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MOTION COMPENSATION PREDICTING CODING METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

i) Field of the invention:

The present invention relates generally to image encoding systems and, more particularly, to motion compensation predicting coding systems.

ii) Description of the Prior Art:

Fig. 1 shows a conventional motion compensation predicting coding apparatus, as disclosed in "A Study on HDTV Signal Coding with Motion Adaptive Noise Reduction" by S. Nogaki, M. Ohta and T. Omachi, The Third HDTV International Workshop Preliminary Report, Vol. 3, 1989. The conventional motion compensation predicting coding apparatus encodes a digital image signal 101 to produce a coded signal 106 that is sent over a transmission line 109. The conventional motion compensation predicting coding apparatus includes a frame memory 1, a motion detector 2, a subtracter 3, a coder 4, a local decoder 5, an adder 6 and a multiplexer (MUX) 7. At a destination, the coded data is decoded to reproduce the original image signal 101. The destination has an architecture similar to that shown in Fig. 1, except that the destination is configured to decode rather than encode.

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Before discussing the operation of the conventional coding apparatus, it is helpful to review the format of the image data to be encoded. An image may be viewed as being made of a number of picture elements or pixels. Each of these pixels has a certain level of luminance that is encoded according to a grey scale or other scale. The luminance for each pixel may be encoded into a digital signal. The digital signals for an entire screen of the display form a frame. This frame may be broken down into rows of pixels. Since many video displays, such as conventional cathode ray tubes, scan odd numbered rows in a first pass and even numbered rows in a second pass when generating an image (i.e., interlaced scanning), it is helpful to view the frame as being composed of an even field having data for even numbered rows and an odd field having data for odd numbered rows. Each of the fields (i.e., the odd field and the even field) may be further divided into blocks of pixel data such as regions of 8 pixels by 8 pixels.

The conventional motion compensation predicting coding apparatus operates as follows. An input image signal 101 or, for example, a digital signal encoding the luminances of pixels in a frame is provided in accordance with an interlaced scanning format. In the interlaced scanning format, the odd rows of pixels are first scanned and then the even rows of pixels are scanned. Hence, the input signal provides a sequence of pixel data beginning with the data for all of the odd rows which is followed by the data for all of the even rows. For purposes of the present discussion, it is

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assumed that the input image signal 101 is already organized into blocks. Each block is made of pixels of the same field. The system operates on a block at a time until all the blocks of a given field are encoded. The system then proceeds to encode the blocks of the other field in a frame. Once a frame is fully encoded, the process of encoding is repeated with a next frame.

The input image signal 101 of the present frame is compared with the image signals for the same field in a preceding frame to carry out motion detection. For instance, suppose a first block in the input image signal 101 encodes luminance information for a block of pixels in the odd field of a present frame. The motion detection of this first block is performed in the motion detector 2 by searching for the most analogous block in the neighboring blocks 102 in the previous frame that are positioned around the corresponding position of the first block. The neighboring blocks 102 are read out of the frame memory 1 and provided to the motion detector 2. The frame memory 1, stores image data (of local decoded signals 108) which has been locally decoded in the local decoder 5 and which has been summed with a motion compensation signal 104 in the adder 6. The frame memory 1 may be realized as a conventional RAM.

The motion detector 2 determines the similarities between the present block and the respective neighboring blocks to select the most analogous neighboring blocks. As a yardstick of similarity, the motion detector 2 may calculate a differential absolute value sum between blocks that is obtained by summing absolute values of

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each difference in luminance values for the corresponding pixels in the blocks, or the motion detector may calculate a differential square sum that is obtained by summing square values of differences in luminance values between the corresponding pixels in the blocks.

Once the most analogous neighboring block is found, the motion detector 2 calculates and outputs a motion vector 103 to the frame memory 1 and the MUX 7. The motion vector indicates the vector displacement difference between the most analogous neighboring block and the first block. This motion vector 103 includes vector components in the horizontal and vertical directions. Also, once the most analogous neighboring block is found, a motion compensation prediction signal 104 that encodes the illuminance of the pixels of the most analogous neighboring block is read out of the frame memory 1 and sent to a subtracter 3.

The subtracter 3 subtracts the motion compensation prediction signal 104 from the input image signal 101 to obtain a prediction error signal 105. In particular, the illuminance of each pixel in the motion compensation prediction signal is subtracted from the illuminance of each corresponding pixel in the input image signal 101. Chips for performing the subtraction are commercially available. The subtracter 3 then outputs the prediction error signal 105 to the coder 4. The coder 4 executes the coding of the prediction error signal 105 to remove spatial redundancy in the signal. The coder 4, thus, helps to compress the prediction error signal 105. The signal 105 includes both low frequency components and

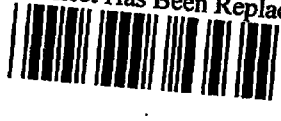
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high frequency components. Usually, in compressing the prediction error signal 105, the coder 4 quantizes the low frequency components of the signal 105 using many bits and quantizes the high frequency components using few bits. More bits are used in the encoding of the low frequency components because the low frequency components typically have much greater power than do the high frequency components. Assigning more bits to the low frequency components enhances coding efficiency and reduces image degradation. The coder 4, may perform, for example, an orthogonal transformation, such as a discrete cosine transformation (DCT), on an 8 x 8 pixel block to effect a frequency conversion that results in scalar quantization of a conversion factor. Scalar-quantized coded data 106 for the block is then sent from the coder 4 to the local decoder 5 and to the MUX 7.

