



LOSSLESS ENCODING AND DECODING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 The present invention relates to a lossless encoding and decoding system, and more particularly, to a lossless encoding and decoding system including a lossless encoding apparatus and a lossless decoding apparatus in which encoded data can be decoded on a real-time basis.

2. Description of the Related Art

10 In general, a digital audio signal is obtained from an analog audio signal by means of a pulse code modulation method, in order to represent audio information with the number of channels, the number of bits and a sampling frequency according to the DVD-audio standards. However, since a digital audio signal includes redundancy data, it is required to use lossless compression encoding methods, in order to improve shorten a
15 recording time of a digital audio signal with respect to a digital versatile disc (DVD) and improve a bitrate.

 A representative example of lossless compression encoding methods is the Huffman coding method, in which input data having a higher frequency of occurrence is assigned with a relatively shorter length of codeword and input data having a lower
20 frequency of occurrence is assigned with a relatively longer length of codeword. In the case that a digital audio signal is losslessly compressed by the Huffman coding method, it is more efficiently coded than the case that only a linear pulse code modulation (PCM) method is used.

 Meanwhile, a predictor is used in the case that input data has predictable properties.
25 The predictor determines prediction data corresponding to new input data using previous input data, and then uses a method for compressing a difference between the prediction data and the new input data. In the case that such a predictor is additionally used in the

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above-described lossless compression unit, an encoding efficiency with respect to digital audio signal can be further enhanced.

When the above-described conventional lossless encoding method is used, a bitrate of the encoded data is varied according to the degree of the property and random of input data, although a bitrate of the input data is constant. Thus, since conventional lossless coding methods require a very large capacity of buffers, in the case of data compression and decompression, it is difficult to encode or decode data in real-time. In addition, although a buffer capacity is increased in order to solve the above problem, a delay in decoding still remains.

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SUMMARY OF THE INVENTION

To solve the above problems, it is an object of the present invention to provide a lossless encoding apparatus for encoding data on a real-time basis.

It is another object of the present invention to provide a lossless decoding apparatus for decoding encoded data on a real-time basis.

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It is still another object of the present invention to provide a lossless encoding and decoding system having a lossless encoding apparatus and a lossless decoding apparatus in which encoded data can be decoded on a real-time basis.

To accomplish one object of the present invention, there is provided a lossless encoding apparatus comprising: an input buffer for storing input audio data; a lossless compression unit for losslessly compression encoding the audio data stored in the input buffer in units of predetermined data and outputting the encoded data in sequence; an output buffer for storing the encoded audio data output from the lossless compression unit; and a bitrate controller for dividing plurality of the encoded audio data stored in the output buffer into first data having a data amount exceeding the maximum bitrate and second data having a data amount less than the maximum bitrate, dividing the first data into third data being the encoded audio data having a data amount of the maximum bitrate

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and fourth data being the encoded data of the portion exceeding over the maximum bitrate, and controlling the output buffer so that the fourth data is output at the same time when the second data is output.

To accomplish another object of the present invention, there is also provided a
5 lossless decoding apparatus comprising: an input buffer for storing input data in its input sequence; a lossless restorer for losslessly restoring data output from the input buffer and generating audio data; a buffer controller for controlling the input buffer in a manner that first data having no identification information among the data stored in the input buffer is supplied to the lossless restorer and second data having identification information
10 combined with third data having identification information is supplied to the lossless restorer, wherein the first data has a data amount by which a result obtained by lossless encoding audio data of a predetermined data unit does not exceed a maximum bitrate, and the second data and third data constitutes fourth data by which a result obtained by lossless encoding audio data of a corresponding predetermined data unit exceeds the
15 maximum bitrate, and wherein the second data is encoded audio data having a data amount of the maximum bitrate among the fourth data and the third data is encoded audio data of the portion exceeding the maximum bitrate among the fourth data; and an output buffer for storing and outputting audio data generated in the lossless restorer.

