A METHOD AND APPARATUS FOR TRANSMITTING A COMPRESSED PICTURE SIGNAL

This invention relates to a method of and apparatus for producing a compressed picture signal, and is applicable, for example, to a recording apparatus for recording a moving picture on a disc-like recording medium rotated with constant linear velocity.

An example of a disc-shaped recording medium rotated at constant line velocity, is the well known digital audio compact disc (usually abbreviated to "the CD"). In a CD, in order to take advantage of digital recording and the available storage capacity, a CLV (constant linear velocity) system has been adopted. Recording a picture signal as well as a digital audio signal onto the CD has also been considered. However, the amount of information needing to be stored in the case of a picture signal is very much greater than for an audio signal and an effective data compression technique is needed for both still and moving pictures. For compression of picture data, so-called highly efficient encoding is employed.

Highly efficient encoding techniques for picture signals can be classified according to the dimensionality of the data being encoded, ie, intraframe encoding (one dimensional and two dimensional) and interframe encoding. The intraframe encoding performs processing on a scanning line (one dimension), or intrafield or intraframe lines (two dimensions), while the interframe encoding performs three dimensional interframe processing. Intraframe encoding tends to provide a low compression rate, but can provide a reproduced picture of high quality. On the other hand, interframe encoding provides a high compression rate, but there are problems that the picture quality of the reproduced picture is inferior to that in intraframe encoding and that, in interframe encoding, propagation

errors are generated.

Such highly efficient encoding can be employed in communication systems such as a video conference facility or a video telephone, which require a high compression rate. To prevent the generation of a propagation error, a first picture may be subjected to intraframe processing and the remaining ones may be subjected to interframe processing (correctly stated, adaptive selection of the intraframe processing and the interframe processing) in these communication systems. However, in the case of CD, data can be obtained from the CD intermittently on occasions of special reproduction such as random access, search or reverse. For this reason, when a frame difference is encoded with the interframe processing as mentioned above, there arises the problem that a reproduced picture cannot be provided.

To solve this problem a system where periodically one picture is completely subjected to the intraframe processing and subsequent pictures are subjected to efficient interframe processing is proposed. With this system, a reproduced picture can be provided intermittently by reproducing intraframe-encoded picture data from the CD at the time of the above mentioned special reproduction operation. Consequently, the special reproducing operation is possible.

As one example, one frame may be subject to intraframe encoding at a period which is equal to six contiguous frames in time, and the remaining five frames may be subjected to the interframe processing. As a result, as shown in figure 1 of the accompanying drawings, encoded data F1 (indicated by hatching area) corresponding to picture data of the first frame, which is generated by the intraframe encoding, is positioned in a two-frame period, for example, of the six frames. Encoded data is generated in the remaining four-frame period so that encoded data F2

to F6 corresponding to each picture data of the second frame to the sixth frame is positioned after the two-frame block allocated to the first frame F1.

Figure 2 shows a part of the innermost circumference side of the spiral track of a CD. Recording data is shown in figure 3A in the state where the track is developed linearly by x-x' line in the radial direction of the disc. As described above, the period of the intraframe encoding is set at 6 frames, and data generated in the intraframe encoding (indicated by each hatched area) is inserted over a two-frame period. The intraframe-encoded data is recorded every six frames from data F1 corresponding to the first frame in a part of the disc shown in figure 2.

During a special reproduction operation, for example, the pick-up feed in the radial direction of the disc is performed at high speed as compared with normal reproduction and when a search operation involving a track jump is performed, only data subjected to the intraframe encoding is reproduced sequentially as shown at an arrow of figure 3A. Reproduction data corresponding to figure 3A is shown in figure 3B. In figure 3B, each hatched area represents the cue time (ie, the total time required for track jump of the pick-up and the next reproduction of intraframe encoded data). Further, in figure 3B, the display operation of the reproduced picture corresponding to reproduced data is shown. Clearly, a reproduced picture P1 provided by the intraframe decoding of the reproduction data F1 is repeatedly displayed on a monitoring device until a reproduced picture P7 of the next seventh frame is obtained. As will be understood from figure 3b, a post-six frame picture is provided every two-frame or three-frame time interval.