The MUX 7 not only multiplexes the coded data 106 and the motion vector 103 but also encodes the data in a format proper for sending the data down the transmission line 109. The local decoder 5 performs a reciprocal operation to that performed by the coder 4. In particular, an inverse scalar quantization or an inverse orthogonal transformation is carried out to obtain a decoded error signal 107. The adder 6 adds the motion compensation predicting signal 104 to the decoded error signal 107 to obtain the local decoded signal 108, which corresponds to the input image signal 101. Chips for implementing the adder 6 are well known in the art. The local decoded signal 108 is stored in the frame memory 1.

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The local decoded signal is subsequently read out of the frame memory 1 for use in carrying out the motion detection of the odd field in the next frame.

For the even field of the input image signal 101, the motion detection in the motion detector 2, the coding in the coder 4, and so forth are carried out in the same manner as described above with respect to the odd field.

In the conventional motion compensation predicting coding apparatus, as described above, the removal of the temporal redundancy included in the motion image signal is carried out by motion compensation predicting coding and by using an appropriate technique such as an orthogonal transformation, differential pulse code modulation (DPCM), vector quantization or the like. As described above, in the conventional motion compensation predicting coding apparatus, the correlation of the data in the same field is utilized. However, the temporal correlation between continuous different fields subjected to the interlaced scanning is not used, and, hence, the coding efficiency is low.

It is, therefore, a general object of the present invention to provide a more efficient motion compensating predicting coding method and apparatus.

SUMMARY OF THE INVENTION

The foregoing objects and and other objects and advantages will be realized by the present invention in which a motion compensation predicting coding apparatus encodes pixel data of an image signal. The image signal

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includes pixel data organized into a even field and odd field for a portion of an image. The apparatus includes a motion detector for comparing the pixel data in the image signal with pixel data of a previous image signal. The motion detector generates a motion vector that is indicative of the displacement differences between the image signal and the previous image signal.

The motion compensation predicting coding apparatus also includes a subtracter for generating a prediction compensation error signal by subtracting the pixel data in the previous image signal from the pixel data of the current image signal. The resulting prediction compensation error signal is passed through an adaptive blocking mechanism that organizes the data of the prediction compensation error signal into blocks in one of several fashions. The blocking strategy is chosen as dictated by the motion vector. The blocking mechanism generates a blocked output that is fed to a coder and encoded.

The motion compensation predicting coding apparatus may alternatively include a field composer for composing the odd field pixel data in the incoming image signal with even field pixel data in the incoming image signal to produce a composed image signal. This composed image signal has pixel data for both the even and odd fields. This composed image signal is used by the motion detector in determining the motion vectors. Thus, in this alternative embodiment, the motion detection is not carried out strictly on single field blocks but rather is carried out on field composed blocks.

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The coder for encoding output may include several components. First, the coder may include a transformation means for performing an orthogonal transformation on the prediction error signal to produce a coefficient matrix. Second, the coder may include a quantizer for quantizing the coefficients from the coefficient matrix and a scanning controller for controlling what order the coefficients are scanned from the coefficient matrix and passed to the quantizer. This order is preferably controlled by the motion vectors. In particular, the motion vectors indicate whether there will be large horizontal components or large vertical components that are most efficiently quantized by altering the scanning order of the coefficient matrix. These elements may be used in conjunction with the above-described components.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will be more fully apparent from the following description of the preferred embodiments with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram of a conventional motion compensation predicting coding apparatus;

Fig. 2 is a block diagram of a first embodiment of a motion compensation predicting decoding apparatus according to the present invention;

Fig. 3A shows a block derived from the field composition frame input signal;

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Fig. 3B shows neighboring blocks to which the odd and even field of Fig. 3A are compared;

Figs. 3C and 3D show alternative methods for forming a motion compensation prediction signal using the blocks of Figs. 3A and 3B;

Fig. 4A shows a block of an odd field;

Fig. 4B shows a block of an even field;

Fig. 4C shows a field composition frame input signal formed from the blocks of Fig. 4A and Fig. 4B using a field composition method;

Fig. 5 shows a coefficient matrix for a DCT coding method;

Fig. 6A is a block diagram of a second embodiment of a motion compensation predicting coding apparatus according to the present invention;

Fig. 6B is a more detailed block diagram of the adaptive composer 39 of Fig. 6A;

Fig. 6C is a more detailed block diagram of the adaptive decomposer 40 of Fig. 6A;

Figs. 7A-7C show a field composition method using the apparatus shown in Fig. 6A;

Figs. 8A and 8B show field composition modes in the apparatus shown in Fig. 6A;

Fig. 9 is a block diagram of a third embodiment of a motion compensation predicting coding apparatus according to the present invention;

Fig. 10 is a block diagram of a fourth embodiment of a motion compensation predicting coding apparatus according to the present invention;

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Fig. 11 shows motion compensation predictings in the apparatus according to the present invention;

Fig. 12 is a block diagram of a fifth embodiment of a motion compensation predicting coding apparatus according to the present invention;

Figs. 13A-13C are explanatory views of conversion factor distribution in the apparatus shown in Fig. 12; and

Fig. 14 is a block diagram of a construction of a receiving side used in the embodiments of the apparatus according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described in connection with its preferred embodiments with reference to the attached drawings, wherein like reference characters designate like or corresponding parts throughout different views.

Fig. 2 shows a first preferred embodiment of a motion compensation predicting coding apparatus, in accordance with the present invention. The motion compensation predicting coding apparatus of Fig. 2 includes a frame memory 1, a subtracter 3, a coder 4, a local decoder 5, an adder 6 and a multiplexer (MUX) 7, which each are of the same construction and have the same functionality as corresponding components of the conventional motion compensation predicting coding apparatus shown in Fig. 1. The coder 4 will be described in more detail below. This embodiment of the invention further includes a field composer 8 for

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composing fields of the input signal into blocks for coding, a field separator 9 for decomposing coded signals, and a blocking controller 12 for blocking input image signals 100 into blocks.

