



Image Processing Apparatus

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an image processing method and apparatus, and more particularly to an image processing method and apparatus for quantizing frequency conversion data and coding the quantized conversion data.

Related Background Art

A number of color image compressing techniques have been proposed in the past. As a typical one of color still image coding techniques, there is proposed an adaptive discrete cosine transform coding method (hereinafter referred to as an ADCT method).

Fig. 3 is a conceptual view showing arrangement of an image coding apparatus using the ADCT method. It is assumed that an input image is given by data converted into 8 bits, i.e., 256 gradations, for each color in a not-shown analog-to-digital converter (hereinafter referred to as an A/D converter) and the number of colors is three, i.e., luminance Y , color P_B and color P_R , in this case.

The digital data of the luminance signal Y inputted through an input terminal 101 in Fig. 3 is subjected to two-dimensional discrete cosine transform

1 (hereinafter abbreviated as DCT) in an $N \times N$ DCT
circuit 102 in units of subblocks each comprising N
 $\times N$ pixels. Thereafter, the conversion coefficients
are linearly quantized in a linear quantizer 113 with
5 a quantizing step size being different for each of
the conversion coefficients. The quantizing step
sizes for respective conversion coefficients are given
by values resulted from multiplying 2^S by quantization
matrix elements of $N \times N$ in consideration of the fact
10 that visual sensitivity for quantizing noise is
different for each of the conversion coefficients.
Here, S is 0 or a positive or negative integer and
called a scaling factor. The image quality or the
data to be generated is controlled depending on the
15 value of S .

One example of the quantization matrix
elements is shown in Fig. 5 in the case of 8×8 .
A quantization matrix generation circuit 111 is
controlled by a control circuit 302 and generates a
20 quantization matrix for the luminance signal Y .
A switch 114 is changed over to select the side a for
supplying the quantization matrix for the luminance
signal Y to a multiplier 110. Using the scaling
factor S supplied from a scaling factor generation
25 circuit 301, the multiplier 110 multiplies 2^S by
each quantized element of the quantization matrix.
The multiplied results are supplied to the linear



1 quantizer 103 where the conversion coefficients are
linearly quantized by using the supplied results.

After the quantization, direct current
conversion coefficients (hereinafter referred to as
5 DC components) are supplied to a one-dimensional
predictor 104 to calculate prediction values using
several subblocks adjacent to each other, and
prediction errors are subjected to Huffman coding in
a Huffman encoder 105. More specifically, after
10 dividing quantized outputs of the prediction errors
into groups, the ID numbers of the groups to which
the respective prediction errors belong are first
subjected to Huffman coding, and which values in each
group correspond to the respective prediction errors
15 are then represented by using equi-length codes.

The conversion coefficients other than the
above DC components, i.e., the alternating current
conversion coefficients (hereinafter referred to as
AC components), are supplied to a zigzag scan circuit
20 106 in which the AC components are scanned in a zigzag
manner with two-dimensional frequencies from low-
frequency component to high-frequency component as
shown in Fig. 4, followed by Huffman coding in a
Huffman encoder 107. More specifically, those conversion
25 coefficients for which the quantized outputs are not
0 (hereinafter referred to as significant coefficients)
are divided into groups depending on their values.



1 The ID numbers of the divided groups and the numbers
of those conversion coefficients which are present
between every two significant coefficients and for
which the quantized outputs are 0 (hereinafter
5 referred to as insignificant coefficients) are
subjected in pair to Huffman coding. Subsequently,
which values in each group correspond to the
significant coefficients are represented by using equi-
length codes.

10 Respective code strings of the DC components
and the AC components are multiplexed in a multiplexer
108 and outputted from an output terminal 109.

Next, when the digital data of the chrominance
signals P_B , P_R are inputted through the input terminal
15 101, the control circuit 302 controls the
quantization matrix generation circuit 111 to generate
quantization matrices for the chrominance signals P_B ,
 P_R . The switch 114 is changed over to select the side
b for supplying the quantization matrices for the
20 chrominance signals to the multiplier 110. Subsequently,
the chrominance signals processed in a like manner to
the luminance signal Y as mentioned above for Huffman
coding.

