit rates is important to reduce the costs incurred in
communications, broadcasting, and storing of speech and music signals.
In order to efficiently encode both speech signals and music signals, a
hybrid-type coding scheme is effective in which a coding scheme
suitable for speech signals and a coding scheme suitable for music
20 signals are selectively utilized. The hybrid-type coding scheme
performs coding efficiently by switching coding schemes in the process
of coding an audio sequence, even when the characteristics of input
signals vary temporally.

[0003] The hybrid-type coding scheme typically includes, as a
25 component, the CELP coding scheme (CELP: Code Excited Linear
Prediction Coding) suitable for coding speech signals. Generally, in

order to encode a residual signal obtained through application of a linear predictive inverse filter to an input signal, an encoder exercising the CELP scheme holds therein information about past residual signals in an adaptive codebook. Since the adaptive codebook is used for coding, a high coding efficiency is achieved.

[0004] A technique for coding speech signals and music signals is described, for example, in Patent Literature 1. In Patent Literature 1, a coding algorithm for coding both speech signals and music signals, etc. is described. The technique described in Patent Literature 1 utilizes a Linear Predictive (LP) synthesis filter functioning commonly to encode speech signals and music signals. The LP synthesis filter switches between a speech excitation generator and a transform excitation generator according to whether a speech signal or music signal is coded, respectively. For coding speech signals, the conventional CELP technique is used, and for coding music signals, a novel asymmetrical overlap-add transform technique is applied. In performing the common LP synthesis filtering, interpolation of the LP coefficients is conducted on a signal in overlap-add operation regions.

[0005] When switching takes place from a coding scheme other than the CELP coding scheme to a coding scheme exercising the CELP scheme in the process of coding an audio sequence, information on a residual signal corresponding to the speech coming before the switching is not held in an adaptive codebook in the encoder. Therefore, the coding efficiency degrades when coding a frame coming immediately after the switching of the coding scheme, resulting in a problem of degradation in the reproduced speech quality. Conventional art is

known such as Adaptive MultiRate Wideband plus (AMR-WB+, Non
Patent Literature 1), which is a speech coding scheme standardized by
the 3rd Generation Partnership Project (3GPP), in which the internal
state of an encoder exercising the CELP scheme is initialized, using a
5 coded result obtained under a coding scheme other than the CELP
scheme. The AMR-WB+ encoder obtains a residual signal through the
linear predictive inverse filtering on an input signal and thereafter
encodes the residual signal selectively using two coding schemes, i.e.,
the CELP scheme and the Transform Coded Excitation (TCX) scheme.
10 When switching from the TCX scheme to the CELP scheme, the
AMR-WB+ encoder updates the adaptive codebook in the CELP
scheme, using an excitation signal in the TCX scheme.

Citation List

Patent Literature

- 15 [0006] Patent Literature 1: Japanese Patent Application Laid-Open No.
2003-44097

Non Patent Literature

- [0007] 3GPP TS 26.290 "Audio codec processing functions; Extended
Adaptive Multi-Rate - Wideband (AMR-WB+) codec; Transcoding
20 functions". [online].[retrieved on 5 March 2009] Retrieved from the
Internet : <URL:<http://www.3gpp.org/ftp/Specs/html-info/26290.htm>>

Summary of Invention

Technical Problem

- [0008] However, under a hybrid-type coding scheme in which a coding
25 scheme based on the CELP scheme and a coding scheme not using
linear predictive coding are selectively used, it is difficult to obtain an

excitation signal from the coding process performed under a coding scheme not using the linear predictive coding. Therefore, when switching from a coding scheme not using the linear predictive coding to a coding scheme based on the CELP scheme, it is difficult to initialize the adaptive codebook in the CELP scheme with an excitation signal corresponding to the speech coming before the switching. An object of the present invention is to initialize, to an appropriate value, the internal state of an encoding means or decoding means exercising a coding scheme using the linear predictive coding to thereby improve the quality of a speech reproduced from a frame coming immediately after the switching, when switching from a coding scheme not using linear prediction to a coding scheme using the linear predictive coding.

Solution to Problem

[0009] An audio signal encoding method of the present invention encodes an audio signal including a plurality of frames, using a first encoding means operating under a linear predictive coding scheme and a second encoding means operating under a coding scheme different from the linear predictive coding scheme. The audio signal encoding method of the present invention comprises: a switching step of switching encoding means for encoding a second frame immediately succeeding a first frame from the second encoding means to the first encoding means after the first frame of the audio signal is encoded by the second encoding means; and an initialization step of initializing an internal state of the first encoding means according to a predetermined method after the switching step is performed.

[0010] According to the audio signal encoding method of the present

invention, even when the second frame is to be encoded under a linear predictive coding scheme, whereas the first frame has been encoded by a coding scheme different from the linear predictive coding scheme, the second frame can be encoded under the linear predictive coding scheme by initializing the internal state of the first encoding means operating under the linear predictive coding scheme. Therefore, encoding processing performed under a plurality of coding schemes including the linear predictive coding scheme and a coding scheme different from the linear predictive coding scheme can be realized.

[0011] In the present invention, the internal state of the first encoding means preferably comprises a content of an adaptive codebook or values held by delay elements of a linear predictive synthesis filter for determining a zero input response. In the initialization step, the internal state of the first encoding means is preferably initialized, using the first frame. In the initialization step, the first encoding means is preferably initialized, using a residual signal obtained by applying the linear predictive inverse filter to either the first frame yet to be encoded by the second encoding means or the first frame decoded back after encoded by the second encoding means. In the initialization step, the linear predictive inverse filter is preferably applied to either the first frame yet to be encoded by the second encoding means or the first frame decoded back after encoded by the second encoding means, using linear predictive coefficients used by the first encoding means to encode a third frame preceding the first frame. Alternatively, in the initialization step, when linear predictive coefficients of the first frame are included in codes of the second frame, the linear predictive inverse

filter is preferably applied to either the first frame yet to be encoded by the second encoding means or the first frame decoded back after encoded by the second encoding means, using the linear predictive coefficients included in the codes of the second frame. In the present invention, in the initialization step, the internal state of the first encoding means may be initialized using the internal state had by the first encoding means when the first encoding means encoded a frame preceding the first frame. As for the linear predictive coefficients in the linear predictive synthesis filter for determining a zero input response, it is desirable to use the linear predictive coefficients used when the first encoding means encoded the third frame preceding the first frame, or when the linear predictive coefficients of the first frame are included in codes of the second frame, the linear predictive coefficients of the first frame calculated when the second frame or those obtained by applying a perceptual weighting filter to the calculated linear predictive coefficients.

[0012] An audio signal decoding method of the present invention decodes an encoded audio signal including a plurality of frames, using a first decoding means operating under a linear predictive coding scheme and a second decoding means operating under a coding scheme different from the linear predictive coding scheme. The audio signal decoding method comprises: a switching step of switching decoding means for decoding a second frame immediately succeeding a first frame from the second decoding means to the first decoding means after the first frame of the encoded audio signal is decoded by the second decoding means; and an initialization step of initializing an internal state of the first

decoding means according to a predetermined method, after the switching step is performed.

[0013] According to the audio signal decoding method of the present invention, even when the second frame is to be decoded using a linear predictive coding scheme, whereas the first frame is decoded by a coding scheme different from the linear predictive coding scheme, the second frame can be decoded under the linear predictive coding scheme by initializing the internal state of the first decoding means operating under the linear predictive coding scheme. Therefore, decoding processing performed under a plurality of coding schemes including the linear predictive coding scheme and a coding scheme different from the linear predictive coding scheme can be realized.