The motion compensation predicting coding apparatus shown in Fig. 2 operates as follows. An input image signal 100 is input to blocking controller 12. This input image signal is not yet organized into blocks. The input image signal 101 includes both even and odd fields of pixel luminance data, for an area of an image sent in an interlaced scanning format. In most instances a block may be made of 8 x 8 pixels or 16 x 16 pixels. The blocking controller 12 organizes the data encoded in the signals into blocks to produce a blocked input image signal 101 having blocks of pixel data. Each block in the blocked input image signal 101 includes either exclusively even field pixel data or exclusively odd field pixel data.

A block of the blocked input image signal 101 is sent to the motion detector 2 and to the subtracter 3. The motion detector 2 performs an evaluation of the similarity of the present block of the blocked input image signal 101 to the neighboring blocks 102 of the same field in the preceding frame, which are read out of the frame memory 1. This evaluation is carried out in the same manner as it is carried out in the conventional apparatus described with reference to Fig. 1. The motion between the present block and the most similar block of the preceding frame is captured in the motion vectors 103 that are output to the frame memory 1 and

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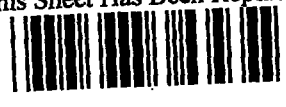


the MUX 7. The motion vectors include a horizontal component vector and a vertical component vector.

Figs. 3A-3B provide an illustration of how motion detection is performed. Fig. 3A shows a present pixel block that is output from the field composer 8 (Fig. 2). The even field pixels are designated by dotted circles and the odd field pixels are designated by solid circles. Fig. 3B shows neighboring pixels of neighboring blocks 202 and 204, which are positioned in the previous frame around the present pixel block position. The neighboring blocks 202 and 204 are read out of the frame memory 1 (Fig. 2). The motion detector 2 compares the present pixel block of Fig. 3A with the neighboring pixel blocks 202 and 204 that are read out of the frame memory 1. In particular, odd field pixels N00-N03 and N20-N23 of the present block of Fig. 3A are compared with the odd field pixels in the neighboring blocks 202 and 204, and the even field pixels N10-N13 and N30-N33 of the present block are compared with the even field pixels in the neighboring blocks 202 and 204 to perform motion detection.

As shown in Fig. 3B, the pixels P23 to P26 and P43 to P46 of the neighboring blocks 204 are selected as the pixels that are most similar to the pixels of the odd field in Fig. 3A. These pixels of block 204 are used to calculate the motion vector V1 = (3,1) (note the X and Y axes in Fig. 3B), which is indicative of the displacement between the present block and the selected neighboring block 24. The pixels P11 to P14 and P31 to P34 within the neighboring block 202 are selected as the

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most similar pixels to the pixels of the even field in Fig. 3A. The selected pixels of block 202 are used to obtain the motion vector V2 = (1,0). The motion vectors 302 (V1 and V2) of the odd and even fields are output from the motion detector 32.

The blocks (P23 to P26 and P43 to P46) of the odd field and the blocks (P11 to P14 and P31 to P34) of the even field that are designated by the motion vector 302 are read out of the frame memory 33 and are composed to form a field composition motion compensation prediction signal 303. The field composition motion compensation prediction signal 303 may be composed in two alternative ways. First, the lines of the fields are alternated in the order shown in Fig. 3C, or second, the lines of the fields designated by the motion vectors 302 are alternated in the order, shown in Fig. 3D. Another alternative is to determine whether the field composition motion compensation prediction signal 303 obtained from the method shown in Fig. 3C or the signal obtained from the method shown in Fig. 3D is more similar to the present pixel block. The similarity may be discriminated by a differential absolute value sum or a differential square sum, and then the more similar signal is selected.

The frame memory 1 reads out a motion compensation prediction signal 104 for the neighboring blocks that are used in the comparison to generate the motion vectors 103. The motion compensation prediction signal 104 encodes luminance pixel data for the neighboring blocks of a previous frame. The subtracter 3 subtracts

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the motion compensation prediction signal 104 from the present pixel data to obtain a prediction error signal 105. In particular, the subtracter 3 subtracts the pixel data for the even field of the input image signal 101 from the even field of a neighboring block which has the most similar even field, when an even blocked image signal 101 is input and subtracts the pixel data for the odd field of the input image signal 101 from the odd field of a neighboring block which has the most similar odd field when an odd blocked image signal 101 is input. The subtraction is performed on a pixel by pixel basis. The prediction error signal is separately obtained for both the odd field and the even field of each area of an image.

The resulting prediction error signal 105, having results from the substracter 3 for the odd field and even field of an area, is composed into one frame in the field composer 8. Figs. 4A-4C illustrate the block composing method performed by the field composer 8. Fig. 4A shows blocked data of an odd field for an area of an image, and Fig. 4B shows blocked data of an even field in the same area as the odd field of Fig. 4A. The lines of these two fields are alternately combined by the field composer 8 to obtain a field composition frame input signal as shown in Fig. 4C. In order to carry out such a frame composing process, the field composer 8 (Fig. 2) includes a memory 17, such as a RAM, for storing more than one field of data.

The field composer 8 produces the composed output, known as a field composition prediction error signal

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110, that is sent to the coder 4. The coder 4 produces coded data 106 and sends the coded data to both the local decoder 5 and the MUX 7.

In the MUX 7, the coded data 106 are multiplexed with the motion vectors 103 of the odd and even fields, and the multiplexed data are placed in a format proper for the transmission line 109. In the local decoder 5, the coded data 106 are locally decoded to obtain a field composition decoded prediction error signal 111 which is sent to the field separator 9. In the field separator 9, the lines of the field composition decoded prediction error signal 111 are alternately separated to obtain separate respective decoded prediction error signals 107a for the odd field and the even field. In the adder 6, each decoded prediction error signal 107a is added to the motion compensation predicting signal 104 of the corresponding field to obtain a local decoded signal 108, which is sent to the frame memory and is stored therein.

