(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 248 472 B9**

(12) **CORRECTED EUROPEAN PATENT SPECIFICATION**

(15) Correction information:
Corrected version no 1 (W1 B1)
Corrections, see
Bibliography INID code(s) 54
Claims EN 5

(48) Corrigendum issued on:
08.09.2010 Bulletin 2010/36

(45) Date of publication and mention of the grant of the patent:
14.04.2010 Bulletin 2010/15

(21) Application number: **00976269.1**

(22) Date of filing: **15.11.2000**

(51) Int Cl.:
H04N 11/04 *(2006.01)*

(86) International application number:
PCT/JP2000/008060

(87) International publication number:
WO 2001/039511 (31.05.2001 Gazette 2001/22)

(54) **IMAGE COMPRESSING DEVICE AND IMAGE DECOMPRESSING DEVICE, AND COMPUTER-READABLE RECORDED MEDIUM ON WHICH PROGRAM FOR ALLOWING COMPUTER TO EXECUTE IMAGE COMPRESSING METHOD AND IMAGE DECOMPRESSING METHOD**

BILDKOMPRESSIONSGERÄT UND BILDDEKOMPRESSIONSGERÄT, SOWIE COMPUTERLESBARES AUFZEICHNUNGSMEDIUM MIT PROGRAMM, WELCHES DEM COMPUTER DIE AUSFÜHRUNG EINER BILDKOMPRESSIONSMETHODE UND EINER BILDDEKOMPRESSIONSMETHODE ERMÖGLICHT

DISPOSITIF ET PROCEDE DE COMPRESSION D'IMAGES ET DISPOSITIF DE DECOMPRESSION D'IMAGES, SUPPORT D'ENREGISTREMENT LISIBLE PAR MACHINE AVEC PROGRAMME PERMETTANT A L'ORDINATEUR D'EXECUTER UN PROCEDE DE COMPRESSION D'IMAGES

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **26.11.1999 JP 33623399**

(43) Date of publication of application:
09.10.2002 Bulletin 2002/41

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- **PATENT ABSTRACTS OF JAPAN vol. 013, no. 128 (E-735), 29 March 1989 (1989-03-29) & JP 63 296583 A (FUJITSU LTD), 2 December 1988 (1988-12-02)**
- **TANIMOTO ET AL.: 'TAT(time-axis transform, jikanjiku henkan) houshiki ni yoru kouhini TV no taiiki asshuku' TELEVISION GAKKAISHI vol. 39, no. 10, 01 October 1985, pages 934(84) - 940(90), XP002936590**

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Printed by Jouve, 75001 PARIS (FR)

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- **ARUNN. NETRAVALE: 'Picture coding: A review' PROCEEDING OF THE IEEE vol. 68, no. 3, 1980, USA, pages 366 - 406, XP002936591**
- **P.W.M. TSANG ET AL.: 'Encoding of colour images using adaptive decimation and interpolation' IEE PROCEEDINGS VISION, IMAGE AND SIGNAL PROCESSING vol. 146, no. 1, February 1999, pages 50 - 56, XP002936592**

Description

Technical Field

[0001] The present invention relates to an image compression apparatus, an image expansion apparatus and a computer readable recording medium recording programs for allowing a computer to execute an image compression method and an image expansion method, respectively. The present invention particularly relates to an image compression apparatus and an image expansion apparatus capable of efficiently encoding an image without color deviation to the eye and to a computer readable recording medium recording programs for allowing a computer to execute an image compression method and an image expansion method, respectively.

Background Art

[0002] In respect to image compression, there is disclosed a thinning-out method for thinning out chrominance element data by utilizing the characteristic of human eyes that the human eyes are relatively insensitive to the change of color, by Japanese Patent Laying-Open No. 7-221993(1995). According to this thinning-out method, the rate of change of chrominance elements in a small block is obtained, the chrominance elements are slightly thinned out if the rate of change is high and the chrominance elements are largely thinned out if the rate of change is low, thereby compressing image data.

[0003] Generally, however, if chrominance elements are thinned out, there often occurs a phenomenon referred to as 'color deviation phenomenon' that false colors are generated. Such a color deviation phenomenon is particularly conspicuous on edges of a character.

[0004] Also, according to a conventional thinning-out method, a thinning-out distance is determined based only on the rate of change of chrominance elements. Due to this, a thinning-out processing is conducted at the same thinning-out distance to a small block consisting of a character having a single color as shown in Fig. 20A and a small block consisting of a graphic form having a plurality of colors as shown in Fig. 20B. If many colors are mixed as shown in Fig. 20B, a person cannot grasp the graphic form in the small block as an object such as a character, with the result that even if color deviation somewhat occurs, the person tends not to notice it. Due to this, in such a case, it must be possible to increase the thinning-out distance.

[0005] EP 0 608 618 A2 discloses a method and a system for encoding and/or decoding of the color signal components of a picture signal. The color signals components are provided in a macroblock consisting of a block of luminance signal and two blocks of color difference signals. Before encoding, those macroblocks are reduced in size by means of a format conversion circuit. Reduction only takes place in the color difference signal blocks by down sampling them.

[0006] US-A-4,319,267 describes another example of a picture encoding and/or decoding equipment. According to said document, a color picture is separated into three color component pictures, which are divided respectively by first, second and third block coding means into blocks and encoded. Each block is given a gray level code representing at least one typical gray level component, and at least one other block is given a plurality of gray level codes and a resolution code. When a change in the gray level of each picture element is small, the mean value of the gray level of the picture element is used as the typical gray level and the block is encoded with only one gray level code. When the change in the gray level is large, a mean value of the gray level of picture elements smaller than a mean value of the gray level of all picture elements of the block and a mean value of the gray level of picture elements larger than the mean value are used as typical gray level components, and these two gray level components are each used as the gray level code.

[0007] According to JP 63 296583, there is disclosed a picture encoding system comprising a pattern reproducer generating a reproduced pattern from the output of a quantizer and an edge detector detecting the edge distribution in the preceding pattern of the pattern reproducer. The edge distribution of the pattern reproduced by the pattern reproducer is detected by the edge detector and a subsampler selects, in response to the result of the detection, various subsample systems prepared in advance to apply the most efficient subsample.