When the compression rate requires to be
25 increased (for a higher degree of compression) from
limitations in a transmission path or other reasons,
control information is entered from an input terminal



1 303 so that the control circuit 302 controls a
scaling factor generation circuit 301 to increase
the scaling factor S . Conversely, in order to obtain
a high-quality image, the scaling factor S is made
5 smaller.

However, because the scaling factor S of the
same value is used when coding the luminance signal
 Y and the chrominance signals P_B , P_R in the above
prior art, there has accompanied a shortcoming that
10 image quality in color areas (particularly in a red
area to which human eyes are more sensitive)
deteriorates to a remarkable extent, when the value
of the scaling factor S is increased to obtain a
high degree of compression.

15

SUMMARY OF THE INVENTION

An object of the present invention is to
solve the problem as set forth above.

Specifically, an object of the present
20 invention is to provide an image processing apparatus
which can realize satisfactory reproducibility of
colors.

To achieve the above object, according to
the present invention, there is disclosed an image
25 processing apparatus comprising generating means
for generating first spatial frequency component
data relating to luminance data and second spatial



1 frequency component data relating to chrominance
data; dividing means for dividing the first and
second spatial frequency component data into a
plurality of blocks, respectively, each of said
5 blocks having a plurality of spatial frequency
component data; first quantizing means for quantizing
the first spatial frequency component data for each
of said blocks; second quantizing means for quantizing
the second spatial frequency component data for each
10 of said blocks; first memory means for storing first
set of quantization parameters for said first
quantizing means; second memory means for storing
second set of quantization parameters for said second
quantizing means; and control means for generating
15 first coefficient for varying the first set of
parameters and second coefficient for varying the
second set of parameters.

Another object of the present invention is to
provide an image encoding method which is suitable
20 for encoding of moving images.

Still another object of the present invention
is to provide a high-speed image encoding method.

Still another object of the present invention
is to provide a highly-efficient image encoding method.

25 Other objects and forms of the present invention
will be apparent from the following description in
conjunction with the drawings and the attached claims.



1 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing a first embodiment of the present invention;

Fig. 2 is a block diagram showing a second
5 embodiment of the present invention;

Fig. 3 is a block diagram showing the prior art;

Fig. 4 is a diagram representing a zigzag scan;

10 Fig. 5 is a diagram showing one example of quantization matrix elements; and

Fig. 6 is a block diagram showing an application example of the present invention.

15 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In the following embodiments of the present invention, a coefficient factor to be multiplied by quantization matrix elements for a chrominance signal is controlled depending on a scaling factor value S_0
20 of a luminance signal Y , thereby reducing an extent of deterioration in image quality even when the scaling factor value is increased for a higher compression rate.

Fig. 1 is a block diagram showing a first
25 embodiment of the present invention. In the drawing, denoted by reference numeral 101 is an input terminal for digital image data, 102 is a DCT circuit per $N \times N$



1 pixels, 103 is a linear quantizer for linearly
quantizing conversion coefficients, 104 is a one-
dimensional predictor for DC components, 105 is a
Huffman encoder, 106 is a zigzag scan circuit for
5 scanning AC components in a zigzag pattern, 107 is
a Huffman encoder, 108 is a multiplexer for multiplexing
codes of the DC and AC components, and 109 is an output
terminal. 110 is a multiplier for multiplying
quantization matrix elements for luminance or
10 chrominance by a scaling factor, 111 is a quantization
matrix generation circuit for generating quantization
matrices for luminance and chrominance, 112 is a control
circuit for controlling the quantization matrix
generation circuit and a scaling factor generation
15 circuit, 113 is a scaling factor generation circuit
for generating scaling factors or coefficients to
be multiplied for a luminance signal Y and chrominance
signals P_B , P_R , 114, 115 are select switches, and 116
is an input terminal through which control information
20 (such as an amount of coded data) is entered to the
control circuit.

Note that components having the same functions
as those in Fig. 3 are denoted by the same reference
numerals. The following description will be made
25 about only different parts between the prior art and
this embodiment.