In the coder 4, two-dimensional predicting coding is performed using the correlation between the neighboring pixels in the horizontal and vertical directions of the motion compensation prediction error signal 110. One approach to coding that may be employed is an approach which uses the discrete cosine transform (DCT). The DCT approach is well-known to those skilled in the art. The DCT approach, as described in the Background of the Invention, transforms a block of input of a given size to produce an equal sized array of transform coefficients. Each composed block that is input to the

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coder 4 undergoes a two-dimensional transformation that yields the transform coefficients. The DCT approach converts the input components into frequency components.

The low frequency coefficients are quantitized more finely (i.e., assigned a larger number of bits) because they typically possess greater energy. Hence, less distortion arises given the higher precision of the encoding of these lower frequencies. In contrast, the higher frequency coefficients are quantitized more coarsely (i.e., assigned fewer bits) and possess less energy. Fig. 5 provides an illustration of a 4 x 4 coefficient matrix that is the product of a DCT approach. The frequency of the coefficients is the lowest in the upper left-hand corner of the matrix. Hence, the coefficient designated as "A" has the lowest frequency. The horizontal frequency of the coefficients increases as one moves horizontally across the rows of the matrix in the direction of arrow 23 in Fig. 5. Likewise, the vertical frequency of the coefficients increases as one moves down a column of the matrix in the direction of arrow 25. Accordingly, coefficient "C" has a greater horizontal frequency than coefficient "A", but has a similar vertical frequency. On the other hand, coefficient "B" has a greater vertical frequency than coefficient "A" but has a similar horizontal frequency.

As was mentioned above, the lower frequency components are assigned more bits than the higher frequency components. Thus, coefficient "A" typically has the greatest number of bits assigned to it. The

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cumulative frequency in the coefficient matrix then increases in a zig-zag fashion. Specifically, coefficients "B" and coefficients "C" are the next highest frequency components and typically are assigned the next highest number of bits relative to coefficient "A". The number of bits assigned to the coefficients continues to decrease until the highest frequency component "D" is reached. Typically, coefficient "D" is assigned zero bits.

In the above discussion, the coder 4 (Fig. 2) is described as performing the coding by DCT, which is kind of orthogonal transformation. It is, however, also possible to perform the coding by utilizing other well-known techniques such as differential pulse code modulation (DPCM) or vector quantization. When vector quantization is used, a codebook is used.

Fig. 6A shows a second embodiment of a motion compensation predicting coding apparatus. This second embodiment includes a motion detector 32, a frame memory 33, a subtracter 34, a coder 35, a local decoder 36, an adder 37 and a multiplexer 38, like the corresponding components in the first described embodiment of Fig. 2. This second embodiment, however, differs from the first embodiment in that it includes an adaptive composer 39, an adaptive decomposer 40 and a memory 41. The operations and functions of these additional components will be described below.

In this second embodiment, an input image signal 300 is input to the motion detector 32 and the memory 41. This input image signal 300 is already organized into

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blocks. In the motion detector 32, a motion vector 302 of the input image signal 300 is detected in the same manner as the first embodiment described above. In the motion detector 32, a motion vector 302 of the input signal 200 is produced using the image signals 305 of the preceding frame, which are read out of the frame memory 33 in the same manner as described above for the first embodiment. The resulting motion vector 302 is fed to the frame memory 33 and to the MUX 38.

A motion compensation prediction signal 303 is read out of the frame memory 33 as specified by the motion vector 302 and is sent to the subtracter 34. The subtracter 34 subtracts the motion compensation prediction signal 303 from the field composition frame input signal 301 to output a field composition prediction error signal 304 to the adaptive composer 39.

In this embodiment, in order to process both the odd and even fields at the same time in the subtracter 34, the input image signal 300 is stored in the memory 41. When the motion vectors for the odd and even fields are obtained in the motion detector 32, a determination is made in the adaptive composer 39 using the motion vector 302 whether the coding is carried out in a field composition mode or in a field independent mode. For example, when the motion vectors of both the fields are coincident with each other, both the fields are composed.

The adaptive composer 39 divides the field composition prediction error signal 304 into blocks on the basis of the motion vector 302, as shown in Figs.

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7A-7C. In Figs. 7A-7C, "O" indicates a pixel of the odd field, and "□" indicates a pixel of the even field. Further, the shading indicates a difference in illuminance. Fig. 7A shows a block of the prediction error signal 304 in which field composition has been properly carried out, that is, by alternately arranging the pixels of the odd field and the pixels of the even field on every line. Thus, the field composition frame becomes a continuous image. By a continuous image, it is meant that the boundary between the illuminated pixels (grey pixels) and the dark pixels (black pixels) is continuous. If the continuous image is obtained by field composing the power concentration of the low frequency component is effectively raised, especially when orthogonal transformation coding is used by the coder 4 (Fig. 6). As a result, the coding efficiency is increased. Fig. 7B, in contrast, shows a block of the prediction error signal 304 in which field composition has been performed but should not have. An instance where such a prediction error signal would result is when there is a great amount of motion in the image. In particular, the object moves between scanning of the odd field and scanning of the even field. As a result, the field composition frame becomes an image having many discontinuous parts (i.e., it does not have a continuous boundary between grey and black pixels in Fig. 7B). The coded signal has a larger number of high frequency components, and the coding efficiency is decreased.

Hence, depending on the motion within the input image signal, a determination is made whether to use field composition or not.

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Fig. 7C shows an example where the above-described adaptive method has been properly applied. In Fig. 7C, the field composition is performed for the region 51, and no field composition is performed for the region 53. Sub-regions 51a and 51b include both even and odd field pixels. In contrast, sub-region 53a includes only odd field pixels, and sub-region 53b includes only even field pixels.