Since the efficiency of the intraframe processing is poor in an encoding system which pays attention to the above mentioned special reproduction, data generated in the

intraframe processing exceeds one frame so as to have a two-frame period (the above stated example) or a much longer period. Therefore, at the time of search operation, the same picture is repeatedly reproduced until the reproduction of data subjected to the next intraframe processing is completed. For this reason, there is a disadvantage that changes of the reproduced picture at the time of reproduction occur only slowly.

One method for solving this disadvantage is a proposal that the encoding of a frame to be subjected to the intraframe processing is done by dividing the frame into two stages. Specifically, in the first stage, after the original picture is subjected to bandwidth restriction, one half of the data is thinned out in the longitudinal and lateral directions to reduce the amount of data to a quarter. By processing this data, the generated data amount is kept within one frame. At the second stage, an approximation to the original picture is produced by interpolation, and the difference between the original and the reconstituted version is encoded.

According to this step-by-step encoding system, a picture of low resolution provided in the first stage is expressed at the time of search. A reproduced picture which varies smoothly every frame time can consequently be obtained. However, there are problems that the circuit size becomes large because of the thinning-out and the interpolation circuitry required for the two stage decoding and that processing efficiency is impaired.

According to the present invention, there is provided an apparatus for generating a compressed picture signal comprising:

means for dividing a single frame picture signal into a plurality of segmented areas;

means for orthogonally transforming at least one of said plurality of segmented areas so as to generate an intraframe coded signal;

means for generating a difference between present and adjacent picture frames, said generating means including a motion compensation circuit for reducing a number of data of said difference, the motion compensation circuit including a motion detector of said picture and a frame memory circuit and being operative to compensate motion of the picture image in only one direction of one of said remaining areas of which a corresponding area of said plurality of segmented areas of an adjacent frame is said intraframe coded signal;

means for orthogonally transforming said difference so as to generate an interframe coded signal of the remaining one(s) of said plurality of areas; and

means for outputting said at least one of and remaining of said plurality of segmented areas as said compressed picture signal.

A second aspect of the invention provides a method of generating a compressed picture signal comprising:

dividing a single frame picture signal into a plurality of segmented areas;

orthogonally transforming at least one of said plurality of segmented areas so as to generate an intraframe coded signal;

generating a difference between present and adjacent picture frames, using a motion compensation circuit for reducing a number of data of said difference, the motion compensation circuit including a motion detector of said picture and a frame memory circuit and being operative to compensate motion of the picture image in only one direction of one of said remaining areas of which a corresponding area of said plurality of segmented areas of an adjacent frame is said intraframe coded signal;

orthogonally transforming said difference so as to generate an interframe coded signal of the remaining one(s) of said plurality of areas; and

outputting said at least one of and remaining of said plurality of segmented areas as said compressed picture signal.

The invention will be further described by way of non-limitative example with reference to the accompanying drawings, in which:-

Figure 1 is a schematic diagram for describing conventional encoding;

Figure 2 is a schematic diagram showing a part of a track of a disc-shaped recording medium to which the invention is applicable;

Figure 3 is a schematic diagram for explanation in a conventional search operation;

Figure 4 is a block diagram of one embodiment of this invention;

Figure 5 is a schematic diagram for describing encoding; and

Figure 6 is a schematic diagram for explanation in a search operation of one embodiment of the invention.

One embodiment of this invention will now be described referring to the drawings. Figure 4 shows a recording circuit to which the invention is applicable. In a CD ROM (CD for which rewriting is impossible), the recording circuit is applied to a master disc manufacturing system. The embodiment is an example where the DCT (Discrete Cosine Transform) is employed as highly efficient encoding technique. However, the invention is not limited to DCT, and other conversion codes can be used. Also, highly efficient codes which do not use conversion codes, for example, sub-sampling and ADRC encoding adaptive to signal dynamic range, ie, the difference between the maximum value and the minimum value of the data within a block, may be employed.