The scaling factor generation circuit 113 is



1 controlled by the control circuit 112 to generate the
scaling factor value S_0 to be multiplied by the
quantization matrix elements for the luminance signal
Y and, at this time, the switch 115 is changed over
5 to select the contact a. When conversion coefficients
of the chrominance signal P_B are linearly quantized by
the linear quantizer 103 after coding the luminance
signal Y, the scaling factor generation circuit 113
is controlled by the control circuit 112 to generate
10 a scaling factor S_B for P_B , and the switch 115 is
changed over to select the contact b. In this case,
 S_B is generated as a function of S_0 , for example, as
expressed below:

$$S_B = f_B(S_0)$$

15 When conversion coefficients of the chrominance
signal P_R are linearly quantized by the linear
quantizer 103, the scaling factor generation circuit
113 is controlled by the control circuit 112 to
generate a scaling factor S_R for P_R , and the switch
20 115 is changed over to select the contact c. In this
case, S_R is generated as a function of S_0 , for example,
as expressed below:

$$S_R = f_R(S_0)$$

25 Example of function forms of S_B , S_R usable in
this embodiment are enumerated below:



1 i) $S_B = f_B(S_0) = S_0 + XB,$
 $S_R = f_R(S_0) = S_0 - XR$

where XB, XR are positive constants

5 ii) $S_B = f_B(S_0) = \begin{cases} S_0 \times KB_1 & (S_0 \geq 0) \\ S_0 \times KB_2 & (S_0 < 0) \end{cases}$
 $S_R = f_R(S_0) = \begin{cases} S_0 \times KR_1 & (S_0 \geq 0) \\ S_0 \times KR_2 & (S_0 < 0) \end{cases}$

where KB_1, KB_2, KR_1, KR_2 are constants

10 iii) $S_B = f_B(S_0) = S_0 \times K_B(S_0),$
 $S_R = f_R(S_0) = S_0 \times K_R(S_0)$

where $K_B(S_0), K_R(S_0)$ are functions of S_0

iv) $S_B = f_B(S_0) = S_0$
 $S_R = f_R(S_0) = \begin{cases} S_0 & (S_0 < A) \\ C & (S_0 \geq A) \end{cases}$

15 where C, A are constants

Optimum ones of the above functions and constants are selected depending on the compression rate required and the nature of an input image so that deterioration of image quality is minimized.

20 This selection can be achieved by, for example, repeating the coding process several times with different quantization characteristics or performing the coding processes with different quantization characteristics in parallel as explained later.

25 As an alternative method of controlling respective quantization steps for the chrominance signals P_B, P_R , the coefficients to be multiplied by



1 the quantization matrix elements for chrominance
signals may be themselves controlled rather than
generating the scaling factors. In this case, the
scaling factor generation circuit 113 generates
5 coefficients M_B , M_R to be multiplied for the
chrominance signals P_B , P_R in place of the scaling
factors. M_B , M_R are functions of S_0 as expressed
below:

$$M_B = g_B(S_0), M_R = g_R(S_0)$$

10 Example of function forms of M_B , M_R usable in
this case are enumerated below:

$$v) M_B = g_B(S_0) = 2^{S_0} + TB,$$

$$M_R = g_R(S_0) = 2^{S_0} - TR$$

where TB, TR are positive constants

15 vi) $M_B = g_B(S_0) = CB \times 2^{S_0},$

$$M_R = g_R(S_0) = CR \times 2^{S_0}$$

where CB, CR are constants

$$vii) M_B = g_B(S_0) = 2^{S_0} \times C_B(S_0),$$

$$M_R = g_R(S_0) = 2^{S_0} \times C_R(S_0),$$

20 where $C_B(S_0)$, $C_R(S_0)$ are functions of S_0

$$viii) M_B = g_B(S_0) = 2^{S_0}$$

$$M_R = g_R(S_0) = \begin{cases} 2^{S_0} & (S_0 < B) \\ CO & (S_0 \geq B) \end{cases}$$

Optimum ones of the above functions and
25 constants are selected depending on the compression
rate required and the nature of an input image so that
deterioration of image quality is minimized.