Fig. 6B provides a more detailed depiction of the adaptive composer 39. This adaptive composer includes a switch "e", a composer "c" and a discriminator "a". These components work together to control blocking in response to the motion vector 302. For example, when the motion vector is zero or ± 1 in the even and odd fields, discriminator "a" permits frame composition. Otherwise, the discriminator does not permit frame composition and sends a signal "b" to the switch "e". The switch "e" is operated in response to signal "b". Upon receiving the signal "b", the switch "e" moves its contact to touch the leg "f", which bypasses the composer "c". When a signal "b" is not received by the switch "e", the switch is positioned to contact the leg leading to the composer "c".

To perform the frame composition, the composer "e" provides a signal "d" by combining the motion compensation prediction signals 304 of the even and odd fields as shown in Fig. 4C. Without frame composition, the motion composition prediction signals are separately output for the even and odd fields.

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The adaptive composer 39 processes the signal 304 into blocks based on the motion vectors 302. When the motion amounts of the odd and even fields are almost equal, the correlation between the fields is high. Therefore, as shown in Fig. 8A, the signals (1O - 4O) of the odd field (shown as darkened circles) and the signals (1E-4E) of the even field are alternately arranged on successive lines. However, when the motion amounts in the odd fields and in the even fields differ, the correlation between the even fields and the odd fields is low. Thus, as shown in Fig. 8B, no field composing is employed. As a result, the odd field signals are arranged in the upper part of the block, and the even field signals are arranged in the lower part of the block.

In accordance with the above-described adaptive method, the adaptive composer 39 outputs a blocking-controlled prediction error signal to the coder 35. The coder 35 performs DCT or the like on the blocking-controlled prediction error signal so as to quantize the signal. Prediction error coded data are output to the decoder 36 and the MUX 38.

In the MUX 38, the prediction error coded data are multiplexed with the motion vector 302 sent from the motion detector 32, and the multiplexed data are sent out to the transmission line.

In the decoder 36, the prediction error coded data are decoded to obtain a decoded prediction error signal. The decoded prediction error signal is sent to the adaptive decomposer 40. In the adaptive decomposer

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40, all blocks have the same blocking structure. That is, the decoder 36 determines on a block-by-block basis what blocking method was employed to create the block by examining the motion vector, and based on that determination, the decoded prediction error signal is made into a predetermined format by the adaptive decomposer 40.

Fig. 6C provides a more detailed depiction of the adaptive decomposer 40. The adaptive decomposer includes a discriminator "m", a switch "k" and a separator "h". The adaptive decomposer 40 functions inversely relative to the adaptive composer 39 (Fig. 6A). In particular, the adaptive decomposer 40 separates the fields of an input block which frames are composed by the adaptive composer 39. A discriminator "m" functions in a fashion analogous to the previously described discriminator "a" (shown in Fig. 6B). When the motion vector 302 is zero in the odd and even fields, the discriminator "m" permits field separation. Otherwise, the discriminator "m" provides a signal "g" that activates switch "k". When the switch is activated by the signal "g", a connection is made to the separator "h". The separator "h" outputs the signal "i" by separating the frame combine restoration prediction error signal "l" for the odd and even fields as shown in Figs. 4A and 4B. If the discriminator does not generate the signal "g", the fields are not separated and the restoration prediction error signal "l" is output. In this instance, the signal "l" has already been separated for the even and odd fields.

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In the adder 37, the blocking-controlled prediction error signal output from the adaptive decomposer 40 is added with the field composition motion compensation prediction signal 303 to obtain a decoded signal. The decoded signal is sent to the frame memory 33 and stored therein. In this illustrative embodiment, the information concerning how the blocking structure is determined is made to correspond with the motion vector information, and hence the switching of blocking approaches may be performed without requiring any supplementary information.

In this embodiment, the motion vectors, which are independently obtained for the odd and even fields, are used for the adaptive blocking approach so that the motion between the odd and even fields is more exactly controlled.

In this embodiment, although the block size of 4 pixels x 4 lines is used in the coder 35, other block sizes such as 8 pixels by 8 lines or the like may be used.

Fig. 9 shows a third embodiment of a motion compensation predicting coding apparatus in accordance with the present invention. This third embodiment has several components like the previously described second embodiment. These like components are given like reference numbers. The third embodiment differs from the second embodiment in that this third embodiment includes two types of motion detectors 32 and 43. The operation of these motion detectors 32 and 43 is described below.

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The third embodiment operates as follows. An input image signal 300, which is organized into blocks of even field pixels and blocks of odd field pixels, is fed to the first motion detector 43 and the memory 41. The input image signal 300 is stored in the memory 41. The input image signal 300 is also sent to the first motion detector 43. The previously received image signal 301 is read out of the memory 41 and sent to the first and second motion detectors 32 and 43. The image signal 301 is also sent to the subtracter 34. The first motion detector 43 calculates a motion vector 306 between the odd and even fields of the input image signal 300 and the image signal 301 in the same manner as described above for the previous embodiments. The motion vector 306 is then sent to the MUX 38, the adaptive composer 39, and the adaptive decomposer 40. The second motion detector 32 calculates a motion vector 302 indicating the motion between the odd field of image signal 301 and an odd field of a neighboring block read out of frame memory 33 and indicating the motion between the even field of image signal 301 and an even field of a neighboring block read out of frame memory 33. Although the first and second motion detectors are independently provided in this embodiment, one motion detector can be used at a time, being shared for the two purposes.

In this embodiment, motion vector 306 determines whether the coding is carried out in a field composition mode (i.e., the fields are composed) or in a field independent mode (i.e., the fields remain separate). For example, when the motion vector 306 between the even

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and odd fields is zero, field composition mode is chosen, and the fields are composed. On the other hand, if there is a substantial disparity between motion of the even fields and motion of the odd fields, field independent mode is chosen. The selection of the modes is realized by passing the motion vector 306 to the adaptive composer 306.