Disclosure of the Invention

[0008] The present invention as set out in the appended claims has been made to solve the above-stated problems and it is an object of the present invention to provide an image compression apparatus capable of efficiently encoding an image without color deviation to the eye.

[0009] It is another object of the present invention to provide an image expansion apparatus for expanding an encoded image without color deviation to the eye.

[0010] It is yet another object of the present invention to provide a computer readable recording medium recording a program for allowing a computer to execute an image compression method capable of efficiently encoding an image without color deviation to the eye.

[0011] It is yet another object of the present invention to provide a computer readable recording medium recording a program for allowing a computer to execute an image expansion method expanding an encoded image without color deviation to the eye.

[0012] An image compression apparatus according to one aspect of the present invention is an image compression apparatus for compressing luminance element image data and two types of chrominance element image data each constituted out of a plurality of blocks, which apparatus includes: a resolution determination processing section adaptively setting a resolution of each block during reduction according to a predetermined criterion for each of the luminance element image data and the two types of chrominance element image data, and creating resolution information; a data creation processing section connected to the resolution determination processing section, and creating data having each block reduced based on the resolution information for each of the luminance element image data and the two types of chrominance element image data; and an encoder connected to the resolution determination section and the data creation processing section, and encoding an output of each of the resolution information and the data creation processing section.

[0013] If each block is reduced and then enlarged, the resolution during the reduction is set so as not to cause color deviation to the human eye. Based on the resolution, each block is reduced and encoded for each of the luminance element image data and the two types of chrominance element image data. Due to this, if data is decoded and enlarged and the luminance element image data and the two types of chrominance element image data are obtained, no color deviation occurs to the eye.

[0014] Preferably, the resolution determination processing section includes: an image reduction processing section reducing each of the plurality of blocks to have a predetermined resolution by a method same as a method of the data creation processing section; an image enlargement processing section connected to the image reduction processing section, and enlarging each of the blocks reduced by the image reduction processing section to have a resolution same as a resolution before reduction; region error calculation processing section connected to the image enlargement processing section, and detecting an error between the image data in each block outputted by the image enlargement processing section and the image data in each block reduced by the image reduction processing section; and a region resolution creation processing section connected to the region error calculation processing section, determining whether each block can be reduced based on the predetermined resolution based on an output of the region error calculation processing section, and creating the resolution information.

[0015] If each block is reduced and then enlarged, the resolution during the reduction is obtained so as not to cause an error. Based on the resolution, each block is reduced and encoded for each of the luminance element image data and the two types of chrominance element image data. Due to this, if data is decoded and enlarged and luminance element image data and two types of chrominance element image data are obtained, no color deviation occurs to the human eye.

[0016] Furthermore, it is preferable that the resolution determination processing section includes: a luminance element edge detection processing section detecting edge elements from the luminance element image data; an edge density calculation means, connected to the luminance element edge detection processing section, for calculating a density of the edge elements in each block for each of the plurality of blocks of the luminance element image data; and resolution creation means, connected to the edge density calculation means, for creating the resolution information on the luminance element image data based on the density.

[0017] The resolution during the reduction is obtained based on the density of the edges of the luminance element in each block. Generally, a character part has concentrated edges. Due to this, it is highly likely that a block in which edges are not concentrated does not include a character and the block does not often contain the same quantity of information as that of a character for a person. Accordingly, even if slight color deviation occurs, the color deviation is less noticed to the human eye. Even if such a block is reduced, no color deviation occurs to the human eye.

[0018] It is more preferable that the resolution determination processing section includes: number-of-colors calculation means for obtaining the number of colors included in each block based on the two types of chrominance element image data; and resolution creation means, connected to the number-of-colors calculation means, for creating the resolution information on each of the two types of chrominance element image data based on an output of the number-of-colors calculation means.

[0019] If many colors are mixed in a block, a person cannot recognize a graphic form in the block as an object such as a character. In addition, a character is generally, often expressed with a single color and it is highly likely that the graphic form in the block is not a character. Due to this, even if slight color deviation occurs to a part in which many colors are mixed, the color deviation is less noticed by the human eye. Even if such a block is reduced, no color deviation occurs to the human eye.

[0020] Moreover, it is preferable that the resolution determination processing section includes: chrominance element edge detection means for extracting edge elements for each of the two types of chrominance element image data; edge density calculation means, connected to the chrominance element edge detection means, for calculating a density of the edge elements in each block for each block for each of the two types of chrominance element image data; and

resolution creation means, connected to the edge density calculation means, for creating the resolution information on each of the two types of chrominance element image data based on the density.

[0021] The resolution during the reduction is obtained based on the density of the edges of the chrominance element in each block. If the positions of the edges of the chrominance element are shifted due to the reduction of the block, color deviation may possibly occur. Considering this, it is possible to prevent color deviation by not reducing a block including many edges.

[0022] It is more preferable that the resolution determination processing section sets the resolution of each of the plurality of blocks in accordance with a degree of influence when the luminance element image data and the two types of chrominance element image data are converted into red element image data, green element image data and blue element image data, respectively, for each block, and creates the resolution information.

[0023] During decoding, the luminance element image data and two types of chrominance element image data are sometimes converted into image data of red, blue and green elements. At this moment, the resolution is determined so as to reduce the block of the luminance element data or two types of chrominance element image data which is not important for conversion. By doing so, it is possible to compress image data without causing color deviation to the human eye.

[0024] An image expansion apparatus according to another aspect of the present invention is an image expansion apparatus for decoding the resolution information and the data for encoding encoded by the image compression apparatus stated above, and repeating luminance element image data and two types of chrominance element image data, which apparatus includes: a resolution information data decoder decoding the resolution information encoded; a data decoder decoding the data for encoding encoded; and an image creation processing section connected to the resolution information data decoder and the data decoder, enlarging the data for encoding to have a resolution before reduction based on the resolution information, and creating the luminance element image data and the two types of chrominance element image data.

[0025] It is possible to decode an encoded image without causing color deviation to the eye.

[0026] A computer readable recording medium according to yet another aspect of the present invention records a program for allowing a computer to execute an image compression method for compressing luminance element image data and two types of chrominance element image data each constituted out of a plurality of blocks. The image compression method includes: a step of adaptively setting a resolution of each block during reduction according to a predetermined criterion for each of the luminance element image data and the two types of chrominance element image data, and creating resolution information; a step of reducing each block based on the resolution information for each of the luminance element image data and the two types of chrominance element image data; and a step of encoding the resolution information and data of each reduced block.