1 The compression rate can be changed by entering
control information to the control circuit 112 through
the input terminal 116 and changing the scaling factor
value S_0 . The mode for the method of deciding the
5 quantizing steps for the chrominance signals P_B , P_R
can also be changed by entering mode information to
the control circuit 112 through the input terminal 116.

As mentioned above, since the scaling factor
values of the luminance signal Y and the chrominance
10 signals P_B , P_R are set by controlling the scaling
factor values of the chrominance signals P_B , P_R
depending on the scaling factor value S_0 of the
luminance signal Y (such that in need of increasing
the compression rate, a smaller scaling factor value
15 is set for P_R which has higher visual sensitivity and
a larger scaling factor value is set for P_B), an image
with less deterioration in image quality can be
obtained even when the compression rate is increased.
Further, by controlling the coefficients to be
20 multiplied by the quantization matrix elements for the
chrominance signals using function such as f_B , f_R , g_B ,
 g_R , the coding can be performed more efficiently than
the case of setting those coefficients individually.

Moreover, even with the image data having
25 other input form (such as GBR inputs) than the
foregoing, the similar operating effect can also be
achieved by weighing the coefficients to be multiplied



1 by the quantization matrix elements in a like manner
to the above case in match with the visual sensitivity of
human eyes (e.g., such that in the case of GBR inputs,
weighing is applied to the G input near a luminance
5 signal, the B input and the R input in this order).

(Another Embodiment)

Fig. 2 shows a second embodiment of the
present invention. Components having the same
functions as those in the prior art are denoted by
10 the same reference numerals and will not be described
here. Blocks a, b and c circumscribed by broken lines
all function in a like manner. However, an input to
the block a is only the luminance signal Y, an input
to the block b is only the chrominance signal P_B , and
15 an input to the block c is only the chrominance signal
 P_C . Thus, the luminance signal and the chrominance
signals are separately processed in parallel for
coding. Accordingly, a control circuit 222 supplies
a control signal suitable for parallel processing to
20 a quantization matrix generation circuit 221 so that
the quantization matrices for the luminance signal and
the chrominance signals are generated almost at the
same timing. Likewise, a scaling factor generation
circuit 220 is controlled by the control circuit 222
25 to generate scaling factors S_Y , S_B , S_R for the luminance
signal Y and the chrominance signals P_B , P_R almost at
the same timing. S_Y , S_B , S_R are functions of S_0 as



1 expressed below:

$$S_Y = S_0, S_B = f_B(S_0), S_R = f_R(S_0)$$

Alternatively, the scaling factor generation circuit 220 may generate coefficients to be directly
5 multiplied by the quantization matrix elements for the chrominance signals. In this case, coefficients M_B, M_R used for the chrominance signals M_B, M_R are given by:

$$M_B = g_B(S_0), M_R = g_R(S_0)$$

By so arranging, it is possible to not only
10 obtain an image with less deterioration in image quality even at the increased compression rate, but also adapt to high-speed coding through parallel processing, which permits real-time coding of moving images and the like.

15 As explained above, by setting the scaling factor values or the coefficients themselves to be multiplied by the quantization matrix elements for the luminance signal Y and the chrominance signals P_B, P_R separately, and controlling the scaling factor values
20 or the coefficients themselves to be multiplied by the quantization matrix elements for the chrominance signals P_B, P_R depending on the scaling factor value S_0 of the luminance signal Y, there can be obtained
25 an image with less deterioration in image quality corresponding to the compression rate (namely, an image with less deterioration in quality of color images can be obtained even at the increased compression rate.



1 through such a control, for example, that in need of
increasing the compression rate, a smaller scaling
factor value than that of the luminance signal Y is
set for the chrominance P_R which has higher visual
5 sensitivity and a larger scaling factor value is set
for the chrominance signal P_B). Further, by
controlling the coefficients to be multiplied by the
quantization matrix elements for the chrominance
signals using functions, the coding can be performed
10 more efficiently than the case of setting those
coefficients individually.

Thus, according to the present invention, it is
possible to provide an image encoding apparatus and
method with which a reproduced image of high quality
15 can be obtained.