To accomplish the other object of the present invention, there is also provided a
20 lossless encoding and decoding system comprising a lossless encoding apparatus and a lossless decoding apparatus, wherein the lossless encoding apparatus comprises: a first input buffer for storing input audio data; a lossless compression unit for losslessly compression-encoding the audio data stored in the first input buffer in units of predetermined data and outputting the encoded data in sequence; a first output buffer for
25 storing the encoded audio data output from the lossless compression unit; and a bitrate controller for dividing plurality of the encoded audio data stored in the output buffer into first data having a data amount exceeding the maximum bitrate and second data having a



data amount less than the maximum bitrate, dividing the first data into third data being the encoded audio data having a data amount of the maximum bitrate and fourth data being the encoded data of the portion exceeding over the maximum bitrate, and controlling the first output buffer so that the fourth data is output at the same time when the second data is output, and wherein the lossless decoding apparatus comprises: a second input buffer for storing input data in its input sequence; a lossless restorer for losslessly restoring data output from the second input buffer and generating audio data; a buffer controller for controlling the second input buffer in a manner that first data having no identification information among the data stored in the second input buffer is supplied to the lossless restorer and second data having identification information combined with third data having identification information is supplied to the lossless restorer, wherein the first data has a data amount by which a result obtained by lossless encoding audio data of a predetermined data unit does not exceed a maximum bitrate, and the second data and third data constitutes fourth data by which a result obtained by lossless encoding audio data of a corresponding predetermined data unit exceeds the maximum bitrate, and wherein the second data is encoded audio data having a data amount of the maximum bitrate among the fourth data and the third data is encoded audio data of the portion exceeding the maximum bitrate among the fourth data; and a second output buffer for storing and outputting audio data generated in the lossless restorer.

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BRIEF DESCRIPTION OF THE DRAWINGS

The objects and other advantages of the present invention will become more apparent by describing in detail the structures and operations of the present invention with reference to the accompanying drawings, in which:

25 Fig. 1 is a block diagram showing a lossless encoding apparatus according to a preferred embodiment of the present invention;

Fig. 2 is a conceptual view for explaining the operation of the bitrate controller



shown in Fig. 1;

Fig. 3 shows the structure of a bitstream output from the output buffer shown in Fig. 1; and

Fig. 4 is a block diagram showing a lossless decoding apparatus corresponding to the lossless encoding apparatus of Fig. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described with reference to the accompanying drawings, in which elements having the same reference numerals perform the same functions.

In Fig. 1 showing a lossless encoding apparatus according to a preferred embodiment of the present invention, an input buffer 11 stores digital audio data input from an external source and supplies the stored audio data to a lossless compression unit 13 in the same sequence as its input sequence. The lossless compression unit 13 losslessly compresses and encodes the audio data supplied from the input buffer 11 in each predetermined data unit. In this embodiment of the present invention, for example, a frame is used as a predetermined data unit. Also, in the present invention, the lossless compression unit 13 losslessly compresses and encodes audio data by means of a lossless compression encoding method such as a well-known Huffman encoding method. The audio data encoded by the lossless compression unit 13 is input to an output buffer 15. The output buffer 15 stores the input encoded audio data. The output buffer 15 stores the encoded audio data in such a pattern that the encoded audio data corresponding to a random frame can be distinguished from the encoded audio data corresponding to the other frames. A bitrate controller 17 stores a maximum bitrate determined based on a bitrate resulting from losslessly encoding the whole audio data corresponding to an audio track. The bitrate controller 17 controls the output buffer 15 in such a manner that the encoded audio data stored in the output buffer is output at an output bitrate which is equal



to or less than the maximum bitrate.