[0027] If each block is reduced and then enlarged, the resolution during the reduction is set so as not to cause color deviation to the human eye. Based on the resolution, each block is reduced and encoded for each of the luminance element image data and the two types of chrominance element image data. Due to this, if data is decoded and enlarged and the luminance element image data and the two types of chrominance element image data are obtained, no color deviation occurs to the eye.

[0028] A computer readable recording medium according to yet another aspect of the present invention records a program for allowing a computer to execute an image expansion method for decoding the resolution information and the data for encoding encoded by executing the program recorded on the computer readable recording medium stated above, and repeating luminance element image data and two types of chrominance element image data. The image expansion method includes: a step of decoding the resolution information encoded; a step of decoding the data for encoding encoded; and a step of enlarging the data for encoding to have a resolution before reduction based on the resolution information, and creating the luminance element image data and the two types of chrominance element image data.

[0029] It is possible to decode an encoded image without causing color deviation to the eye.

Brief Description of the Drawings

[0030]

Fig. 1 is a block diagram showing the configuration of a multiple resolution image compression apparatus according to a first embodiment of the present invention;

Fig. 2 is a block diagram showing the configuration of a resolution determination section according to the first embodiment;

Fig. 3 is a flow chart for a multiple resolution image compression processing according to the first embodiment;

Fig. 4 is a flow chart for the multiple resolution image compression processing according to the first embodiment;

Fig. 5 is a flow chart for the multiple resolution image compression processing according to the first embodiment;

Fig. 6 is a view showing that image data is divided into a plurality of blocks;
Fig. 7 is a view for describing the relationship between a block before reduction and a block after reduction and enlargement;
Fig. 8 is a view showing resolution information;
Fig. 9 is a view for describing a function convert 0;
Fig. 10 is a view for describing a method for creating reduced data and non-reduced data;
Fig. 11 is a view for describing connected encoded data;
Fig. 12 is a block diagram showing the configuration of a multiple resolution image expansion apparatus;
Fig. 13 is a flow chart for a multiple resolution image expansion processing;
Fig. 14 is a view for describing a method for creating image data on elements Y, U and V by connecting enlarged data to non-reduced data;
Fig. 15 is a view showing the configuration of a multiple resolution image compression apparatus according to a second embodiment;
Fig. 16 is a view showing the configuration of a resolution determination section according to the second embodiment;
Fig. 17 is a flow chart for a multiple resolution image compression processing according to the second embodiment;
Fig. 18 is an outside view of a computer which realizes the multiple resolution image compression apparatus or the multiple resolution image expansion apparatus;
Fig. 19 is a block diagram showing the internal configuration of the computer; and
Figs. 20A and 20B are views for describing problems with a conventional thinning-out method.

Best Mode for Carrying Out the Invention

[First Embodiment]

[0031] Referring to Fig. 1, a multiple resolution image compression apparatus 20 according to a first embodiment of the present invention includes an input image device 22 inputting a color image, an image compression device 22 connected to input image device 22 and compressing color input image data with different resolutions according to respective blocks, and a output data device 26 connected to image compression device 24 and outputting final encoded data.

[0032] Image compression device 24 is includes an input image buffer 32 connected to input image device 22 and temporarily storing input image data, a color space conversion processing section 34 connected to input image buffer 32 and converting three pieces of input image data of R (Red), G (Green) and B (Blue) into image data on color spaces (YUV spaces) consisting of a luminance signal (Y) and chrominance signals (U, V), a color space converted image buffer 36 connected to color space conversion processing section 34 and temporarily storing three pieces of color space image data, a resolution determination processing section 38 connected to color space converted image buffer 36 and determining the resolution of the color space image data in accordance with a predetermined criterion to be described later for each block of each image data, a resolution information buffer 40 connected to resolution determination processing section 38 and temporarily storing the determined resolution information, and a resolution information encoding section 42 connected to resolution information buffer 40 and encoding the resolution information by certain reversible coding such as reversible encoding JBIG (Joint Bi-level Image coding experts Group) scheme.

[0033] The image compression apparatus 24 also includes a data creation processing section 44 connected to resolution information buffer 40 and color space converted image buffer 36 and creating data having each block reduced by half from each block of the color space image data (which data will be referred to as "reduced data" hereinafter) and data having the same block as each block of the color space image data (which data will be referred to as "non-reduced data" hereinafter), a reduced data buffer 46A connected to data creation processing section 44 and temporarily storing the non-reduced data, an encoder 48A for the reduced data buffer connected to reduced data buffer 46A and encoding the reduced data according to the JPEG (Joint Photographic Experts Group) scheme, an encoder 48B for the non-reduced data buffer connected to non-reduced data buffer 46B and encoding the non-reduced data according to the JPEG scheme, an encoded data connection processing section 50 connected to resolution information encoding processing section 42, reduced data encoder 48A and non-reduced data encoder 48B and connecting the JPEG-encoded resolution information, reduced data and non-reduced data to one another to thereby provide one data, and a connected encoded data buffer 52 connected to encoded data connection processing section 50, temporarily storing the encoded data which are connected (to be referred to as "connected encoded data" hereinafter) and outputting the connected encoded data to output data device 26.

[0034] Referring to Fig. 2, resolution determination processing section 38 includes an image reduction processing section 64 connected to color space converted image buffer 36 and reducing image data by the same method as the reduction method of data creation processing method 44 based on a plurality of preset resolutions, a reduced image buffer 66 connected to image reduction processing section 64 and temporarily storing the reduced image data, an image

enlargement processing section 68 connected to reduced image buffer 66 and enlarging the reduced image data so as to have the same size as that of original image data, an enlarged image data buffer 70 connected to image enlargement processing section 68 and temporarily storing the enlarged image data region error calculation processing section 72 connected to color space converted image buffer 36 and enlarged image data buffer 70 and calculating block by block region error between the image data held by color space converted image buffer 36 and the image data held by enlarged image data buffer 70, and region resolution creation processing section 74 connected to region error calculation processing section 72, calculating best resolution information for each block based on the output of region error calculation processing section 72 and writing the resolution information to resolution information buffer 40.