[0014] In the present invention, the internal state of the first decoding means preferably comprises a content of an adaptive codebook or values held by delay elements of a linear predictive synthesis filter. In the initialization step, the internal state of the first decoding means is preferably initialized using the first frame. In the initialization step, the first decoding means is preferably initialized, using a residual signal obtained by applying the linear predictive inverse filter to the first frame decoded by the second decoding means. In the initialization step, the linear predictive inverse filter is preferably applied to the first frame decoded by the second decoding means, using linear predictive coefficients used by the first decoding means to decode a third frame preceding the first frame. Alternatively, in the initialization step, when linear predictive coefficients of the first frame are included in codes of the second frame, the linear predictive inverse filter is preferably

applied to the first frame decoded by the second decoding means, using the linear predictive coefficients included in the codes of the second frame. In the present invention, in the initialization step, the internal state of the first decoding means may be initialized, using the internal state had by the first decoding means when the first decoding means decoded a frame preceding the first frame.

[0015] An encoding device of the present invention includes a first encoding means operating under a linear predictive coding scheme and a second encoding means operating under a coding scheme different from the linear predictive coding scheme and encodes an audio signal, using the first encoding means and the second encoding means. The encoding device comprises a first coding determination means that determines whether the first or second encoding means is used to encode an encoding target frame that is included in the audio signal. The encoding device of the present invention further comprises a second coding determination means that determines, if the first coding determination means determines that the encoding target frame is to be encoded by the first encoding means, whether a frame immediately preceding the encoding target frame has been encoded by the first encoding means or the second encoding means, and a coding internal state calculation means that decodes, if the second coding determination means determines that the immediately preceding frame has been encoded by the second encoding means, an encoded result of the immediately preceding frame and calculates an internal state of the first encoding means using the decoded result. The encoding device of the present invention further comprises a coding initialization means that

initializes an internal state of the first encoding means using the internal state calculated by the coding internal state calculation means. The first encoding means encodes the encoding target frame after the coding initialization means.

5 [0016] According to the encoding device of the present invention, even when the encoding target frame is to be encoded by the first encoding means operating under a linear predictive coding scheme, whereas the frame immediately preceding the encoding target frame is encoded by the second encoding means operating under a coding scheme different
10 from the linear predictive coding scheme, the encoding target frame can be encoded under the linear predictive coding scheme by initializing the internal state of the first encoding means. Therefore, coding processing performed under a plurality of coding schemes including the linear predictive coding scheme and a coding scheme different from the
15 linear predictive coding scheme can be realized.

[0017] A decoding device of the present invention includes a first decoding means operating under a linear predictive coding scheme and a second decoding means operating under a coding scheme which is different from the linear predictive coding scheme and decodes an
20 encoded audio signal using the first decoding means and the second decoding means. The decoding device comprises a first decoding determination means that determines whether the first decoding means or the second decoding means is used to decode a decoding target frame that is included in the encoded audio signal. The decoding device also
25 comprises a second decoding determination means that determines, if the first decoding determination means determines that the decoding

target frame is to be decoded by the first decoding means, whether a frame immediately preceding the decoding target frame has been decoded by the first decoding means or the second decoding means. The decoding device further comprises a decoding internal state calculation means that calculates, if the second decoding determination means determines that the immediately preceding frame has been decoded by the second decoding means, an internal state of the first decoding means, using a decoded result of the immediately preceding frame, and a decoding initialization means that initializes an internal state of the first decoding means, using the internal state calculated by the decoding internal state calculation means. The first decoding means decodes the decoding target frame after the internal state thereof is initialized by the decoding initialization means.

[0018] According to the decoding device of the present invention, even when the decoding target frame is to be decoded by the first decoding means operating under a linear predictive coding scheme, whereas the immediately preceding frame is decoded by the second decoding means operating under a coding scheme different from the linear predictive coding scheme, the decoding target frame can be decoded under the linear predictive coding scheme by initializing the internal state of the first decoding means. Therefore, decoding processing performed under a plurality of coding schemes including the linear predictive coding scheme and a coding scheme different from the linear predictive coding scheme can be realized.

[0019] An audio signal processing system of the present invention includes the encoding device and the decoding device. The decoding

device decodes an encoded audio signal encoded by the encoding device.

[0020] According to the audio signal processing system of the present invention, even when the encoding target frame is to be encoded by the first encoding means operating under a linear predictive coding scheme, whereas the immediately preceding frame is encoded by the second encoding means operating under a coding scheme different from the linear predictive coding scheme, the encoding target frame can be encoded under the linear predictive coding scheme by initializing the internal state of the first encoding means. Even when the decoding target frame is to be decoded using the first decoding means operating under a linear predictive coding scheme, whereas the immediately preceding frame is decoded by the second decoding means operating under a coding scheme different from the linear predictive coding scheme, the decoding target frame can be decoded under the linear predictive coding scheme by initializing the internal state of the first decoding means. Therefore, encoding processing and decoding processing performed under a plurality of coding schemes including the linear predictive coding scheme and another coding scheme different from the linear predictive coding scheme can be realized.

[0021] An audio signal encoding program of the present invention for encoding an audio signal, using a first encoding means operating under a linear predictive coding scheme and a second encoding means operating under a coding scheme which is different from the linear predictive coding scheme causes a computer device to function as: first coding determination means for determining whether the first encoding

means or the second encoding means is used to encode an encoding target frame that is included in the audio signal; second coding determination means for, if the first coding determination means determines that the encoding target frame is to be encoded by the first encoding means, determining whether a frame immediately preceding the encoding target frame has been encoded by the first encoding means or the second encoding means; coding internal state calculation means for, if the second coding determination means determines that the immediately preceding frame has been encoded by the second encoding means, decoding an encoded result of the immediately preceding frame and calculating an internal state of the first encoding means, using the decoded result; coding initialization means for initializing an internal state of the first encoding means, using the internal state calculated by the coding internal state calculation means; and encoding means for encoding the encoding target frame by the first encoding means after the internal state thereof is initialized.

[0022] According to the audio signal encoding program of the present invention, even when the encoding target frame is to be encoded by the first encoding means operating under a linear predictive coding scheme, whereas the immediately preceding frame is encoded by the second encoding means operating under a coding scheme different from the linear predictive coding scheme, the encoding target frame can be encoded under the linear predictive coding scheme by initializing the internal state of the first encoding means. Therefore, encoding processing performed under a plurality of coding schemes including the linear predictive coding scheme and a coding scheme different from the

linear predictive coding scheme can be realized.

[0023] An audio signal decoding program of the present invention for decoding an encoded audio signal using a first decoding means operating under a linear predictive coding scheme and a second decoding means operating under a coding scheme which is different from the linear predictive coding scheme causes a computer device to function as: first decoding determination means for determining whether the first decoding means or the second decoding means is used to decode a decoding target frame that is included in the encoded audio signal; second decoding determination means for, if the first decoding determination means determines that the decoding target frame is to be decoded by the first decoding means, determining whether a frame immediately preceding the decoding target frame has been decoded by the first decoding means or the second decoding means; decoding internal state calculation means for, if the second decoding determination means determines that the immediately preceding frame has been decoded by the second decoding means, calculating an internal state of the first decoding means, using a decoded result of the immediately preceding frame; decoding initialization means for initializing an internal state of the first decoding means, using the internal state calculated by the decoding internal state calculation means; and decoding means for decoding the decoding target frame by the first decoding means after the internal state thereof is initialized.

[0024] According to the audio signal decoding program of the present invention, even when the decoding target frame is to be decoded using the first decoding means operating under a linear predictive coding

scheme, whereas the immediately preceding frame is decoded by the second decoding means operating under a coding scheme different from the linear predictive coding scheme, the decoding target frame can be decoded under the linear predictive coding scheme by initializing the internal state of the first decoding means. Therefore, decoding processing performed under a plurality of coding schemes including the linear predictive coding scheme and a coding scheme different from the linear predictive coding scheme can be realized.