The subtracter 34 subtracts the motion compensation prediction signal 303, which is read out of the frame memory 33, from the image signal 301 which is read out of the memory 41 to obtain a prediction error signal 304. The prediction error signal 304 is fed to the adaptive composer 39. The adaptive composer 39 controls the blocking of the prediction error signal 304 on the basis of the motion vector 306 in the same manner as described for the second embodiment. The other illustrated components are operated in the same manner as the second embodiment described above.

Although the motion vectors that are independently obtained for the odd and even fields are used for the blocking switching in the second embodiment, in the third embodiment the motion vector obtained between the odd and even fields is used to control the adaptive blocking. In this embodiment, the motion vectors between the odd fields and between the even fields in the first motion detector 43 are compared with each other. Hence, the motion between the two fields is exactly known, and suitable blocking control is performed.

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Fig. 10 shows a fourth embodiment of a motion compensation predicting coding apparatus according to the present invention. In this embodiment, the motion compensation predicting coding apparatus comprises a field composer 31, a motion detector 32, a frame memory 33, a subtracter 34, a coder 35, a decoder 36, an adder 37, a MUX 38, an adaptive composer 39 and an adaptive decomposer 40.

The fourth embodiment operates as follows. In this embodiment, motion compensation is carried out from a frame input signal in which two fields are being composed (i.e., the frame input signal is compared with the frame image data stored in frame memory 33). Specifically, an input image signal 300 that has been obtained by an interlaced scanning is composed into one frame in the field composer 31. The field composing performed by field composer 31 is realized in the manner shown in Figs. 4A - 4C. That is, when the input image signals of the odd and even fields are as shown in Figs. 4A and 4B, respectively, the lines of these two fields are alternately combined to obtain a field composition frame input signal 301 as shown in Fig. 4C. The obtained field composition frame input signal 301 is sent to the motion detector 32 and the subtracter 34.

In the above discussion, the coder is described as performing the coding by DCT, which is kind of orthogonal transformation. It is, however, also possible to perform the coding by utilizing other well-known techniques such as differential pulse code modulation (DPCM) or vector quantization. When vector

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quantization is used, two types of codebooks are used (i.e., one codebook for the field blocking and the other codebook for frame blocking) so that the desired codebook will be selected according to either the field or frame blocking done by the blocking controller to further improve coding efficiency.

In above embodiments, the methods of determining the motion vectors and selecting a motion compensation predicting signal may vary. In particular, the methods may vary as to which frames of pixel data are compared with the current frame of the pixel data. Fig. 11 provides an illustration of one approach to motion compensation prediction. The frames of pixel data are labeled I, II, III and IV and correspond to temporally continuous fields wherein frame IV is the oldest frame. Fig. 11 assumes that frame I and frame IV have already been coded. In accordance with the method illustrated in Fig. 11, the motion detection for frame II is performed by comparing the pixel data in frame II with the pixel data in frame I and comparing the pixel data in frame II with the pixel data in frame IV. These comparisons are indicated in Fig. 11 by arrows 73. The results of the comparison with the lower power for both the even and odd fields is selected. Hence, if the results of the comparison with frame I has lower power than the results of the comparison with frame IV, the results of frame I are selected. Likewise, a similar set of comparisons with frames I and IV are performed with frame III (see arrow 75 in Fig. 11). The lower power results are selected.

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Fig. 12 shows a fifth embodiment of a motion compensation predicting coding apparatus, having a similar construction to the fourth embodiment shown in Fig. 10. This fifth embodiment differs from the fourth embodiment in that it employs an orthogonal transformation coder 44 that is capable of controlling a scanning order of conversion factors rather than employing the coder 35 (Fig. 10) and the adaptive composer 39 of the fourth embodiment. In addition, this fifth embodiment, employs an orthogonal transformation decoder 45 (Fig. 12) that is capable of controlling a scanning order of conversion factors for carrying out an inverse processing of the orthogonal transformation coder 44. This decoder 45 is used in place of the decoder 36 (Fig. 10) and the adaptive decomposer 40 of the fourth embodiment.

The fifth embodiment operates as follows. A motion vector 302 obtained in the motion detector 32 in the same manner as described above. This motion vector 302 is fed to the orthogonal transformation coder 44 and to the orthogonal transformation decoder 45. A prediction error signal 304 is obtained in the subtracter 34 in the same manner as described above. The prediction error signal 304 is also fed to the orthogonal transformation coder 44. The orthogonal transformation coder 44 performs orthogonal transformation coding. The conversion factor is scanned within the block to perform quantization, and the scanning order is controlled by using the motion vector. This processing will now be explained with reference to Figs. 13A to 13C.

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Fig 13A shows a power distribution of coefficients in a coefficient matrix obtained by an orthogonal transformation, such as a DCT. The darkness of the pixel in Fig. 13A indicates the power level of the pixel. A dark pixel indicates a high power level and a light pixel indicates a low power level. For the distribution shown in Fig. 13A, it is apparent that the lower frequency components have much greater power than the higher frequency components. The arrows 205 indicate the normal scanning order of the coefficients.

As shown in Fig. 13B, in coefficients obtained by orthogonal transformation of signals which have many transverse components frequency components in the vertical direction are large. In contrast, in an image having many longitudinal components, the frequency components in the horizontal direction are large as shown in Fig. 13C.