[0035] Resolution determination processing section 38 further includes a chrominance element quantization processing section 82 connected to color space converted image buffer 36 and quantizing image data on chrominance elements (elements U and V) among the color space image data to 16 gradations, and a resolution information change processing section 84 connected to chrominance element quantization processing section 82 and resolution information buffer 40, calculating for each block the number of colors included in each block in accordance with the output of chrominance element quantization processing section 82 and changing the resolution information stored in resolution information buffer 40 in accordance with the number of colors.

[0036] Further, resolution determination processing section 38 includes a luminance element edge detection processing section 78 connected to color space converted image buffer 36 and detecting edge elements from image data on the luminance element (element Y) among the image data on color spaces, and a resolution information change processing section 80 connected to luminance element edge detection processing section 78 and changing the resolution information stored in resolution information buffer 40 based on the output of luminance element edge detection processing section 78.

[0037] Referring to Figs. 3 to 5, the respective sections of multiple resolution image compression apparatus 20 operate as follows. Input image device 22 inputs three pieces of input image data of R, G and B and stores the input image data in input image buffer 32 (S2). Color space conversion processing section 34 reads the three pieces of input image data stored in input image buffer 32 and converts the three pieces of input image data thus read into three pieces of image data on color spaces (YUV spaces) (S4). Color space conversion processing section 34 stores the converted three pieces of image data in color space converted image buffer 36 (S6).

[0038] Image reduction processing section 64 reads the three pieces of image data stored in color space converted image buffer 36 and reduces each image data so as to have a preset resolution (S8). It is assumed herein that a resolution is set so that image data after reduction is half as large as image data before reduction. Image reduction processing section 64 stores the reduced image data in reduced image data buffer 66 (S10). Image enlargement processing section 68 reads the reduced image data from reduced image data buffer 66 and enlarges the reduced image data so as to have the same size as that of the image data before reduction (S12). Image enlargement processing section 68 stores the enlarged image data in enlarged image data buffer 70 (S14).

[0039] Referring to Fig. 6, it is assumed that the three pieces of image data stored in color space converted image buffer 36 and the three pieces of enlarged image data stored in enlarged image data buffer 70 are divided into n1×m1 blocks, respectively. Region resolution creation processing section 74 extracts one block out of the n1×m1 blocks (S16). It is assumed that the position of the extracted block is (n, m). The extract order starts at (n, m) = (0, 0) and the extracting continues until (n, m) = (n1-1, m1-1) in accordance with a raster scan order.

[0040] Region error calculation processing section 72 obtains difference-square-sum SN_Y of a pixel value to be described later between the image data before reduction and the image data after reduction and enlargement for each (n, m) block of the element Y image, and region resolution creation processing section 74 determines whether or not difference-square-sum SN_Y is greater than a predetermined threshold value SNth_Y (S18).

[0041] Referring to Fig. 7, it is assumed that each block has a size of 16x 16, the pixel value of the element Y image data before reduction is expressed as f_Y(x, y) (x = 0 to 15, y = 0 to 15) and that the pixel value of the element Y image data after reduction and enlargement is expressed as g_Y(x, y) (x = 0 to 15, y = 0 to 15) for each block. Difference-square-sum SN_Y is calculated according to an equation (1). Likewise, it is assumed that the pixel values of the element U image data and the element V image data before reduction are expressed as f_U(x, y) and f_V(x, y), respectively and that the pixel values of the element U image data and the element V image data after reduction and enlargement are expressed as g_U(x, y) and g_V(x, y), respectively. Difference-square-sums SN_U and SN_V for the elements U and V are calculated according to equations (2) and (3), respectively.

$$SN_U = \left[\sum_{x=0}^{15} \sum_{y=0}^{15} \{ f_U(x,y) - g_U(x,y) \}^2 \right] / 16^2 \qquad \ldots(2)$$

$$SN_V = \left[\sum_{x=0}^{15} \sum_{y=0}^{15} \{ f_V(x,y) - g_V(x,y) \}^2 \right] / 16^2 \quad \ldots(3).$$

$$SN_V = \left[\sum_{x=0}^{15} \sum_{y=0}^{15} \{ f_V(x,y) - g_V(x,y) \}^2 \right] / 16^2 \quad \ldots(3).$$

[0042] In parallel to the processing in S18, region resolution creation processing section 74 determines whether or not difference-square-sums SN_U and SN_V for the elements U and V are greater than predetermined threshold values SNth_U and SNth_V, respectively (S24 and S30).

[0043] If the difference-square-sum SN_Y of the element Y is greater than the threshold value SNth_Y ('YES' in S18), 1 is assigned to resolution information F_Y(n, m) on the element Y blocks (n, m) (S22). If difference-square-sum SN_Y is not greater than threshold value SNth_Y ('NO' in S18), 0 is assigned to resolution information F_Y(n, m) (S20). The resolution information of 0 represents that even if the reduced image is enlarged back to the original image, there is a small error between the reduced image and the original image. This, therefore, indicates that the image data can be reduced. Also, the resolution information of 1 represents that the image data cannot be reduced.

[0044] Likewise, if difference-square-sum SN_U for the element U is greater than threshold value SNth_U ('YES' in S24), 1 is assigned to resolution information F_U(n, m) on the element U blocks (n, m) (S28). If difference-square-sum SN_U is not greater than threshold value SNth_U ('NO' in S24), 0 is assigned to resolution information F_U(n, m) (S26).

[0045] If difference-square-sum SN_V for the element V is greater than threshold value SNth_V ('YES' in S30), 1 is assigned to resolution information F_V(n, m) on the element V blocks (n, m) (S34). If difference-square-sum SN_V is not greater than threshold value SNth_V ('NO' in S30), 0 is assigned to resolution information F_V(n, m) (S32).

[0046] Region resolution creation processing section 74 determines whether or not the presently processed block is the last block (n1-1, m1-1) (S36). If the presently processed block is not the last block (n1-1, m1-1) ('NO' in S36), the processings after S16 are repeated.

[0047] If the presently processed block is the last block (n1-1, m1-1) ('YES' in S36), region resolution creation processing section 74 writes resolution information F_Y(n, m), F_U(n, m) and F_V(n, m) obtained by the processings in S18 to S34 to resolution information buffer 40 (S38).