Advantageous Effects of Invention

[0025] According to the present invention, when switching from a coding scheme not using the linear prediction to a coding scheme using the linear predictive coding, the internal state of the encoding means or the decoding means exercising a coding scheme using the linear predictive coding can be initialized to appropriate values, and the quality of a speech reproduced from the frame coming immediately after the switching can be improved.

Brief Description of the Drawings

[0026] FIG. 1 is a diagram showing a configuration of an encoding device and a decoding device according to an embodiment;

FIG. 2 is a diagram showing a configuration of the encoding device according to the embodiment;

FIG. 3 is a flowchart to describe an operation of the encoding device according to the embodiment;

FIG. 4 is a diagram showing a configuration of a decoding device according to the embodiment; and

FIG. 5 is a flowchart to describe an operation of the decoding

device according to the embodiment.

Description of the Preferred Embodiments

[0027] A preferable embodiment of the present invention is described below in detail with reference to the accompanying drawings. In the description of the drawings, the same elements are labeled with the same reference numerals, if possible, and descriptions thereof are not repeated. An audio signal processing system according to an embodiment includes an encoding device 10 which encodes an input audio signal and a decoding device 20 which decodes an encoded audio signal encoded by the encoding device 10. FIG. 1 and FIG. 2 are diagrams showing a configuration of the encoding device 10 according to the embodiment. The encoding device 10 encodes an input speech/music signal (audio signal) and outputs the encoded signal. The speech/music signal is first divided into frames having a finite length and thereafter inputted to the encoding device 10. The encoding device 10 performs encoding using a first coding scheme when the speech/music signal is a speech signal, and performs encoding using a second coding scheme when the speech/music signal is a music signal. The first coding scheme may be the CELP scheme such as ACELP based on linear predictive coding having an adaptive codebook. The second coding scheme is a coding scheme different from the first coding scheme and not utilizing the linear prediction. The second coding scheme may, for example, be a transform coding scheme such as AAC.

[0028] The encoding device 10 physically includes a computer device including a CPU 10a, a ROM 10b, a RAM 10c, a storage device 10d, a communication device 10e, and the like. The CPU 10a, the ROM 10b,

the RAM 10c, the storage device 10d, and the communication device 10e are connected to a bus 10f. The CPU 10a centrally performs control of the encoding device 10 by executing a preset computer program (for example, an audio signal encoding program for executing the process shown in the flowchart of FIG. 3), which is stored in an internal memory such as the ROM 10b and loaded therefrom onto the RAM 10c. The storage device 10d is a writable and readable memory and stores a variety of computer programs, a variety of data required to execute computer programs (for example, an adaptive codebook and linear predictive coefficients used for encoding under the first coding scheme, and in addition, various parameters required for encoding under the first coding scheme and the second coding scheme, and a predetermined number of pre-coded and coded frames). The storage device 10d stores at least a frame of speech/music signal coded most recently (a latest coded frame).

[0029] The encoding device 10 functionally includes a coding scheme switching unit 12 (first coding determination means, second coding determination means), a first encoding unit 13 (first encoding means), a second encoding unit 14 (second encoding means), a code multiplexing unit 15, an internal state calculation unit 16 (internal coding state calculation means), and an internal state initialization method specifying unit 17 (coding initialization means). The coding scheme switching unit 12, the first encoding unit 13, the second encoding unit 14, the code multiplexing unit 15, the internal state calculation unit 16, and the internal state initialization method specifying unit 17 are functions implemented by the CPU 10a executing the computer programs stored

in an internal memory of the encoding device 10, such as the ROM 10b, to operate each component of the encoding device 10 shown in FIG. 1. The CPU 10a executes the process shown in the flowchart in FIG. 3 by executing an audio signal encoding program (using the coding scheme switching unit 12, the first encoding unit 13, the second encoding unit 14, the code multiplexing unit 15, the internal state calculation unit 16, and the internal state initialization method specifying unit 17).

[0030] Next, referring to FIG. 3, the operation of the encoding device 10 is described. A speech/music signal is first divided into frames having a finite length and then inputted to the communication device 10e of the encoding device 10. When a speech/music signal is inputted through the communication device 10e, the coding scheme switching unit 12 determines, based on an encoding target frame (a frame that is a target of encoding) of the speech/music signal, whether the first coding scheme or the second coding scheme is used to encode the encoding target frame and, based on the determination, sends the encoding target frame to either the first encoding unit 13, which exercises the first coding scheme to encode a speech/music signal, or the second encoding unit 14, which exercises the second coding scheme to encode a speech/music signal (step S11; a first switching step). In step S11, the coding scheme switching unit 12 determines that encoding is to be performed by the first coding scheme if the encoding target frame is a speech signal and that encoding is to be performed by the second coding scheme if the encoding target frame is a music signal. Then, after this first switching step, a first initialization step (steps S12 to S18) is performed for initializing the internal state of the first

encoding unit 13 (which is hereinafter referred to as including the content of an adaptive codebook or values held by delay elements of a linear predictive synthesis filter which calculates a zero input response, etc.)

- 5 [0031] If the coding scheme switching unit 12 determines in step S11 that the encoding target frame is a music signal and that the encoding target frame is to be encoded by the second coding scheme (step S11: SECOND ENCODING UNIT), the coding scheme switching unit 12 sends the encoding target frame to the second encoding unit 14, and the
- 10 second encoding unit 14 encodes the encoding target frame sent from the coding scheme switching unit 12, using the second coding scheme, and outputs the encoded target frame (encoded speech/music signal) through the communication device 10e (step S18). If the coding scheme switching unit 12 determines in step S11 that the encoding
- 15 target frame is a speech signal and that the encoding target frame is to be encoded by the first coding scheme (step S11: FIRST ENCODING UNIT), the encoding scheme switching unit 12 refers to the content of the storage device 10d and determines whether a frame immediately preceding the encoding target frame (the immediately preceding frame)
- 20 has been encoded by the first encoding unit 13 or encoded by the second encoding unit 14 (step S12). The encoded results of a predetermined number of encoded frames (including the immediately preceding frame and frames preceding the encoding target frame) and frames yet to be encoded are all stored in the storage device 10d.
- 25 [0032] If the coding scheme switching unit 12 determines in step S12 that the immediately preceding frame has been encoded by the first

encoding unit 13 (step S12; YES), the coding scheme switching unit 12 sends the encoding target frame to the first encoding unit 13, and the first encoding unit 13 encodes the encoding target frame sent from the coding scheme switching unit 12, using the first coding scheme, and
5 outputs the encoded result of the encoding target frame (encoded speech/music signal) through the communication device 10e (step S17). If the coding scheme switching unit 12 determines in step S12 that the immediately preceding frame has been encoded by the second encoding unit 14 (step S12; NO), the internal state calculation unit 16 decodes the
10 encoded result of the immediately preceding frame stored in the storage device 10d and obtains the decoded result of the immediately preceding frame (step S13). The decoded result used by the encoding device 10 is obtained by a decoder (not shown) included in the encoding device 10 or the decoding device 20 described later. This decoding operation
15 may not be necessary if the immediately preceding frame yet to be encoded by the second encoding unit 14 is used, in place of the decoded result obtained by decoding the encoded result of the immediately preceding frame. This immediately preceding frame yet to be encoded is stored in the storage device 10d.