An example of the present invention applied to
a moving image encoding apparatus will be described
below in detail. Fig. 6 is a block diagram of the
apparatus.

20 In the drawing, denoted by 20 is an input
terminal for an analog TV signal. The TV signal
sensed by using a CCD sensor and inputted through the
terminal 20 is converted by an A/D converter 22 into a
digital signal of 8 bits. The digital signal is
25 divided into blocks each comprising (8×8) pixels by
an (8×8) block formation circuit 26 which operates
in a like manner to the $(N \times N)$ DCT circuit 102 in



1 Fig. 1, the blocks being supplied to a DCT circuit 26
one by one.

Pixel data D_{11} to D_{88} of each block are converted
by the DCT circuit 28 into a data matrix X_{11} to X_{88} for
5 two-dimensional frequency regions as with the case of
Fig. 1, followed by being supplied to quantization
circuits 32a to 32d and a 1F (one-frame) delay circuit
34.

A quantization matrix generation circuit 36
10 generates similar matrices to those generated from the
aforesaid quantization matrix generation circuit 111.

Supplied to multipliers 38a to 38d are initial
coefficients C_1 to C_4 as control coefficients (scaling
factors) C from a coefficient calculator 48. As with
15 the case of Fig. 1, the multipliers 38a to 38d
multiply outputs of the quantization matrix generation
circuit 36 and the control coefficients C_x for
respective components, i.e., $(W_{ij} \times C_x / C_0)$, the
multiplied results being outputted to the quantization
20 circuits 32a to 32d. The quantization circuits 32a to
32d respectively quantize conversion coefficients with
the quantizing steps controlled by the control
coefficients C_1 to C_4 and output the quantized values
to VLCs (Variable Length Coders) 40a to 40d.

25 In this embodiment, the VLCs 40a to 40d do not
output the actual coded data, but output only
information nb1 to nb4 of total bit number for each



1 image as resulted from the similar processing to an ordinary VLC.

Using the information nb1 to nb4 outputted from the VLCs 40a to 40d and the control coefficients
5 C_1 to C_4 , the coefficient calculator 48 calculates a control coefficient C_5 desired for the total bit number and outputs it to a multiplier 38e.

The coefficient calculator 48 also outputs control coefficients C_6 , C_7 as an approximate value of
10 C_5 to multipliers 38f, 38g and, on the other hand, outputs the control coefficients C_5 to C_7 to terminals 44a to 44c, respectively.

It is here assumed that when $C_n \leq C_5 \leq C_{n+1}$ holds for C_5 , C_6 and C_7 meet the relationships $C_n \leq C_6$
15 $< C_5$ and $C_5 < C_7 \leq C_{n+1}$, respectively, and n meets the relationship $1 \leq n \leq 3$.

The multipliers 38e to 38g respectively multiply outputs of the quantization matrix generation circuit 36 and the control coefficients C_5 to C_7 as with
20 the multipliers 38a to 38d, the multiplied results being outputted to quantization circuits 32e to 32g within a vertical blanking period.

Meanwhile, those DCT conversion coefficients resulted from delaying DCT conversion coefficients
25 through one frame by the 1F delay circuit 34 are inputted to the quantization circuits 32e to 32g.

The conversion coefficients are quantized in



1 the quantization circuits 32e to 32g with the
quantizing steps controlled by the control coefficients
C₅ to C₇, and the quantized values are outputted to
VLCs 40e to 40g. In this embodiment, the VLCs 40e to
5 40g output the actual coded data to entry buffers 42a
to 42c and also output the total bit numbers nb5 to nb7
to a judgment circuit 50. The judgment circuit 50
delivers such an output to switches 44 and 46 as to
select the quantization result which is less than the
10 desired total bit number and nearest thereto. The
entry buffers 42a to 42c store the coded data until
the judgment circuit 50 issues the judgment result.
The switch 44 selects one of the control coefficients
in accordance with the judgment result and outputs it
15 to a multiplexer 52. Also, the switch 46 selects one
of the coded data and outputs it to the multiplexer
52. The multiplexer 52 multiplexes the control
coefficient and the coded data, followed by outputting
to an output terminal 54.