In figure 4, picture data is supplied to an input terminal indicated at 1. The picture data is non-interlaced data in which one picture is constituted by one frame. The picture data may be either monochrome or colour. Input picture data is supplied to a block segmentation circuit 2, and the order of the data is converted into a block structure of (m x m) constructed by segmenting one frame. The output signal of the block segmentation circuit 2 is

supplied to one input terminal 4a of a switch circuit 3 and a subtractor 5. The data of a previous frame, which is formed as mentioned later, is supplied to the subtractor 5, and a frame difference is provided from the subtractor 5. The frame difference is supplied to the other input terminal 4b of the switch circuit 3 whose output is supplied to a transformation circuit 6 of the DCT.

The switch circuit 3 is periodically switched by control pulses from a control pulse generator 7. A synchronisation signal, which is in synchronism with the input picture data, is supplied from an input terminal 8 to the control pulse generator 7. As a result, control pulses synchronised with the input picture data are formed. Intraframe encoding is performed when the switch circuit 3 selects a picture signal from the input terminal 4a, while interframe encoding is performed when the switch circuit 3 selects a picture signal from the input terminal 4b. As described later, the intraframe encoding and the interframe encoding are switched, so that one frame is divided into five-divided areas in the longitudinal direction, one of the divided areas is subjected to the intraframe encoding, and the remaining four-divided areas are subjected to the interframe encoding.

At the transformation circuit 6, the processing of two-dimensional cosine conversion is made, so that the transformation circuit 6 generates coefficient data. The coefficient data is supplied to a quantisation circuit 9, and the quantisation of the coefficient data is performed at a predetermined quantisation step. The output signal of the quantisation circuit 9 is sent to a variable length encoder 10 to be subjected to run-length encoding and Hufman encoding. The output signal of the variable length encoder 10 is supplied to a multiplexer 11. Data of the quantisation step from the quantisation circuit 9 is fed to the multiplexer 11, and a movement vector from a movement

compensating circuit 19 is supplied to the multiplexer 11. These side information and coefficient data are converted into transmission data at the multiplexer 11. The information of the quantisation step is also supplied to the variable length encoder 10.

The output signal of the multiplexer 11 is fed to a buffer memory 12. Transmission data read out of the buffer memory 12 is supplied to a modulator 13 and subjected to digital modulation processing such as EFM (a known modulation system for converting 8-bit data into 14-bit data). The transmission data from the output terminal 14 of the modulator 13 is recorded onto a disc. An encoder for error detection/correction is connected to the output terminal 14 although not shown. The transmission data with error corrected and coded is supplied to a write head for recording.

The buffer memory 12 is provided to buffer the encoded data so that the data rate of the transmission data does not exceed the capacity of the transmission line path. A control signal for controlling the quantisation step is supplied from the buffer memory 12 to the quantisation circuit 9. The control of the quantisation step is performed such that when there is too much transmission data, the quantisation step is made coarse (thus reducing the amount of transmission data produced), while when there is less transmission data, the quantisation step is made fine.

The output signal of the quantisation circuit 9 is fed to an inverse transformation circuit 15, and the output signal (frame difference) of the inverse transformation circuit 15 is applied to one input of an adder 16. The output signal of the adder 16 is sent to a frame memory 17. A reproduced picture is reproduced at the frame memory 17. The output signal of the frame memory 17 is fed to the subtractor 5 and the adder 16 through a loop filter 18. The

loop filter 18 is provided to lessen random noise and block distortion generated in the quantisation of the coefficient data at the quantisation circuit 9.