20 [0033] After step S13, the internal state calculation unit 16 calculates the internal state of the first encoding unit 13 using the decoded result of the immediately preceding frame (step S14). As an exemplary process of calculating the internal state with the decoded result of the immediately preceding frame, the process of calculating the internal
25 state of the first encoding unit 13, which is performed by the internal state calculation unit 16, includes a process of calculating linear

predictive coefficients, using a method such as a covariance method, from the decoded result of the immediately preceding frame (or the immediately preceding frame yet to be encoded by the second encoding unit 14) and then obtaining a residual signal by applying a linear predictive inverse filter to the decoded result, using the calculated linear predictive coefficients.

[0034] Since the process of calculating linear predictive coefficients from the decoded result of the immediately preceding frame requires a large amount of calculation, instead of calculating the linear predictive coefficients from the decoded result of the immediately preceding frame, the internal state calculation unit 16 may use the linear predictive coefficients (stored in the storage device 10d) of a frame neighboring the immediately preceding frame (a frame preceding the immediately preceding frame) which is encoded by the first coding scheme, in place of the linear predictive coefficients used in the aforementioned process (the process of calculating the internal state of the first encoding unit 13), or may use values obtained by interpolating those linear predictive coefficients between frames, in place of the linear predictive coefficients used in the aforementioned process (the process of calculating the internal state of the first encoding unit 13). The internal state calculation unit 16 may use values obtained by extrapolating the linear predictive coefficients of frames neighboring the immediately preceding frame which is encoded under the first coding scheme or values obtained by extrapolating values obtained by interpolating the linear predictive coefficients between frames, in place of the linear predictive coefficients used in the aforementioned process (the process of

calculating the internal state of the first encoding unit 13). The internal state calculation unit 16 may convert the linear predictive coefficients into linear spectral frequencies, extrapolate the linear spectral frequencies and reconvert the extrapolated result back into linear predictive coefficients. If the linear predictive coefficients of the immediately preceding frame are included in the codes of the encoding target frame, the internal state calculation unit 16 may use the linear predictive coefficients included in the codes of the encoding target frame in place of the linear predictive coefficients used in the aforementioned process (the process of calculating the internal state of the first encoding unit 13). The internal state calculation unit 16 may use the decoded result of the immediately preceding frame as it is as a replacement for the residual signal, without calculating the linear predictive coefficients. The internal state of the first encoding unit 13 may be initialized by using the internal state (information indicating the internal state is stored in the storage device 10d) obtained during the process of encoding a frame neighboring the immediately preceding frame (and preceding the immediately preceding frame) which is encoded under the first coding scheme. The process of applying the linear predictive inverse filter to the decoded result of the immediately preceding frame may not be performed on the entire frame but may be performed on only a part of the frame.

[0035] After step S14, the internal state initialization method specifying unit 17 specifies, based on the encoding target frame or the decoded result of the immediately preceding frame, one of predetermined initialization methods including a method of initializing the internal

state of the first encoding unit 13, using the internal state calculated by the internal state calculation unit 16, a method of initializing the internal state with "0", and the like (step S15). Then, the internal state initialization method specifying unit 17 initializes the internal state of the first encoding unit 13 by executing the initialization method specified in step S15 (step S16). Initialization of the internal state of the first encoding unit 13, which is performed by the internal state initialization method specifying unit 17, is a process of initializing the internal state of the first encoding unit 13 using the internal state calculated by the internal state calculation unit 16 and may include a process of initializing the internal state (indicating values held by delay elements) of the linear predictive synthesis filter of the first encoding unit 13 for use in calculating the residual signal under the first coding scheme. When specifying a method of initializing the internal state of the first encoding unit 13, the internal state initialization method specifying unit 17 may, for example, encode the encoding target frame using the first coding scheme according to each of a plurality of initialization methods including the above two initialization methods and select an initialization method minimizing square error or perceptual weighted error.

[0036] After the internal state initialization method specifying unit 17 initializes the internal state of the first encoding unit 13 in step S16, the first encoding unit 13 encodes the encoding target frame under the first coding scheme and outputs the encoded result of the encoding target frame (encoded speech/music signal) through the communication device 10e (step S17).

[0037] The above process may be so configured that the code multiplexing unit 15 multiplexes information of the initialization method selected by the internal state initialization method specifying unit 17 in step S15, as supplemental information, into the encoded result obtained under the first coding scheme. It may also be so configured to specify the initialization method of the internal state of the first encoding unit 13, based on information (described below) obtained in common between the first encoding unit 13 and the second encoding unit 14, and the decoder (the decoder included in the encoding device 10 or the decoding device 20). In this case, the code multiplexing unit 15 does not multiplex the supplemental information indicating the specified initialization method for initializing the internal state of the first encoding unit 13 into the encoded result. For example, when the adaptive codebook gain of the encoding target frame under the first coding scheme is large, or when the periodicity of the decoded result in the immediately preceding frame is high, or in the similar cases, the internal state initialization method specifying unit 17 can initialize the internal state of the first encoding unit 13 using the internal state calculated by the internal state calculation unit 16.

[0038] Alternatively, the internal state initialization method specifying unit 17 may be dispensed with if the first encoding unit 13 always initializes the internal state thereof using the internal state calculated by the internal state calculation unit 16. Although the internal state calculation unit 16 and the internal state initialization method specifying unit 17 are configured to perform the aforementioned process (the first initialization step) on the encoding target frame immediately after the

coding scheme switching unit 12 switches from the second coding scheme to the first coding scheme (after the first switching step), it needs not be so limited if the internal state calculation unit 16 and the internal state initialization method specifying unit 17 perform the
5 aforementioned process when the immediately preceding frame (immediately before the encoding target frame) is encoded immediately before the coding scheme switching unit 12 switches from the second coding scheme to the first coding scheme. Although it has been discussed that switching is performed between the two coding schemes,
10 that is, the first coding scheme (the first encoding unit 13) and the second coding scheme (the second encoding unit 14), switching may be performed among three or more coding schemes including a plurality of coding schemes different from the first coding scheme.

[0039] FIG. 1 and FIG. 4 are diagrams showing the configuration of the
15 decoding device 20 according to one embodiment. The decoding device 20 physically includes a computer device including a CPU 20a, a ROM 20b, a RAM 20c, a storage device 20d, a communication device 20e, and the like. The CPU 20a, the ROM 20b, the RAM 20c, the storage device 20d, and the communication device 20e are connected to
20 a bus 20f. The CPU 20a centrally performs control of the decoding device 20 by executing a preset computer program (for example, an audio signal decoding program for executing the process shown in the flowchart of FIG. 5) which is stored in an internal memory, such as the ROM 20b and loaded onto the RAM 20c. The storage device 20d is a
25 writable and readable memory and stores a variety of computer programs, a variety of data required to execute computer programs

(including, for example, an adaptive codebook and linear predictive coefficients used in decoding under the first coding scheme, and in addition, various parameters required for performing decoding under the first coding scheme and the second coding scheme, a prescribed number of decoded frames and frames before decoding, and the like). The storage device 20d stores at least a speech/music signal decoded most recently (a latest decoded frame).

[0040] The decoding device 20 functionally includes a coding scheme determination unit 22 (first decoding determination means, second decoding determination means), a code separation unit 23, a first decoding unit 24 (first decoding means), a second decoding unit 25 (second decoding means), an internal state initialization method specifying unit 26 (decoding initialization means), and an internal state calculation unit 27 (decoding internal state calculation means). The coding scheme determination unit 22, the code separation unit 23, the first decoding unit 24, the second decoding unit 25, the internal state initialization method specifying unit 26, and the internal state calculation unit 27 are functions implemented by the CPU 20a executing the computer program stored in an internal memory of the decoding device 20, such as the ROM 20b, to operate each component of the decoding device 20 shown in FIG. 1. The CPU 20a executes the process shown in the flowchart of FIG. 5 by executing the audio signal decoding program (using the coding scheme determination unit 22, the code separation unit 23, the first decoding unit 24, the second decoding unit 25, the internal state initialization method specifying unit 26, and the internal state calculation unit 27).