Referring to Fig. 2, the operation of the bitrate controller 17 will be described below. The bitrate controller 17 divides a plurality of the encoded audio data stored in the output buffer 15 into first data having a data amount exceeding the maximum bitrate and second data having a data amount not exceeding the maximum bitrate. By the
5 above division, for example, the encoded audio data of the frames of frame numbers 6, 7 and 10 shown in Fig. 2 is defined as first data. The bitrate controller 17 divides respective first data into third data being the encoded audio data having a data amount of the maximum bitrate and fourth data being the encoded audio data of the portion
10 exceeding the maximum bitrate. The fourth data is shown as hatching portions in Fig. 2. The bitrate controller 17 adds identification information by which the fourth data and the third data corresponding to the fourth data can be distinguished from data of the other frame, to the fourth data and the third data corresponding to the fourth data. Then, the bitrate controller 17 controls the output buffer 15 in such a manner that the fourth data is
15 output from the output buffer 15 at the same time as that of the second data of the other frame. In this embodiment of the present invention, the bitrate controller 17 selects a particular frame temporally preceding the frame of the fourth data, and controls the output buffer 15 in such a manner that the fourth data is output at the same time as that of the second data of the selected frame. In this case, the bitrate controller 17 selects a
20 preceding frame in order to add the fourth data based on the bitrate corresponding to a predetermined number of frames preceding the frame of the fourth data. In response to the control of the bitrate controller 17, the output buffer 15 outputs the second data, both the second and fourth data, or the third data in the form of a bitstream, in correspondence to a respective frame of the encoded audio data supplied from the lossless compression
25 unit 13. Thus, in the case of the frames having the numbers shown in Fig. 2, the output buffer 15 outputs the bitstream as shown in Fig. 3. In Fig. 3, the frames which are not hatched are frames output from the output buffer 15 in the same sequence as that input to



the output buffer 15 from the lossless compression unit 13, and the hatched portions show the fourth data added to the second data of the frame temporally preceding the original frame.

Fig. 4 is a block diagram showing a lossless decoding apparatus for restoring the bitstream output from the lossless encoding apparatus of Fig. 1. In Fig. 4, an input buffer 41 stores bitstream data generated in the encoding apparatus of Fig. 1 in the same sequence as its input sequence. A buffer controller 43 controls the input buffer 41 in order to output the data stored in the input buffer 41 to a lossless restorer 45. Under the control of the buffer controller 43, the second data is output to the lossless restorer 45 without change, and the fourth data is combined with the third data and the first data corresponding to the fourth data, based on identification information added to the third data and the fourth data. The combined first data is output to the lossless restorer 45. Here, the buffer controller 43 determines the sequence of the first data and the second data both output to the lossless restorer 45 based on the second data and the third data. Thus, in the case that the second data precedes the third data among the data of the bitstream input to the input buffer 41, the second data is output to the lossless restorer 45 and then the first data corresponding to the third data is output to the lossless restorer 45. As a result, the input buffer 41 can supply the stored data to the lossless restorer 45 so that the lossless restorer 45 can restore data without any delay.

The lossless restorer 45 performs a reverse process of a signal processing in the above-described lossless compression unit 13 in order to restore audio data, and outputs the restored audio data to an output buffer 47. The output buffer 47 stores the audio data supplied from the lossless restorer 45 and supplies the stored audio data to a following device (not shown).

Since it is apparent to those who are skilled in the art that the above lossless encoding apparatus and the above lossless decoding apparatus can be employed in the lossless encoding and decoding system although it has not been shown in the drawing and



described in the specification, the detailed description thereof will not be omitted.

As described above, the lossless encoding and decoding system including the lossless encoding apparatus and the lossless decoding apparatus controls the bitrate of the encoded audio data so that the encoded audio data can be decoded on a real-time basis.

5 Thus, the present invention can be used in a real-time system with limited bitrate as in a disc playback device or a communications channel.

What is claimed is:

1. A lossless encoding apparatus comprising:

an input buffer for storing input audio data;

10 a lossless compression unit for losslessly compression encoding the audio data stored in the input buffer in units of predetermined data and outputting the encoded data in sequence;

an output buffer for storing the encoded audio data output from the lossless compression unit; and

15 a bitrate controller for dividing plurality of the encoded audio data stored in the output buffer into first data having a data amount exceeding the maximum bitrate and second data having a data amount less than the maximum bitrate, dividing the first data into third data being the encoded audio data having a data amount of the maximum bitrate and fourth data being the encoded data of the portion exceeding over the maximum bitrate,
20 and controlling the output buffer so that the fourth data is output at the same time when the second data is output.

2. The lossless encoding apparatus according to claim 1, wherein said output buffer sequentially outputs the data stored by said bitrate controller at the output bitrate which is equal to or less than the maximum bitrate.

25 3. The lossless encoding apparatus according to claim 1, wherein said bitrate controller adds the fourth data to the frame of the second data preceding the frame of the fourth data.