Further, a movement compensating circuit 19 is provided. The picture data (the output signal of the block segmentation circuit 2) of the present frame and the picture frame (the output signal of the frame memory 17) of the previous frame are supplied to the movement compensating circuit 19. At the movement compensating circuit 19, a movement vector indicative of movement between frames is detected, and the movement vector is supplied to the frame memory 17 and the multiplexer 11. Control pulses are supplied from the control pulse generator 7 to the movement compensating circuit 19 to switch between the case where movement compensation in both of the longitudinal and lateral directions is carried out and the case where movement compensation in the lateral direction only is carried out. Also, a pulse signal for controlling the switch circuit 3 from the pulse generator 7 is supplied to the multiplexer 11 as an ID signal for distinguishing the intraframe encoding and the interframe encoding and added to the transmission data.

The above mentioned interframe encoding is hybrid encoding of DCT and DPCM and performs cosine conversion of a frame difference provided by DPCM so as to achieve a high compression rate.

The above described encoding process will be explained referring to figure 5.

Figure 5 shows pictures FL1 to FL6 of six frames contiguous in time. Each frame is divided into n, for example, 5 so that each frame has boundaries in the horizontal scanning direction. Encoded data of each divided area (called a "block group") of frame FLi is indicated as Gi1, Gi2, ..., Gi5. One block group of the five block groups is subjected to intraframe encoding and remaining

four block groups are subjected to the interframe encoding. In figure 5, the area indicated by a hatched solid line shows a block group to be processed by intraframe encoding. As seen from figure 5, the position of the block group subjected to the interframe encoding is shifted toward the lower side every frame. In addition with respect to the block group corresponding to the position subjected to intraframe encoding in the previous frame among the block groups processed by the interframe encoding, only the movement compensation in the horizontal direction is done at the movement compensating circuit 19 as shown as at the area indicated by the hatched broken line. The movement compensation in the horizontal direction means that movement compensation is carried out among the block groups. The other block groups subjected to the interframe encoding receive the movement compensation in the lateral and longitudinal directions.

By dividing one frame picture into five block groups, performing intraframe encoding with respect to one block group thereof and performing interframe encoding with respect to the remaining block groups, the amount of generated encoded data has a length which is contained in one frame period.

In the special reproduction operation, for instance, in the search operation where the pickup feed in the radial direction of the disc is performed at high speed as compared with the normal reproduction operation and were a track jump occurs, only data of the block group subjected to the intraframe encoding is read out sequentially as shown at an arrow of figure 6A. Reproduction data corresponding to figure 6A is shown in figure 6B. In figure 6B, the hatched area represents the cue time (that is, the total of time required for the track jump and the next reproduction of the intraframe encoded data). Further, in figure 6B, the display operation of the reproduced picture corresponding to

reproduced data is shown. Namely, by the intraframe encoding of reproduction data G11, a reproduced picture is displayed on one fifth of the screen of the upper portion of a monitor device. Hereunder, similarly, reproduction data of data G72, G132, G194, G255, ... is decoded to display a reproduced picture over one fifth of the width sequentially. As a result, when a five-frame period elapses after the start of search reproduction, one decoded picture can be provided and one reproduced picture is always displayed on the monitor device in subsequent frames.

Therefore, at the time of the search operation, a change of one fifth of the width of a reproduced picture occurs every frame. This reproduced picture has a lateral stripe pattern. However, is quite usable as a cue during a search.

The invention is applicable to the case where recording of a picture signal onto a disc-shaped recording medium other than CD-ROM is carried out with highly efficient encoding.

The invention enables the amount of data which it is necessary to record by subjecting a part of a picture of one frame to intraframe encoding and the remaining parts to interframe encoding. Also, the invention allows reproduced pictures varying every frame to be read out utilising data subjected to the intraframe encoding at the time of special reproduction operations such as searches. Further, the invention can dispense with circuits for thinning out and interpolating data, so that the circuit size can be decreased.