[0041] Next, referring to FIG. 5, the operation of the decoding device 20 is described. The coding scheme determination unit 22 determines whether the first coding scheme or the second coding scheme has been used to encode a decoding target frame of an encoded speech/music signal inputted through the communication device 20e and, based on the determination result, sends the decoding target frame to either the first decoding unit 24 for applying decoding under the first coding scheme or the second decoding unit 25 for applying decoding under the second coding scheme (step S21; a second switching step). In step S21, the coding scheme determination unit 22 determines that decoding is to be performed by the first decoding unit 24 if the decoding target frame has been encoded under the first coding scheme and that decoding is to be performed by the second decoding unit 25 if the decoding target frame has been encoded under the second coding scheme. Then, after this second switching step, a second initialization step (steps S22 to S27) is performed in which the internal state of the first decoding unit 24 (which is hereinafter referred to as including the content of an adaptive codebook or values held by delay elements of a linear predictive synthesis filter, or the like) is initialized.

[0042] If the coding scheme determination unit 22 determines in step 21 that the decoding target frame has been encoded under the second coding scheme (that is, the decoding target frame is to be decoded by the second decoding unit 25) (step S21: SECOND DECODING UNIT), the coding scheme determination unit 22 sends the decoding target frame to the second decoding unit 25, and the second decoding unit 25 decodes the decoding target frame sent from the coding scheme

determination unit 22 under the second coding scheme and outputs the decoded result of the decoding target frame (decoded speech/music signal) through the communication device 20e (step S27). If the coding scheme determination unit 22 determines in step S21 that the decoding target frame has been encoded under the first coding scheme (that is, the decoding target frame is to be decoded by the first decoding unit 24) (step S21: FIRST DECODING UNIT), the coding scheme determination unit 22 refers to the content of the storage device 20d and determines whether the frame immediately before the decoding target frame (the immediately preceding frame) has been encoded under the first coding scheme (that is, the immediately preceding frame has been decoded by the first decoding unit 24) or encoded under the second coding scheme (that is, the immediately preceding frame has been decoded by the second decoding unit 25) (step S22). The decoded results of a predetermined number of decoded frames (including the immediately preceding frame and frames preceding the decoding target frame) and frames yet to be decoded are all stored in the storage device 20d.

[0043] If the coding scheme determination unit 22 determines in step S22 that the immediately preceding frame has been encoded under the first coding scheme (that is, the immediately preceding frame has been decoded by the first decoding unit 24) (step S22; YES), the coding scheme determination unit 22 sends the decoding target frame to the first decoding unit 24, and the first decoding unit 24 decodes the decoding target frame sent from the coding scheme determination unit 22 under the first coding scheme and outputs the decoded result of the

decoding target frame (decoded speech/music signal) through the communication device 20e (step S26).

[0044] If the coding scheme determination unit 22 determines in step S22 that the immediately preceding frame has been encoded under the second coding scheme (that is, the immediately preceding frame has been decoded by the second decoding unit 25) (step S22; NO), the coding scheme determination unit 22 sends the immediately preceding frame to the code separation unit 23, and the code separation unit 23 separates the multiplexed codes of the immediately preceding frame into codes of the first coding scheme and supplemental information indicating the initialization method of the internal state of the first decoding unit 24 (for example, information indicating the initialization method of the internal state of the first encoding unit 13 which is specified by the internal state initialization method specifying unit 17 and is used when the immediately preceding frame is encoded). Then, the internal state calculation unit 27 calculates the internal state of the first decoding unit 24 using the decoded result of the immediately preceding frame (step S23). As an exemplary process of calculating the internal state from the decoded result of the immediately preceding frame, the process of calculating the internal state of the first decoding unit 24, which is performed by the internal state calculation unit 27, includes a process of calculating linear predictive coefficients, using a method such as a covariance method, from the decoded result of the immediately preceding frame and then calculating a residual signal by applying a linear predictive inverse filter to the decoded result, using the calculated linear predictive coefficients.

[0045] Since the process of calculating linear predictive coefficients from the decoded result of the immediately preceding frame requires a large amount of calculation, instead of calculating the linear predictive coefficients from the decoded result of the immediately preceding frame, the internal state calculation unit 27 may use linear predictive coefficients (, which are the linear predictive coefficients used at the time of decoding by the first decoding unit 24 and are stored in the storage device 20d) of a frame neighboring the immediately preceding frame (and preceding the immediately preceding frame) which is encoded under the first coding scheme, in place of the linear predictive coefficients used in the aforementioned process (the process of calculating the internal state of the first decoding unit 24), or may use values obtained by interpolating the linear predictive coefficients between frames, in place of the linear predictive coefficients used in the aforementioned process (the process of calculating the internal state of the first decoding unit 24). The internal state calculation unit 27 may use values obtained by extrapolating the linear predictive coefficients of a frame neighboring the immediately preceding frame which is encoded under the first coding scheme or values obtained by extrapolating values obtained by interpolating the linear predictive coefficients between frames, in place of the linear predictive coefficients used in the aforementioned process (the process of calculating the internal state of the first decoding unit 24). The internal state calculation unit 27 may convert the linear predictive coefficients into linear spectral frequencies, extrapolate the linear spectral frequencies and reconvert the extrapolated result back into linear predictive coefficients. If the linear predictive

coefficients of the immediately preceding frame are included in the codes of the decoding target frame, the internal state calculation unit 27 may use the linear predictive coefficients included in the codes of the decoding target frame, in place of the linear predictive coefficients used in the aforementioned process (the process of calculating the internal state of the first decoding unit 24). Alternatively, calculation of the linear predictive coefficients may be dispensed with by omitting application of the linear predictive inverse filter. Furthermore, the internal state of the first decoding unit 24 may be initialized by using the internal state (information indicating the internal state is stored in the storage device 20d) obtained during the process of decoding a frame neighboring the immediately preceding frame (and preceding the immediately preceding frame) which is encoded under the first coding scheme. The process of applying the linear predictive inverse filter to the decoded result of the immediately preceding frame may not be performed on the entire frame but may be performed on only a part of the frame.

[0046] After step S23, the internal state initialization method specifying unit 26 specifies, based on the supplemental information included in the multiplexed codes of the immediately preceding frame and indicating the initialization method of the internal state of the first decoding unit 24, one of predetermined initialization methods including a method of initializing the internal state of the first decoding unit 24, using the internal state calculated by the internal state calculation unit 27, a method of initializing by "0", and the like (step S24). Then, the internal state initialization method specifying unit 26 initializes the

internal state of the first decoding unit 24 according to the initialization method specified in step S24 (step S25). The initialization of the internal state of the first decoding unit 24, which is performed by the internal state initialization method specifying unit 26, is a process of
5 initializing the internal state of the first decoding unit 24, using the internal state calculated by the internal state calculation unit 27, and may include a process of initializing the internal state (the values held by the delay elements) of the linear predictive synthesis filter of the first decoding unit 24, which calculates an output signal from a residual
10 signal under the first coding scheme.
[0047] After the internal state initialization method specifying unit 26 initializes the internal state of the first decoding unit 24 in step S25, the first decoding unit 24 decodes the decoding target frame in accordance with the first coding scheme and outputs the decoded result of the
15 decoding target frame (decoded speech/music signal) through the communication device 20e (step S26).
[0048] If the supplemental information indicating an initialization method of initializing the internal state of the first decoding unit 24 is not multiplexed into the codes of the immediately preceding frame, an
20 initialization method of initializing the internal state of the first decoding unit 24 may be specified, using a fixed codebook gain of the decoding target frame under the first coding scheme or the result of analyzing the periodicity of the decoded result in the immediately preceding frame or the like (using information obtained in common
25 from the first decoding unit 24 and the second decoding unit 25, and the encoder (the encoder included in the decoding device 20 or the first