[0048] Luminance element edge detection processing section 78 detects edge elements (S40) by applying Sobel filter to the element Y image data stored in color space converted image buffer and extracts. Resolution information change processing section 80 extracts one block out of the n1×m1 blocks as in the case of the processing in S 16 (S42).

[0049] Resolution information change processing section 80 determines whether or not an edge density ED_Y of the edges included in each element Y block (n, m) is greater than a predetermined threshold value EDth_Y (S44). Edge density ED_Y means the number of edge elements having values exceeding a predetermined threshold value among edge elements included in a certain block. If edge density ED_Y of element Y is greater than threshold value EDth_Y ('YES' in S44), 0 is assigned to resolution information F_Y(n, m) (S46). Namely, this indicates that the image data can be reduced.

[0050] In parallel to the processing in S44 to S46, chrominance element quantization processing section 82 obtains the number of colors CN included in each block (n, m) by a method to be described later and determines whether or not the obtained number of colors CN is greater than a predetermined threshold value CNth (S48). If the obtained number of colors is greater than the predetermined threshold value, 0 is assigned to resolution information F_U(n, m) and F_V (n, m), respectively (S50 and S52). Namely, this represents that the image data can be reduced.

[0051] Here, a method for calculating the number of colors included in one block will be described. It is assumed that pixel values f_U(x, y) and f_V(x, y) for the elements U and V can take values in a range of 0 to 255, respectively. At this moment, function convert 0 is defined as shown in Fig. 9. Namely, function convert 0 is a function for quantizing values of 256 levels to values of 16 levels. A color number 'color (x, y)' of each pixel (x, y) in each block (n, m) is defined as shown in the following equation (4):

$$color(x,y) = convert(f_U(x,y)) + [convert(f_V(x,y)) + 1] \times 6 \quad \ldots(4).$$

[0052] The number of colors CN included in each block (n, m) is defined as the number of types of color(x, y) included in each block (n, m) and the number of colors CN is obtained.

[0053] Resolution information change processing section 84 determines whether or not the presently processed block is the last block (n1-1, m1-1) (S53). If the presently processed block is not the last block (n1-1, m1-1) ('NO' in S53), the processings after S42 are repeated.

[0054] If the presently processed block is the last block (n1-1, m1-1) ('YES' in S53), data creation processing section 44 creates reduced data and enlarged data for each element based on resolution information F_Y, F_U and F_V and the image data on elements Y, U and V held by color space converted image buffer 36 (S54).

[0055] Referring to Fig. 10, a method for creating reduced data and non-reduced data will be described. Blocks each having resolution information of 0 are extracted from resolution information F_Y on the element Y, and corresponding blocks from the element Y image data are reduced by half and arranged to thereby create reduced data. Also, blocks each having resolution information of 1 are extracted from resolution information F_Y, and corresponding blocks are selected from the element Y image data and arranged to thereby create non-reduced data. Likewise, non-reduced data and reduced data are created for each of the elements U and V.

[0056] Data creation processing section 44 stores the reduced data in reduced data buffer 46A and the non-reduced data in non-reduced data buffer 46B (S56).

[0057] Encoder 48A for reduced data buffer and encoder 48B for non-reduced data buffer read the reduced data and non-reduced data from reduced data buffer 46A and non-reduced data buffer 46B, respectively and encode the read data according to the JPEG scheme. Also, resolution information encoding processing section 42 reads resolution information from resolution information buffer 40 and encodes the read data according to the JBIG scheme in a reversible format (S58). Encoded data connection processing section 50 connects the JBIG-encoded resolution information obtained from resolution information encoding processing section 42, encoder 48A for reduced data buffer and encoder 48B for non-reduced data buffer and the JPEG-encoded reduced data and non-reduced data to one another to thereby obtain connected encoded data as shown in Fig. 11 and writes the obtained data to connected data buffer 52. Thereafter, output data device 26 reads the connected encoded data from connected data buffer 52 and outputs the read data (S60).

[0058] Referring to Fig. 12, a multiple resolution image expansion apparatus according to this embodiment includes a data input device 102 inputting the connected encoded data created by multiple resolution image compression apparatus 20, an input data buffer 104 connected to data input device 102 and temporarily storing the connected encoded data thus inputted, and an encoded data division processing section 106 connected to input data buffer 104, reading the connected encoded data stored in input data buffer 104 and dividing the connected encoded data into the encoded resolution information, the encoded reduced data and the encoded non-reduced data.

[0059] Also, multiple resolution image expansion device 100 includes a buffer 108 for encoded resolution information connected to encoded data division processing section 106 and temporarily storing the encoded resolution information, a decoder 110 for resolution information connected to buffer 108 for encoded resolution information and decoding the encoded resolution information, a buffer 112 for decoded resolution information connected to decoder 110 for resolution information and temporarily storing the decoded resolution information, a buffer 114A for encoded reduced image data connected to encoded data division processing section 106 and temporarily storing the encoded reduced data, a decoder 116A for reduced image data information connected to buffer 114A for encoded reduced image data and decoding the encoded reduced data, a buffer 118A for decoded reduced image data connected to decoder 116A for reduced image data information and temporarily storing the decoded reduced data, a data enlargement section 119 connected to buffer 118A for decoded reduced image data and enlarging the reduced data so as to have the same size as that of original data, an enlarged data buffer 121 connected to data enlargement section 119 and temporarily storing the enlarged data, a buffer 114B for encoded non-reduced image data connected to encoded data division processing section 106 and temporarily storing the encoded non-reduced data, a decoder 116B for non-reduced image data information connected to buffer 114B for encoded non-reduced image data and decoding the encoded non-reduced data, and a buffer 118B for decoded non-reduced image data connected to decoder 116B for non-reduced image data information and temporarily storing the decoded non-reduced data.

[0060] Multiple resolution image expansion apparatus 100 further includes a resolution data connection processing section 120 connected to buffer 112 for decoded resolution information, enlarged image data buffer 121 and buffer 118B for decoded non-reduced image data, connecting the enlarged data to the non-reduced data based on the resolution information and thereby creating image data on the elements Y, U and V, a buffer 122for YUV image data connected to resolution data connection processing section 120 and temporarily storing the image data on the elements Y, U and V, an image conversion processing section 124 connected to buffer 122 for YUV image data and converting image data on the elements Y, U and V into image data on elements R, G and B, a buffer 126 for output image data connected to image conversion processing section 124 and temporarily storing the image data on the elements R, G and B , and an output image device 128 connected to buffer 126 for output image data and outputting the image data stored in buffer 126 for output image data.