Having described a specific preferred embodiment of the present invention with reference to the accompanying drawings, it is to be understood that the invention is not limited to that precise embodiment, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope of the invention as

1. An apparatus for generating a compressed picture signal comprising:

means for dividing a single frame picture signal into a plurality of segmented areas;

means for orthogonally transforming at least one of said plurality of segmented areas so as to generate an intraframe coded signal;

means for generating a difference between present and adjacent picture frames, said generating means including a motion compensation circuit for reducing a number of data of said difference, the motion compensation circuit including a motion detector of said picture and a frame memory circuit and being operative to compensate motion of the picture image in only one direction of one of said remaining areas of which a corresponding area of said plurality of segmented areas of an adjacent frame is said intraframe coded signal;

means for orthogonally transforming said difference so as to generate an interframe coded signal of the remaining one(s) of said plurality of areas; and

means for outputting said at least one of and remaining of said plurality of segmented areas as said compressed picture signal.

2. The apparatus according to claim 1, in which said dividing means divides the picture signal vertically, and said one direction is a horizontal direction of said picture signal.

3. The apparatus according to claim 1, in which said dividing means divides the picture signal horizontally, and said one direction is a vertical direction of said picture signal.

4. The apparatus according to any one of claims 1 to

3 and comprising a modulation circuit for modulating said intraframe coded area and remaining interframe coded area(s) so as to be recordable on a disc-shaped recording medium.

5. The apparatus according to claim 4, in which said interframe coding means includes a detector for detecting a motion of said picture signal.

6. The apparatus according to claim 5, in which said interframe coding means further includes a frame memory for storing a single frame picture signal and a subtracter for producing a difference between an output signal of said frame memory and a present frame of the picture signal.

7. The apparatus according to claim 6, in which said motion detector is operative to control said frame memory for motion compensation of the single frame picture signal stored in said frame memory so as to reduce the amount of data of said difference.

8. The apparatus according to claim 7, in which motion compensation includes a full motion compensation for shifting the stored picture signal in both of horizontal and vertical directions and a motion compensation in part for shifting the stored picture signal in one of said directions.

9. The apparatus according to claim 8, in which said motion compensation in part is employed to one of said remaining segmented areas, a corresponding area of which in a previous frame is processed by said intraframe coding, and said full motion compensation is employed to another areas of said remaining segmented areas.

10. The apparatus according to claim 9, in which said dividing means divides said frame of picture signal in a vertical direction.

11. The apparatus according to claim 10, in which said motion compensation in part is employed for shifting the stored picture signal only in horizontal direction.

12. The apparatus according to claim 9, 10 or 11 in which said dividing means divides said frame of picture signal in a horizontal direction.

13. The apparatus according to claim 12, in which said motion compensation in part is employed for shifting the stored picture signal only in vertical direction.

14. A method of generating a compressed picture signal comprising:

dividing a single frame picture signal into a plurality of segmented areas;

orthogonally transforming at least one of said plurality of segmented areas so as to generate an intraframe coded signal;

generating a difference between present and adjacent picture frames, using a motion compensation circuit for reducing a number of data of said difference, the motion compensation circuit including a motion detector of said picture and a frame memory circuit and being operative to compensate motion of the picture image in only one direction of one of said remaining areas of which a corresponding area of said plurality of segmented areas of an adjacent frame is said intraframe coded signal;

orthogonally transforming said difference so as to generate an interframe coded signal of the remaining one(s) of said plurality of areas; and

outputting said at least one of and remaining of said plurality of segmented areas as said compressed picture signal.

15. A method of producing a compressed picture signal substantially as hereinbefore described with reference to and as illustrated in figures 4A to 6 of the accompanying drawings.

16. Apparatus for producing a compressed picture signal constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in figures 4A to 6 of the accompanying drawings.

17. A record medium having recorded thereon a picture signal compressed by the method of claim 14 or 15 or using the apparatus of any one of claims 1 to 13 and 16.