encoding unit 13)). It may be so configured that the internal state initialization method specifying unit 26 is dispensed with if the first decoding unit 24 always initializes the internal state thereof using the internal state calculated by the internal state calculation unit 27. In this case, it is not necessary to use the supplemental information indicating the initialization method which is multiplexed into the codes of the immediately preceding frame. Although the operation of the internal state calculation unit 27 and the operation of the internal state initialization method specifying unit 26 are described above in relation to the case where the immediately preceding frame has been encoded under the second coding scheme and the decoding target frame has been encoded under the first coding scheme, it is not so limited. If it is determined by look-ahead that the decoding target frame has been encoded under the second coding scheme and the frame immediately succeeding the decoding target frame has been encoded under the first coding scheme, the internal state calculation unit 27 and the internal state initialization method specifying unit 26 may perform calculation of the internal state for the first decoding unit 24 and selection of the internal state initialization method, based on the look-ahead information. Although the configuration has been discussed in which switching is performed between two coding schemes, that is, the first coding scheme and the second coding scheme, it may be so configured that switching is performed among three or more coding schemes including a plurality of coding schemes different from the first coding scheme.

[0049] Next, the operation and effect of the encoding device 10

according to the embodiment will be described. The encoding device 10 includes the first encoding unit 13 functioning under a linear predictive coding scheme and the second encoding unit 14 functioning under another coding scheme different from the linear predictive coding scheme and encodes an audio signal using the first encoding unit 13 and the second encoding unit 14. The encoding device 10 further includes the coding scheme switching unit 12, the internal state calculation unit 16, and the internal state initialization method specifying unit 17. The coding scheme switching unit 12 determines whether the first encoding unit 13 or the second encoding unit 14 should be used to encode an encoding target frame that is a target frame to be encoded included in the audio signal. If it is determined that the encoding target frame is to be encoded by the first encoding unit 13, the coding scheme switching unit 12 determines whether the frame immediately preceding the encoding target frame has been encoded by the first encoding unit 13 or the second encoding unit 14. If it is determined by the coding scheme switching unit 12 that the immediately preceding frame has been encoded by the second encoding unit 14, the internal state calculation unit 16 decodes the coded result of the immediately preceding frame and calculates the internal state of the first encoding unit 13 using the decoded result. The internal state initialization method specifying unit 17 initializes the internal state of the first encoding unit 13 using the internal state calculated by the internal state calculation unit 16. Then, the first encoding unit 13 encodes the encoding target frame after the internal state is initialized by the internal state initialization method specifying unit 17.

[0050] In the encoding device 10, even when the encoding target frame is to be encoded by the first encoding unit 13 under a linear predictive coding scheme, whereas the immediately preceding frame has been encoded by the second encoding unit 14 under a coding scheme different from the linear predictive coding scheme, the encoding target frame can be encoded under the linear predictive coding scheme by initializing the internal state of the first encoding unit 13. Therefore, encoding processing performed under a plurality of encoding schemes including the linear predictive coding scheme and another coding scheme different from the linear predictive coding scheme can be realized.

[0051] Next, the operation and effect of the decoding device 20 according to the embodiment will be described. The decoding device 20 includes the first decoding unit 24 functioning under a linear predictive coding scheme and the second decoding unit 25 functioning under another coding scheme different from the linear predictive coding scheme and decodes an encoded audio signal, using the first decoding unit 24 and the second decoding unit 25. The decoding device 20 further includes the coding scheme determination unit 22, the internal state calculation unit 27, and the internal state initialization method specifying unit 26. The coding scheme determination unit 22 determines whether the first decoding unit 24 or the second decoding unit 25 should be used to decode a decoding target frame that is a target frame to be decoded included in an encoded audio signal. If it is determined by the coding scheme determination unit 22 that the decoding target frame is to be decoded by the first decoding unit 24, the

coding scheme determination unit 22 determines whether a frame immediately preceding the decoding target frame has been decoded by the first decoding unit 24 or decoded by the second decoding unit 25. If it is determined by the coding scheme determination unit 22 that the immediately preceding frame has been decoded by the second decoding unit 25, the internal state of the first decoding unit 24 is calculated using the decoded result of the immediately preceding frame. The internal state of the first decoding unit 24 is initialized using the internal state calculated by the internal state calculation unit 27. Then, the first decoding unit 24 decodes the decoding target frame after the internal state is initialized according to the internal state initialization method specifying unit 26.

[0052] In the decoding device 20, even when the decoding target frame is to be decoded with the first decoding unit 24 under a linear predictive coding scheme, whereas the immediately preceding frame has been decoded by the second decoding unit 25 under a coding scheme different from the linear predictive coding scheme, the decoding target frame can be decoded under the linear predictive coding scheme by initializing the internal state of the first decoding unit 24. Therefore, decoding processing performed under a plurality of coding schemes including the linear predictive coding scheme and another coding scheme different from the linear predictive coding scheme can be realized.

Industrial Applicability

[0053] When switching from a coding scheme not using linear prediction to a coding scheme using linear predictive coding, the

internal state of encoding means or decoding means operating under the coding scheme using linear predictive coding is set to an appropriate initial value, whereby the quality of a speech reproduced from a frame coming immediately after the switching can be improved.

5 Reference Signs List

[0054] 10 encoding device

10a, 20a CPU

10b, 20b ROM

10c, 20c RAM

10 10d, 20d storage device

10e, 20e communication device

10f, 20f bus

12 coding scheme switching unit

13 first encoding unit

15 14 second encoding unit

15 code multiplexing unit

16, 27 internal state calculation unit

17, 26 internal state initialization method specifying unit

20 decoding device

20 22 coding scheme determination unit

23 code separation unit

24 first decoding unit

25 second decoding unit

CLAIMS

1. An audio signal encoding method for encoding an audio signal including a plurality of frames, using first encoding means operating under a linear predictive coding scheme and second encoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal encoding method comprising:

a switching step of switching encoding means for encoding a second frame immediately succeeding a first frame from the second encoding means to the first encoding means after the first frame of the audio signal is encoded by the second encoding means; and

an initialization step of initializing an internal state of the first encoding means according to a predetermined method, only after the switching step,

wherein, in the initialization step, an encoded result of the first frame generated by the second encoding means is decoded to obtain a decoded result, a residual signal is calculated from the decoded result, and, as the internal state of the first encoding means, an adaptive codebook of the first encoding means is initialized with the residual signal.

2. An audio signal decoding method for decoding an encoded audio signal including a plurality of frames, using first decoding means operating under a linear predictive coding scheme and second decoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal decoding method comprising:

a switching step of switching decoding means for decoding a second frame immediately succeeding a first frame from the second decoding means to the first decoding means after the first frame of the encoded audio signal is decoded by the second decoding means; and

an initialization step of initializing an internal state of the first decoding means according to a predetermined method, only after the switching step,

wherein, in the initialization step, a residual signal is calculated from the decoded result of the first frame, and, as the internal state of the first decoding means, an adaptive codebook of the first decoding means is initialized with the residual signal.