When it is determined by the motion vector that the horizontal components are large, the high frequency components are large, even in the error signal. Hence, as shown in Fig. 13C, the coding is carried out in order by scanning in the horizontal direction (as indicated by the arrows). On the other hand, when it is determined that the vertical components are large, as shown in Fig. 13B, the coding is carried out in order in the vertical direction as indicated by the arrows. Further, when the components are almost equal in both the horizontal and vertical directions, as shown in Fig. 13A, the coding should take place in the diagonal direction indicated by the arrows 205. Depending on the transformation

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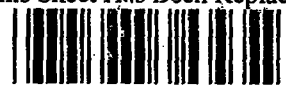
methods, the relationship between the motion and the scanning direction can be opposite. By adjusting the scanning in this fashion, the fifth embodiment encodes the signals more efficiently.

The orthogonal transformation coder 44 outputs coded data to the MUX 38 and the orthogonal transformation decoder 45. In the MUX 38, the coded data are processed in the same manner as described above for previous embodiments. In the orthogonal transformation decoder 45, an orthogonal transformation and decoding of the coded data are carried out to obtain a decoded prediction error signal. The decoding follows the same scanning order that was followed in the coding. The obtained decoded prediction error signal is fed to the adder 37. The other parts are processed in the same manner as described above.

Preferably, this embodiment is practiced in combination with the previously described embodiments. That is, since the distance between the lines is different in the field composed block and the independent (not field composed) block, the power distribution in the vertical direction is different. Hence, the scanning control based on the difference of the power distribution may be performed, and as a result, effective quantization processing may be carried out. In this embodiment, since the motion vector includes the control information, no supplementary information is required.

Fig. 14 shows an embodiment of a receiving side for the above-described embodiments of the motion

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compensation predicting coding apparatus. The receiving side includes a data separator 46 for separating the multiplexed coded data that is output from the transmitter side, an orthogonal transformation decoder 47, a blocking controller 48, a frame memory 49 and an adder 50. The latter four components perform the inverse operation to the corresponding components in the transmitter side which have been described above.

The receiving side shown in Fig. 14 operates as follows. Coded data 401 that has been output from the MUX 38 of the motion compensation predicting coding apparatus are input to the data separator 46. The data separator 46 separates the coded data 401 and outputs first data 407 or factor data that concerns an orthogonal transformation, a motion vector 402, that is sent to the frame memory 49, second data 408 that represents a factor scanning order and third data 409 that exhibits a block structure of a prediction error signal. The decoder 47 receives the first and second data 407 and 408 and carries out an inverse orthogonal transformation for every block unit to decode the prediction error signal. At this time, the decoder 47 determines the scanning order of the transformation factors within the block on the basis of the second data 408. The blocking controller 48 receives the third data 409 from the data separator 46 and a decoded prediction error signal from the decoder 47. The blocking controller 48 determines whether the decoded prediction error signal is a field composed block or a field independent block on the basis of the third data 409.

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The block structure is unified by the blocking controller 48 to output a blocking-controlled prediction error signal 410 to the adder 50. The adder 50 adds a motion compensation prediction signal 411, that has been read out of the frame memory 49 at an address specified by the motion vector 402, to the blocking-controlled prediction error signal 410 and obtains a decoded signal 412. The decoded signal 412 is sent to the frame memory 49 and is stored therein.

In this embodiment, both the second data 408 representing the factor scanning order and the third data 409 representing the block structure of the prediction error signal may be replaced with the motion vector 402.

Although the present invention has been described in its preferred embodiments with reference to the accompanying drawings, it is readily understood that the present invention is not restricted to the preferred embodiments and that various changes and modifications can be made by those skilled in the art without departing from the spirit and scope of the present invention.

We claim:

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CLAIMS

1. A motion compensation predicting coding apparatus for processing input image signals that encode pixel data for pixels of an image, each input image signal encoding pixel data for a particular field in a first block of pixels in the image and coding the input image signals, comprising:

a motion detector for comparing each input image signal with a previously coded frame image signal to detect a motion vector from the compared signals;

producing means for obtaining a motion compensation prediction signal of a signal of a second block in the previously coded frame image signal which is most similar to the first block, on the basis of the motion vector;

a subtracter for obtaining an error signal between the first block and the motion compensation prediction signal; and

a composer for composing the error signal to obtain a frame error signal;

a coder for coding the frame error signal on the basis of correlation of adjacent pixels within the frame error signal to obtain a coded error signal.

2. The apparatus of claim 1, wherein the motion detector compares pixel data in like fields of the first block and the second block to obtain a motion vector for each field, and the producing means obtains the motion prediction signal of each field on the basis of the motion vector corresponding to each field.

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3. The apparatus of claim 2, wherein the producing means obtains the motion compensation prediction signal by reading pixel data out of a memory storing the previously coded frame image signals.

4. The apparatus of claim 3, further comprising:

a decoder for decoding the coded frame error signal output by the coding means to obtain a decoded signal;

a separator for separating the decoded signal into signals for the respective fields; and

an adder for adding the decoded and separated signals to the motion compensation prediction signal to reproduce the input image signal.

5. A motion compensation predicting coding apparatus for processing an input image signal, including blocks of a plurality of pixels, and coding the input image signal in consideration of motion within an image, the input image signal being obtained by an interlaced scanning for every field and being composed of pixel data, comprising:

a motion detector for comparing a first block of the input image signal to be coded with a second block in a previously coded frame image signal to detect a motion vector from the first and second blocks;

producing means for obtaining a motion compensation prediction signal of the second block from the coded frame image signals on the basis of the motion vector;

a subtracter means for obtaining an error signal between the first block and the second block;

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adaptive blocking means for blocking the error signal by either a first method of alternately arranging odd and even field signals every other line or a second method of independently arranging the odd and even field signals for each field; and

a coder for coding the signals of each block of the error signal obtained by the adaptive blocking means on the basis of correlation of adjacent pixels within the block.

6. The apparatus of claim 5, wherein the motion detector compares pixel data in like fields of the first block and the previously coded frame image signal to obtain a motion vector for each field, and the producing means obtains the motion compensation prediction signal of each field on the basis of the motion vector corresponding to each field.