[0061] Referring to Fig. 13, the respective sections of multiple resolution image expansion apparatus 100 operate as

follows. Data input device 102 inputs the connected encoded data created by multiple resolution image compression apparatus 20 and stores the connected encoded data thus inputted in input data buffer 104 (S72). Encoded data division processing section 106 divides the connected encoded data stored in input data buffer 104 into resolution information, reduced data and non-reduced data (S74). Encoded data division processing section 106 stores the resolution information, the reduced data and the non-reduced data in buffer 108 for encoded resolution information, buffer 114A for encoded reduced image data and buffer 114B for encoded non-reduced image data, respectively (S76).

[0062] Decoder 110 for resolution information decodes the resolution information stored in buffer 108 for encoded resolution information (S78). Decoder 110 for resolution information stores the decoded resolution information in buffer 112 for decoded resolution information (S80). Decoder 116A for reduced image data information decodes the reduced data stored in buffer 114A for encoded reduced image data (S82). Decoder 116A for reduced image data information stores the decoded reduced data in buffer 118A for decoded reduced image data (S84). Data enlargement section 119 enlarges the reduced data stored in buffer 118A for decoded reduced image data by two times and creates data of original size (S86). Data enlargement section 119 stores the data of original size in enlarged image data buffer 121 (S88).

[0063] Decoder 116B for non-reduced image data information decodes the non-reduced data stored in buffer 114B for encoded non-reduced image data (S90). Decoder 116B for non-reduced image data information stores the decoded non-reduced data in buffer 118B for decoded non-reduced image data (S92). Referring to Fig. 14, resolution data connection processing section 120 connects the enlarged data to the non-reduced data based on the resolution information stored in buffer 112 for decoded resolution information to thereby create image data on elements Y, U and V, and stores the image data thus created in buffer 122 for YUV image data (S94). Image conversion processing section 124 converts the image data on the elements Y, U and V stored in buffer 122 for YUV image data into image data on elements R, G and B, creates output image data and then stores the output image data in buffer 126 for output image data. Thereafter, output image device 128 outputs the output images stored in buffer 126 for output image data (S96).

[0064] As stated so far, multiple resolution image compression apparatus 200 according to this embodiment reduces image data for each block and, if the error between enlarged image data and original image data is small, reduces image data in the block. Also, if many colors are mixed in a block, a person cannot grasp a graphic form in the block as an object such as a character. In addition, a character is often expressed with a single color and if many colors are mixed, a graphic form in a block is not, highly likely, a character. Due to this, even if slight color deviation occurs in a portion in which many colors exist, a person tends not to notice it. In case of such a block, therefore, image data is reduced. Further, a character includes many edges. Due to this, it is highly likely that a block in which the edges of chrominance elements are not concentrated does not include a character and image data in the block is, therefore, reduced. As a result, it is possible to compress an image without causing color deviation to the eye. The image compression method according to this embodiment is particularly effective for image data including a character.

[0065] It is noted that the edges of chrominance elements (elements U and V) may be detected for each block, the density of edges (sum of the absolute values of the intensities of edge elements) in blocks may be calculated and image data may be reduced in such a block as to have an edge density not greater than a threshold value. If the position of a chrominance edge is deviated due to the reduction of a block, color deviation may possibly occur. Considering this, in a block including many edges, image data is not reduced to thereby prevent color deviation. A determination as to whether or not image data is reduced based on the density of the edges of chrominance elements may be used simultaneously and in combination with the above-stated three methods or may be used independently thereof.

[0066] While description has been given to the same resolution as that of an original image and the resolution of an image reduced by half from the original image as resolutions in the embodiment stated above, it goes without saying that the other resolutions are applicable. Further, more resolutions may be preset and it may be determined whether or not image data can be reduced using the above-stated determination methods based on each resolution. If it is determined that image data can be reduced based on a plurality of resolutions, each block of the image data may be reduced based on a resolution with which the size of the image data becomes the smallest.

[0067] Furthermore, while resolution information is encoded according to the JBIG scheme, any encoding method may be used as long as the method is based on a reversible compression scheme such as Huffman method. In addition, reduced data and non-reduced data may be compressed by any compression scheme.

[0068] Needless to say, not only the edge detection method using a Sobel filter but also the other edge detection methods using the other filters such as Canny filter.

[Second Embodiment]

[0069] Referring to Fig. 15, a multiple resolution image compression apparatus 140 according to this embodiment is almost the same in hardware configuration as multiple resolution image compression apparatus 20 described with reference to Fig. 1. Multiple resolution image compression apparatus 140 differs from multiple resolution image compression apparatus 20 in that a resolution determination processing section 142 determining a resolution so as not to cause color deviation when image data is converted into image data of RGB spaces is employed instead of resolution

determination processing section 38. Since the other constituent elements are the same as those of multiple resolution image compression apparatus 20, no detail description thereto will be repeated herein.

[0070] Referring to Fig. 16, resolution determination processing section 142 includes a element U weight section 144 connected to a color space converted image buffer 36, multiplying the pixel value of each pixel of element U image data by a preset coefficient and weighing the element U, an element V weight section 146 connected to color space converted image buffer 36, multiplying the pixel value of each pixel of element V image data by a preset coefficient and weighing the element V, and a size comparison section 148 connected to color space converted image buffer 36, element U weight section 144 and element V weight section 146, comparing the weight-added elements U and V with the element Y according to a method to be described later, calculating the best resolution for each block and writing the calculated resolutions to resolution information buffer 40.

[0071] Resolution determination processing section 142 according to this embodiment determines that a block in image data on an unimportant element can be reduced and a block in image data on an important element cannot be reduced when each block in image data on YUV spaces is returned to image data on RGB spaces. If the pixel values of the coordinates (x, y) of image data on RGB spaces are set at f_R(x, y), f_G(x, y) and f_B(x, y), respectively, and the pixel values of the coordinates (x, y) of image data on YUV spaces are set at f_Y(x, y), f_U(x, y) and f_V(x, y), respectively, then relationships expressed by equations (5) to (7) are established.