3. An encoding device including first encoding means operating under a linear predictive coding scheme and second encoding means operating under a coding scheme which is different from the linear predictive coding scheme and encoding an audio signal using the first encoding means and the second encoding means, the encoding device comprising:

first determination means that determines whether the first or second encoding means is used to encode a target frame that is included in the audio signal and serves as an encoding target;

second determination means that determines, if the first determination means determines that the target frame is to be encoded by the first encoding means, whether an immediately preceding frame that immediately precedes the target frame has been encoded by the first encoding means or the second encoding means;

internal state calculation means that decodes, only if the second determination means determines that the immediately preceding frame has been encoded by the second encoding means, an encoded result of the immediately preceding frame and calculates a residual signal from the decoded result; and

initialization means that initializes an adaptive codebook of the first encoding means using the residual signal calculated by the internal state calculation means, wherein

the first encoding means encodes the target frame after initialization of the adaptive codebook by the initialization means.

4. A decoding device including first decoding means operating under a linear predictive coding scheme and second decoding means operating under a coding scheme which is different from the linear predictive coding scheme and decoding an encoded audio signal using the first decoding means and the second decoding means, the decoding device comprising:

first determination means that determines whether the first or second decoding means is used to decode a target frame that is included in the encoded audio signal and serves as a decoding target;

second determination means that determines, if the first determination means determines that the target frame is to be decoded by the first decoding means, whether an immediately preceding frame that

immediately precedes the target frame has been decoded by the first decoding means or the second decoding means;

internal state calculation means that calculates, only if the second determination means determines that the immediately preceding frame has been decoded by the second decoding means, a residual signal from a decoded result of the immediately preceding frame; and

initialization means that initializes an adaptive codebook of the first decoding means using the residual signal calculated by the internal state calculation means, wherein

the first decoding means decodes the target frame after initialization of an internal state thereof by the initialization means.

5. An audio signal processing system comprising:
the encoding device according to claim 3; and
the decoding device according to claim 4, wherein
the decoding device decodes an encoded audio signal encoded by the encoding device.

6. An audio signal encoding program for encoding an audio signal using first encoding means operating under a linear predictive coding scheme and second encoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal encoding program causing a computer device to function as:

first determination means for determining whether the first or second encoding means is used to encode a target frame that is included in the audio signal and serves as an encoding target;

second determination means for, if the first determination means determines that the target frame is to be encoded by the first encoding means, determining whether an immediately preceding frame that immediately precedes the target frame has been encoded by the first encoding means or the second encoding means;

internal state calculation means for, only if the second determination means determines that the immediately preceding frame has been encoded by the second encoding means, decoding an encoded result of the immediately preceding frame and calculating a residual signal from the decoded result;

initialization means for initializing an adaptive codebook of the first encoding means using the residual signal calculated by the internal state calculation means; and

encoding means for encoding the target frame by the first encoding means after initialization of the adaptive codebook by the initialization means.

7. An audio signal decoding program for decoding an encoded audio signal using first decoding means operating under a linear predictive coding scheme and second decoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal decoding program causing a computer device to function as:

first determination means for determining whether the first or second decoding means is used to decode a target frame that is included in the encoded audio signal and serves as a decoding target;

second determination means for, if the first determination means determines that the target frame is to be decoded by the first decoding means, determining whether an immediately preceding frame that immediately precedes the target frame has been decoded by the first decoding means or the second decoding means;

internal state calculation means for, if the second determination means determines that the immediately preceding frame has been decoded by the second decoding means, a residual signal from a decoded result of the immediately preceding frame;

initialization means for initializing an adaptive codebook of the first decoding means using the residual signal calculated by the internal state calculation means; and

decoding means for decoding the target frame by the first decoding means after initialization of the adaptive codebook by the initialization means.

8. An audio signal encoding method for encoding an audio signal including a plurality of frames, using first encoding means operating under a linear predictive coding scheme and second encoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal encoding method comprising:

a switching step of switching encoding means for encoding a second frame immediately succeeding a first frame from the second encoding means to the first encoding means after the first frame of the audio signal is encoded by the second encoding means; and

an initialization step of initializing an internal state of the first encoding means according to a predetermined method, after the switching step,

wherein, in the initialization step, an internal state of the first encoding means is initialized by setting a residual signal as a content of an adaptive codebook of the first encoding means, wherein the residual signal is obtained by applying a linear predictive inverse filter to either the first frame yet to be encoded by the second encoding means or a signal obtained by decoding an encoded result of the first frame generated by the second encoding means, and

wherein linear predictive coefficients of the first frame are included in codes of the second frame, and, in the initialization step, the linear predictive coefficients is utilized for the linear predictive inverse filter.

9. An audio signal decoding method for decoding an encoded audio signal including a plurality of encoded frames generated from an audio signal including a plurality of frames, using first decoding means operating under a linear predictive coding scheme and second decoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal decoding method comprising:

a switching step of switching decoding means for decoding a second encoded frame immediately succeeding a first encoded frame from the second decoding means to the first decoding means after the first encoded frame of the encoded audio signal is decoded by the second decoding means, the first encoded frame being generated from a first frame of the audio signal and the second encoded frame being generate from a second frame immediately succeeding the first frame in the audio signal; and

an initialization step of initializing an internal state of the first decoding means according to a predetermined method, after the switching step,

wherein, in the initialization step, an internal state of the first

decoding means is initialized by setting a residual signal as a content of an adaptive codebook of the first decoding means, wherein the residual signal is obtained by applying a linear predictive inverse filter to a signal obtained by decoding the first encoded frame by the second decoding means, and

wherein linear predictive coefficients of the first frame are included in codes of the second encoded frame, and, in the initialization step, the linear predictive coefficients are utilized for the linear predictive inverse filter.

10. An encoding device including first encoding means operating under a linear predictive coding scheme and second encoding means operating under a coding scheme which is different from the linear predictive coding scheme and encoding an audio signal using the first encoding means and the second encoding means, the encoding device comprising:

first determination means that determines whether the first or second encoding means is used to encode a target frame that is included in the audio signal and serves as an encoding target;

second determination means that determines, if the first determination means determines that the target frame is to be encoded by the first encoding means, whether an immediately preceding frame that immediately precedes the target frame has been encoded by the first encoding means or the second encoding means;

internal state calculation means that, if the second determination means determines that the immediately preceding frame has been encoded by the second encoding means, calculates an internal state of the first encoding means by applying a linear predictive inverse filter to a signal obtained by decoding an encoded result of the immediately preceding frame to calculate a residual signal; and

initialization means that initializes an internal state of the first encoding means by setting the residual signal calculated by the internal state calculation means as a content of an adaptive codebook of the first encoding means, wherein

linear predictive coefficients of the immediately preceding frame are included in codes of the target frame, and the internal state calculation means utilizes the linear predictive coefficients for the linear predictive inverse filter, and

the first encoding means encodes the target frame after initialization of the internal state by the initialization means.

11. A decoding device including first decoding means operating under a linear predictive coding scheme and second decoding means operating under a coding scheme which is different from the linear predictive coding scheme and decoding an encoded audio signal generated from an audio signal, using the first decoding means and the second decoding means, the decoding device comprising:

first determination means that determines whether the first or second decoding means is used to decode a target encoded frame that is included in the encoded audio signal and serves as a decoding target;

second determination means that determines, if the first determination means determines that the target encoded frame is to be decoded by the first decoding means, whether an immediately preceding encoded frame that immediately precedes the target encoded frame has been decoded by the first decoding means or the second decoding means;

internal state calculation means that calculates, if the second determination means determines that the immediately preceding encoded frame has been decoded by the second decoding means, an internal state of the first decoding means by applying a linear predictive inverse filter to a signal obtained by decoding the immediately preceding encoded frame to calculate a residual signal; and

initialization means that initializes an internal state of the first decoding means by setting the residual signal calculated by the internal state calculation means as a content of an adaptive codebook of the first decoding means, wherein

the immediately preceding encoded frame and the target encoded frame are generated from a first frame of the audio signal and a second frame immediately succeeding the first frame in the audio signal, respectively,

linear predictive coefficients of the first frame are included in codes of the target encoded frame,

the internal state calculation means utilizes the linear predictive coefficients for the linear predictive inverse filter, and

the first decoding means decodes the target encoded frame after

initialization of an internal state by the initialization means.