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What is claimed is:

1. A lossless encoding apparatus comprising:

an input buffer for storing input audio data;

10 a lossless compression unit for losslessly compression encoding the audio data stored in the input buffer in units of predetermined data and outputting the encoded data in sequence;

an output buffer for storing the encoded audio data output from the lossless compression unit; and

15 a bitrate controller for dividing plurality of the encoded audio data stored in the output buffer into first data having a data amount exceeding the maximum bitrate and second data having a data amount less than the maximum bitrate, dividing the first data into third data being the encoded audio data having a data amount of the maximum bitrate and fourth data being the encoded data of the portion exceeding over the maximum bitrate,
20 and controlling the output buffer so that the fourth data is output at the same time when the second data is output.

2. The lossless encoding apparatus according to claim 1, wherein said output buffer sequentially outputs the data stored by said bitrate controller at the output bitrate which is equal to or less than the maximum bitrate.

25 3. The lossless encoding apparatus according to claim 1, wherein said bitrate controller adds the fourth data to the frame of the second data preceding the frame of the fourth data.

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4. The lossless encoding apparatus according to claim 1, wherein said bitrate controller controls said output buffer in such a manner that the second data, both the second and fourth data, or the third data can be output in the same sequence as that by which the encoded audio data is supplied from said lossless compression unit.

5 5. The lossless encoding apparatus according to claim 1, wherein said bitrate controller adds same identification information to the third data and the fourth data corresponding to the third data.

6. The lossless encoding apparatus according to claim 5, wherein said identification information is a frame number.

10 7. A lossless decoding apparatus comprising:

an input buffer for storing input data in its input sequence;

a lossless restorer for losslessly restoring data output from the input buffer and generating audio data;

a buffer controller for controlling the input buffer in a manner that first data having
15 no identification information among the data stored in the input buffer is supplied to the lossless restorer and second data having identification information combined with third data having identification information is supplied to the lossless restorer, wherein the first data has a data amount by which a result obtained by lossless encoding audio data of a predetermined data unit does not exceed a maximum bitrate, and the second data and third
20 data constitutes fourth data by which a result obtained by lossless encoding audio data of a corresponding predetermined data unit exceeds the maximum bitrate, and wherein the second data is encoded audio data having a data amount of the maximum bitrate among the fourth data and the third data is encoded audio data of the portion exceeding the maximum bitrate among the fourth data; and

25 an output buffer for storing and outputting audio data generated in the lossless restorer.

8. A lossless encoding and decoding system comprising:





a lossless encoding apparatus; and

a lossless decoding apparatus,

wherein said lossless encoding apparatus comprises: a first input buffer for storing input audio data; a lossless compression unit for losslessly compression-encoding the audio data stored in the first input buffer in units of predetermined data and outputting the encoded data in sequence; a first output buffer for storing the encoded audio data output from the lossless compression unit; and a bitrate controller for dividing plurality of the encoded audio data stored in the output buffer into first data having a data amount exceeding the maximum bitrate and second data having a data amount less than the maximum bitrate, dividing the first data into third data being the encoded audio data having a data amount of the maximum bitrate and fourth data being the encoded data of the portion exceeding over the maximum bitrate, and controlling the first output buffer so that the fourth data is output at the same time when the second data is output, and

wherein said lossless decoding apparatus comprises: a second input buffer for storing input data in its input sequence; a lossless restorer for losslessly restoring data output from the second input buffer and generating audio data; a buffer controller for controlling the second input buffer in a manner that first data having no identification information among the data stored in the second input buffer is supplied to the lossless restorer and second data having identification information combined with third data having identification information is supplied to the lossless restorer, wherein the first data has a data amount by which a result obtained by lossless encoding audio data of a predetermined data unit does not exceed a maximum bitrate, and the second data and third data constitutes fourth data by which a result obtained by lossless encoding audio data of a corresponding predetermined data unit exceeds the maximum bitrate, and wherein the second data is encoded audio data having a data amount of the maximum bitrate among the fourth data and the third data is encoded audio data of the portion exceeding the maximum bitrate among the fourth data; and a second output buffer for storing and



outputting audio data generated in the lossless restorer.



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