7. The apparatus of claim 6, wherein the producing means obtains the motion compensation prediction signal by reading pixel data out of a memory storing the previously coded frame image signals.

8. The apparatus of claim 7, further comprising:

a decoder means for decoding the coded error signal output by the coding means to obtain a decoded signal;

a separator for separating the decoded signal into signals for the respective fields; and

an adder means for adding the decoded and separated signals and the motion prediction signal to reproduce the input image signal.

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9. The apparatus of claim 8, further comprising a memory for storing at least one field of the input image signal, and

a second motion detector, wherein the second motion detector detects a motion vector between the like fields of the input image signal and an image signal of a preceding input image signal read out of the memory, and the adaptive blocking means changes the selected method according to the motion vector between the like fields.

10. The apparatus of claim 8, further comprising:

a decoder for decoding the coded signal to obtain a decoded signal; and

rearranging means for either rearranging the decoded signal by using the selected one of the first and second methods in the blocking means or a predetermined arrangement without using the first or second methods in the blocking means to obtain a rearranged signal, and

an adder for adding the rearranged signal and the motion compensation prediction signal,

wherein the image signal with respect to the coded block is reproduced according to the rearranged signal and the reproduced image signal is fed to the producing means.

11. A motion compensation predicting coding apparatus for processing input image signals that encode pixel data for pixels of an image, each input image signal encoding pixel data for a particular field in a first block of pixels in the image and coding the input image signal, comprising:

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a composer for composing the input image signals to obtain a frame image signal;

a motion detector for comparing each input image signal with a previously coded frame image signal to detect a motion vector from the similarity of the compared signals;

producing means for obtaining a motion compensation prediction signal of a signal of a second block in the previously coded frame image signal which is most similar to the first block, on the basis of the motion vector;

a subtracter for obtaining an error signal between the first block and the motion compensation prediction signal;

blocking means for blocking the error signal; and

a coder for coding the signals of each block of the error signal on the basis of correlation of adjacent pixels within the block.

12. The apparatus of claim 11, wherein the producing means obtains the motion compensation prediction signal by reading corresponding pixel data out of a memory storing the coded frame image signal.

13. The apparatus of claim 11, wherein the blocking means selects whether to block the error signal in a field composition mode having alternating fields or in a field independent mode having a single field based on the magnitude of the motion vector.

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14. The apparatus of claims 13, further comprising:

a decoder for decoding the coded error signal to obtain a decoded signal; and

re-arranging means for re-arranging the decoded signal; and

an adder for adding the re-arranged signal and the motion compensation prediction signal,

wherein the image signal is decoded and stored in the memory as a coded image signal.

15. A motion compensation predicting coding apparatus for encoding pixel data of an image signal, wherein said image signal includes pixel data organized into an even field and an odd field for a portion of an image, said apparatus comprising:

a) a motion detector for comparing the pixel data in the image signal with pixel data of a previous image signal to generate a motion vector indicative of displacement differences between the image signal and the previous image signal;

b) a subtracter for generating a prediction compensation error signal by subtracting the pixel data in the previous image signal from the pixel data of the image signal;

c) an adaptive blocking mechanism for receiving the prediction compensation error signal and organizing data in the prediction compensation error signal into blocks in one of several fashions as dictated by the motion vector to generate a blocked output; and

d) a coder for receiving and encoding the blocked output from the adaptive blocking mechanism.

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16. A motion compensation predicting coding apparatus for encoding pixel data of a first image signal and a second image signal, wherein the first image signal encodes pixel data in an odd field of a portion of an image and the second image signal encodes pixel data in an even field of the portion of the image, said apparatus comprising:

a) a field composer for composing the pixel data in the first signal for the odd field with the pixel data in the second signal for the even field to produce a composed image signal having pixel data for both fields;

b) a motion detector for comparing the pixel data in previous image signals to generate a motion vector indicative of displacement differences between the pixels of the first and second image signals relative to the previous image signals;

c) a subtracter for generating a prediction error signal by subtracting the pixel data in the previous image signals that are used to generate the motion vector from pixel data in the composed image signal; and

d) a coder for receiving and encoding the prediction error signal from the subtracter.

17. A motion compensation predicting coding apparatus for encoding pixel data of a first image signal and a second image signal, wherein the first image signal encodes pixel data in an odd field of a portion of an image and the second image signal encodes pixel data in an even field of the portion of the image, said apparatus comprising:

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a) a field composer for composing the pixel data in the first signal for the odd field with the pixel data in the second signal for the even field to produce a composed image signal having pixel data for both fields;

b) a motion detector for comparing the pixel data in previous image signals to generate a motion vector indicative of displacement differences between the first and second images relative to the previous image signals;

c) a subtracter for generating a prediction error signal by subtracting the pixel data in the previous image signals that are used to generate the motion vector from pixel data in the composed image signal; and

d) a coder for receiving and encoding the prediction error signal from the subtracter, said coder including

i) a transformation means for performing an orthogonal transformation on the prediction error signal to produce a coefficient matrix; and

ii) a quantizer for quantizing coefficients from the coefficient matrix; and

iii) a scanning controller for controlling what order the coefficients are scanned from the coefficient matrix and passed to the quantizer, based on the motion vector.

18. In a motion compensation predicting coding apparatus, a method of encoding pixel data for a portion of a current image, wherein said pixel data includes data from an even field and data from an odd field, said method comprising the steps of:

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a) receiving pixel data for the current image;

b) detecting motion between the pixel data of the current image and pixel data of a previous image and generating a motion vector indicative of the motion;

c) subtracting the pixel data of the previous image from the pixel data of the current image to generate a prediction error signal;

c) encoding the prediction error signal using a coder.

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