12. An audio signal processing system comprising:
the encoding device according to claim 10; and
the decoding device according to claim 11, wherein
the decoding device decodes an encoded audio signal encoded by
the encoding device.

13. An audio signal encoding program for encoding an audio signal
using first encoding means operating under a linear predictive coding
scheme and second encoding means operating under a coding scheme
which is different from the linear predictive coding scheme, the audio
signal encoding program causing a computer device to function as:

the first encoding means;

the second encoding means;

first determination means for determining whether the first or
second encoding means is used to encode a target frame that is included in
the audio signal and serves as an encoding target;

second determination means for, if the first determination means
determines that the target frame is to be encoded by the first encoding
means, determining whether an immediately preceding frame that
immediately precedes the target frame has been encoded by the first
encoding means or the second encoding means;

internal state calculation means that, if the second determination
means determines that the immediately preceding frame has been encoded
by the second encoding means, calculates an internal state of the first
encoding means by applying a linear predictive inverse filter to a signal
obtained by decoding an encoded result of the immediately preceding
frame to calculate a residual signal; and

initialization means that initializes an internal state of the first
encoding means by setting the residual signal calculated by the internal
state calculation means as a content of an adaptive codebook of the first
encoding means,

wherein linear predictive coefficients of the immediately preceding
frame are included in codes of the target frame, and the internal state
calculation means utilizes the linear predictive coefficients for the linear

predictive inverse filter

14. An audio signal decoding program for decoding an encoded audio signal generated from an audio signal, using first decoding means operating under a linear predictive coding scheme and second decoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal decoding program causing a computer device to function as:

the first decoding means;

the second decoding means;

first determination means for determining whether the first or second decoding means is used to decode a target encoded frame that is included in the encoded audio signal and serves as a decoding target;

second determination means for, if the first determination means determines that the target encoded frame is to be decoded by the first decoding means, determining whether an immediately preceding encoded frame that immediately precedes the target encoded frame has been decoded by the first decoding means or the second decoding means;

internal state calculation means that calculates, if the second determination means determines that the immediately preceding encoded frame has been decoded by the second decoding means, an internal state of the first decoding means by applying a linear predictive inverse filter to a signal obtained by decoding the immediately preceding encoded frame to calculate a residual signal; and

initialization means that initializes an internal state of the first decoding means by setting the residual signal calculated by the internal state calculation means as a content of an adaptive codebook of the first decoding means,

wherein the immediately preceding encoded frame and the target encoded frame are generated from a first frame of the audio signal and a second frame immediately succeeding the first framed in the audio signal, respectively,

linear predictive coefficients of the first frame are included in codes of the target encoded frame, and

the internal state calculation means utilizes the linear predictive coefficients for the linear predictive inverse filter.

15. An audio signal encoding method for encoding an audio signal including a plurality of frames, using first encoding means operating under a linear predictive coding scheme and second encoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal encoding method comprising:

a switching step of switching encoding means for encoding a second frame immediately succeeding a first frame from the second encoding means to the first encoding means after the first frame of the audio signal is encoded by the second encoding means; and

an initialization step of initializing an internal state of the first encoding means according to a predetermined method, after the switching step,

wherein, in the initialization step, the internal state of the first encoding means is initialized using the internal state had by the first encoding means when the first encoding means encoded a frame preceding the first frame.

16. The audio signal encoding method according to claim 1, wherein the internal state of the first encoding means comprises a content of an adaptive codebook or values held by delay elements of a linear predictive synthesis filter.

17. An audio signal decoding method for decoding an encoded audio signal including a plurality of frames, using first decoding means operating under a linear predictive coding scheme and second decoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal decoding method comprising:

a switching step of switching decoding means for decoding a second frame immediately succeeding a first frame from the second decoding means to the first decoding means after the first frame of the encoded audio signal is decoded by the second decoding means; and

an initialization step of initializing an internal state of the first decoding means according to a predetermined method, after the switching step,

wherein, in the initialization step, the internal state of the first

decoding means is initialized using the internal state held by the first decoding means when the first decoding means decoded a frame preceding the first frame.

18. The audio signal decoding method according to claim 10, wherein the internal state of the first decoding means comprises a content of an adaptive codebook or values held by delay elements of a linear predictive synthesis filter.

19. An encoding device including first encoding means operating under a linear predictive coding scheme and second encoding means operating under a coding scheme which is different from the linear predictive coding scheme and encoding an audio signal using the first encoding means and the second encoding means, the encoding device comprising:

first determination means that determines whether the first or second encoding means is used to encode a target frame that is included in the audio signal and serves as an encoding target;

second determination means that determines, if the first determination means determines that the target frame is to be encoded by the first encoding means, whether an immediately preceding frame that immediately precedes the target frame has been encoded by the first encoding means or the second encoding means; and

initialization means that, if the second determination means determines that the immediately preceding frame has been encoded by the second encoding means, initializes an internal state of the first encoding means using the internal state held by the first encoding means when the first encoding means encoded a frame preceding the immediately preceding frame.

20. A decoding device including first decoding means operating under a linear predictive coding scheme and second decoding means operating under a coding scheme which is different from the linear predictive coding scheme and decoding an encoded audio signal using the first decoding means and the second decoding means, the decoding device comprising:

first determination means that determines whether the first or second decoding means is used to decode a target frame that is included in

the encoded audio signal and serves as a decoding target;

second determination means that determines, if the first determination means determines that the target frame is to be decoded by the first decoding means, whether an immediately preceding frame that immediately precedes the target frame has been decoded by the first decoding means or the second decoding means; and

initialization means that, if the second determination means determines that the immediately preceding frame has been decoded by the second decoding means, initializes an internal state of the first decoding means using the internal state held by the first decoding means when the first decoding means decoded a frame preceding the immediately preceding frame.

21. An audio signal processing system comprising:
the encoding device according to claim 19; and
the decoding device according to claim 20, wherein
the decoding device decodes an encoded audio signal encoded by the encoding device.

22. An audio signal encoding program for encoding an audio signal using first encoding means operating under a linear predictive coding scheme and second encoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal encoding program causing a computer device to function as:

the first encoding means;

the second encoding means

first determination means for determining whether the first or second encoding means is used to encode a target frame that is included in the audio signal and serves as an encoding target;

second determination means for, if the first determination means determines that the target frame is to be encoded by the first encoding means, determining whether an immediately preceding frame that immediately precedes the target frame has been encoded by the first encoding means or the second encoding means; and

initialization means for, if the second determination means determines that the immediately preceding frame has been encoded by the second encoding means, initializing an internal state of the first encoding means using the

internal state held by the first encoding means when the first encoding means encoded a frame preceding the immediately preceding frame.

23. An audio signal decoding program for decoding an encoded audio signal using first decoding means operating under a linear predictive coding scheme and second decoding means operating under a coding scheme which is different from the linear predictive coding scheme, the audio signal decoding program causing a computer device to function as:

- the first decoding means;

- the second decoding means;

- first determination means for determining whether the first or second decoding means is used to decode a target frame that is included in the encoded audio signal and serves as a decoding target;

- second determination means for, if the first determination means determines that the target frame is to be decoded by the first decoding means, determining whether an immediately preceding frame that immediately precedes the target frame has been decoded by the first decoding means or the second decoding means; and

- initialization means for, if the second determination means determines that the immediately preceding frame has been decoded by the second decoding means, initializing an internal state of the first decoding means using the internal state had by the first decoding means when the first decoding means decoded a frame preceding the immediately preceding frame.