[0072] From equations (5) to (7), the maximum of the absolute value of the coefficient of pixel value f_Y(x, y) is 1. Also, the maximum of the absolute value of the coefficient of pixel value f_U(x, y) is 1.772. Further, the maximum of the absolute value of the coefficient of pixel value f_V(x, y) is 1.402. Accordingly, if equation (8) is established, it is determined that pixel value f_V(x, y) is not important and that a block for element V can be reduced. Also, if equation (9) is established, it is determined that pixel value f_U(x, y) is not important and that a block for element U can be reduced. Further, if equation (10) is established, it is determined that pixel value f_Y(x, y) is not important and that a block for element Y can be reduced.

[0073] Actually, whether or not equations (8) to (10) are established is determined depending on whether or not equations (11) to (13) are established, respectively. TH11, TH12 and TH13 represents experimentally obtained threshold values.

$$f_R(x,y) = f_Y(x,y) - 7.1525\times10^{-6}\times f_U(x,y) + 1.402\times f_V(x,y) \quad \ldots(5)$$

$$f_G(x,y) = f_Y(x,y) - 0.34413\times f_U(x,y) - 0.71414\times f_V(x,y) \quad \ldots(6)$$

$$f_B(x,y) = f_Y(x,y) - 1.772\times f_U(x,y) + 1.5405\times10^{-5}\times f_V(x,y) \quad \ldots(7)$$

$$f_Y(x,y) + 1.772\times|f_U(x,y)| >> 1.402\times|f_V(x,y)| \quad \ldots(8)$$

$$f_Y(x,y) + 1.402\times|f_V(x,y)| >> 1.772\times|f_U(x,y)| \quad \ldots(9)$$

$$1.772\times|f_U(x,y)| + 1.402\times|f_V(x,y)| >> f_Y(x,y) \quad \ldots(10)$$

$$\frac{f_Y(x,y) + 1.772\times|f_U(x,y)|}{1.402\times|f_V(x,y)|} > TH11 \quad \ldots(11)$$

$$\frac{f_Y(x,y) + 1.402\times|f_V(x,y)|}{1.772\times|f_U(x,y)|} > TH12 \quad \ldots(12)$$

$$\frac{1.772\times|f_U(x,y)|+1.402\times|f_V(x,y)|}{f_Y(x,y)} > TH13 \qquad \ldots(13)$$

[0074] Referring to Fig. 17, the respective sections of multiple resolution image compression apparatus 140 operate as follows. Processings in S102 to S106 are the same as those in S2 to S6 shown in Fig. 3. No detailed description will be, therefore, repeated herein. It is assumed that three pieces of image data stored in color space converted image buffer 36 are divided into n1×m1 blocks, respectively. Element U weight section 144, element V weight section 146 and size comparison section 148 extract one block from the n1×m1 blocks, respectively (S108). The blocks respectively selected by element U weight section 144, element V weight section 146 and size comparison section 148 are the same.

[0075] Size comparison section 148 calculates the number of pixels satisfying equation (8) in a block using the pixel values of the weight-added element U image data, those of the weight-added element V image data and those of element Y image data stored in color space converted image buffer 36. It is determined whether or not the number of pixels satisfying equation (8) is greater than predetermined threshold value TH8 (S110). If the number of pixels satisfying equation (8) is greater than threshold value TH8 ('YES' in S110), it is possible to reduce a noted block in the element Y image data and 0 is, therefore, assigned to resolution information F_V(n, m) (S112). If the number of pixels satisfying equation (8) is not greater than threshold value TH8 ('NO' in S110), it is not possible to reduce a noted block in the element Y image data and 1 is, therefore, assigned to resolution information F_V(n, m) (S114).

[0076] In parallel to the processings in S110 to S114, size comparison section 148 calculates the number of pixels satisfying equation (9) in a block and determines whether or not the number of pixels satisfying equation (9) is greater than predetermined threshold value TH9 (S116). If the number of pixels satisfying equation (9) is greater than threshold value TH9 ('YES' in S116), it is possible to reduce a noted block in the element U image data and 0 is, therefore, assigned to resolution information F_U(n, m) (S118). If the number of pixels satisfying equation (9) is not greater than threshold value TH9 ('NO' in S116), it is not possible to reduce a noted block in the element U image data and 1 is, therefore, assigned to resolution information F_U(n, m) (S120).

[0077] Further, in parallel to the processings in S110 to S114 and the processings in S116 to S120, size comparison section 148 calculates the number of pixels satisfying equation (10) in a block and determines whether or not the number of pixels satisfying equation (10) is greater than predetermined threshold value TH10 (S122). If the number of pixels satisfying equation (10) is greater than threshold value TH10 ('YES' in S 122), it is possible to reduce a noted block in the element Y image data and 0 is, therefore, assigned to resolution information F_Y(n, m) (S124). If the number of pixels satisfying equation (10) is not greater than threshold value TH10 ('NO' in S122), it is not possible to reduce a noted block in the element Y image data and 1 is, therefore, assigned to resolution information F_Y(n, m) (S126).

[0078] After the processings in S110 to S126, size comparison section 148 determines whether or not the presently processed block is the last block (n1-1, m1-1) (S128). If the presently processed block is not the last block (n1-1, m1-1) ('NO' in S128), the processings after S108 are repeated.

[0079] If the presently processed block is the last block (n1-1, m1-1) ('YES' in S128), size comparison section 148 writes resolution information F_Y(n, m), F_U(n, m) and F_V(n, m) on each block (n, m) (n = 0 to n1-1, m = 0 to m1-1) obtained by the processings in S110 to S126 to resolution information buffer 40 (S130)

[0080] Thereafter, processings in S132 to S138 are carried out to thereby output connected encoded data. The processings in S132 to S138 are the same as those in S54 to S60 shown in Fig. 5. No detailed description thereto will be, therefore, given herein.

[0081] By expanding the connected encoded data obtained as stated above by multiple resolution image expansion apparatus 100 similar to that in the first embodiment, it is possible to reconstitute three pieces of input images of R, G and B.

[0082] Multiple resolution image compression apparatus 140 according to this embodiment reduces image data for element Y, U or V determined not to be important for the reconstitution of image data on RGB spaces during expansion for each block. Due to this, multiple resolution image compression apparatus 140 can compress an image without causing color deviation to the eye.