20 The scaling factor for quantizing the
chrominance data may be controlled independently
rather than being dependent on the scaling factor for
quantizing the luminance data as stated before. In
other words, the luminance data and the chrominance
25 data may be coded in a completely parallel manner.

The scaling factor may be fixed in one frame of
an image as mentioned before, or may be varied per



1 block of $N \times N$ pixels.

Further, the scaling factor may be controlled depending on the amount of coded data resulted from the coding, or may be controlled depending on whether
5 the original image is a line image including characters and the like or a natural image.

Additionally, while the component Y is extracted as luminance data and the components P_B , P_R are extracted as chrominance data in the above
10 embodiments, those components may be (Y, C_R, C_B) , (L^*, a^*, b^*) , (L^*, u^*, v^*) , (Y, u, v) or the like.

Moreover, the functions of the control circuit 112, the scaling factor generation circuit 113 and the quantization matrix generation circuit 111 can be
15 executed by a CPU and a RAM, a ROM, etc. connected to the CPU.

It should be understood that the present invention is not limited to the embodiments as set forth above and may be variously changed and modified
20 within the scope of the invention defined in the attached claims.

25





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CLAIMS:

1. An image processing apparatus comprising:
generating means for generating first spatial
frequency component data relating to luminance data
5 and second spatial frequency component data relating
to chrominance data;
dividing means for dividing the first and
second spatial frequency component data into a
plurality of blocks, respectively, each of said
10 blocks having a plurality of spatial frequency
component data;
first quantizing means for quantizing the
first spatial frequency component data for each of
said blocks;
15 second quantizing means for quantizing the
second spatial frequency component data for each of
said blocks;
first memory means for storing first set of
quantization parameters for said first quantizing
20 means;
second memory means for storing second set
of quantization parameters for said second quantizing
means; and
control means for generating first coefficient
25 for varying the first set of parameters and second
coefficient for varying the second set of parameters.





1 2. An image processing apparatus according
to claim 1, further comprising input means for inputting
image data relating to the first and second spatial
frequency component data.

5 3. An image processing apparatus according
to claim 2, wherein said input means comprises a CCD
sensor.

10 4. An image processing apparatus according to
claim 1, wherein said dividing means divides the data
into blocks each comprising $N \times N$ pixels.

15 5. An image processing apparatus according to
claim 1, wherein said first set of quantization
parameters is smaller than said second set of quantization
parameters.

20 6. An image processing apparatus according to
claim 1, wherein said second coefficient depends on
said first coefficient.

25 7. An image processing apparatus according to
claim 1, wherein said apparatus is a moving image
coding apparatus.

8. An image processing apparatus according to





1 claim 1, wherein said apparatus performs quantizing in
parallel by using a pair of first and second
coefficients different from each other.

5 9. An image processing apparatus according to
claim 1, further comprising coding means which makes
the data quantized by said first and second quantizing
means subjected to variable length coding.

10 10. An image processing method comprising
steps of:

generating step of generating first spatial
frequency component data relating to luminance data
and second spatial frequency component data relating
15 to chrominance data;

dividing step of dividing the first and
second spatial frequency component data into a
plurality of blocks, respectively, each of said
blocks having a plurality of spatial frequency component
20 data;

first quantizing step of quantizing the first
spatial frequency component data for each of said
blocks; and

second quantizing step of quantizing the
25 second spatial frequency component data for each of
said blocks,

wherein first set of quantization parameters





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is used for said first quantizing step and second set of quantization parameters is used for said second quantizing step and further first coefficient for varying the first set of parameters and second
5 coefficient for varying the second set of parameters are used.

11. Apparatus or a method for compressing video data having a luminance component and a chrominance component,
10 characterised by generating a first coefficient to control the compression of the luminance component and generating a second coefficient to control the compression of the chrominance component.

15
12. Apparatus or a method according to claim 11, wherein said data undergoes spatial compression in response to parameters defining frequency components and the quantization of said frequency components; in
20 which a first set of parameters are controlled by said first coefficient and second set of parameters are controlled by said second coefficient.

This Sheet Has Been Replaced