[0083] In this embodiment as in the case of the first embodiment, a plurality of reduction ratios may be predetermined and whether or not image data can be reduced for each reduction ratio may be determined.

[0084] Multiple resolution image compression apparatuses 20 and 140 and multiple resolution image expansion apparatus 100 described so far can be realized by a computer. Referring to Fig. 18, each of multiple resolution image compression apparatus 20 or 140 and multiple resolution image expansion apparatus 100 includes a computer 151, a keyboard 155 and a mouse 156 for issuing an indication to computer 151, a display 152 for displaying operation results or the like of computer 151 as well as a magnetic tape device 153, a CD-ROM (Compact Disc-Read Only Memory) drive 157 and a communication modem 159 for reading programs executed by computer 151, respectively.

[0085] A program for the image compression method described with reference to Figs. 3 to 5 and Fig. 17 and that for the image expansion method described with reference to Fig. 13 are recorded on a magnetic tape 154 or a CD-ROM

158 which is a recording medium readable by computer 151, and are read by magnetic tape device 153 or CD-ROM drive 157. Alternatively, the programs are read by communication modem 159 through a communication line.

[0086] Referring to Fig. 19, computer 151 includes a CPU (Central Processing Unit) 160 for executing the programs read through magnetic tape device 153, CD-ROM drive 157 or communication modem 159, a ROM (Read Only Memory) 161 for storing other programs and data necessary for the operation of computer 151, a RAM (Random Access Memory) 162 for storing the programs as well as parameters, operation results and the like during the execution of the programs, and a magnetic disc 163 for storing the programs and data.

[0087] The programs read by magnetic tape device 153, CD-ROM drive 157 or communication modem 159 are executed by CPU 160.

Industrial Applicability

[0088] As stated so far, the image compression apparatus according to the present invention can efficiently encode an image without causing color deviation to the eye. The image compression apparatus is, therefore, suited for encoding an image, to which color deviation tends to occur, such as a character.

Claims

1. An image compression apparatus for compressing luminance element image data and two types of chrominance element image data each constituted out of a plurality of blocks, comprising:

a resolution determination processing section (38, 142) adaptively setting a resolution of each block during encoding according to a predetermined criterion for each of said luminance element image data and said two types of chrominance element image data, and creating resolution information;
a data creation processing section (44) connected to said resolution determination processing section (38, 142), and creating data having each block reduced based on said resolution information for each of said luminance element image data and said two types of chrominance element image data; and data having each block unreduced ; and
an encoder (42, 48A, 48B) connected to said resolution determination processing section (38, 142) and said data creation processing section (44), and encoding said resolution information and an output of said data creation processing section (44),

wherein
said resolution determination processing section (38, 142) comprises:

a luminance element edge detection processing section (78) detecting edge elements from said luminance element image data;
an edge density calculation means (80), connected to said luminance element edge detection processing section (78), for calculating a density of the edge elements in each block for each of said plurality of blocks of said luminance element image data; and
resolution creation means (80), connected to said edge density calculation means (80), for creating said resolution information on said luminance element image data based on said density.

2. An image compression apparatus for compressing luminance element image data and two types of chrominance element image data each constituted out of a plurality of blocks, comprising:

a resolution determination processing section (38, 142) adaptively seting a resolution of each block during encoding according to a predetermined criterion for each of said luminance element image data and said two types of chrominance element image data, and creating resolution information;
a data creation processing section (44) connected to said resolution determination processing section (38, 142), and creating data having each block reduced based on said resolution information for each of said luminance element image data and said two types of chrominance element image data; and data having each block unreduced; and
an encoder (42, 48A, 48B) connected to said resolution determination processing section (38, 142) and said data creation processing section (44), and encoding said resolution information and an output of said data creation processing section (44);
wherein

said resolution determination processing section (38, 142) comprises:
number-of-colors calculation means (82, 84) for obtaining the number of colors included in each block based on said two types of chrominance element image data; and
resolution creation means (84), connected to said number-of-colors calculation means (82, 84), for creating said resolution information on each of said two types of chrominance element image data based on an output of said number-of-colors calculation means (82, 84).

3. The image compression apparatus according to claim 1, wherein
said resolution determination processing section (38, 142) sets said resolution of each of the plurality of blocks in accordance with a degree of influence when said luminance element image data and said two types of chrominance element image data are converted into red element image data, green element image data and blue element image data, respectively, for each block, and creates said resolution information (144 to 148).

4. An image expansion apparatus for decoding the resolution information and the encoded data encoded by the image compression apparatus according to claim 1, and restoring luminance element image data and two types of chrominance element image data, comprising:

a resolution information data decoder (110) decoding said resolution information encoded;
a data decoder decoding said encoded data encoded; and
an image creation processing section (116A, 116B, 118A, 118B, 119, 121, 120) connected to said resolution information data decoder and said data decoder, enlarging said encoded data to have a resolution before reduction based on said resolution information, and creating the luminance element image data and the two types of chrominance element image data.

5. A computer readable recording medium having stored thereon a program for allowing a computer to execute an image compression method for compressing luminance element image data and two types of chrominance element image data each constituted out of a plurality of blocks, wherein
said image compression method comprises:

a step (S8 to S53, S108 to S130) of adaptively setting a resolution of each block during encoding according to a predetermined criterion for each of said luminance element image data and said two types of chrominance element image data, and creating resolution information;
a step (S54 to S56) of creating data having each block reduced and creating data having each block unreduced based on said resolution information for each of said luminance element image data and said two types of chrominance element image data; and
a step (S58) of encoding said resolution information and said created data, wherein said step (S8 to S53, S108 to S130) of creating the resolution information comprises
a step (S40) of detecting edge elements from said luminance element image data;
a step (S42, S44, S53) of calculating a density of the edge elements in each block for each of said plurality of blocks of said luminance element image data; and
a step (S42, S44, S46, S53) of creating said resolution information on said luminance element image data based on said density.

6. A computer readable recording medium having stored thereon a program for allowing a computer to execute an image compression method for compressing luminance element image data and two types of chrominance element image data each constituted out of a plurality of blocks, wherein
said image compression method comprises:

a step (S8 to S53, S108 to S130) of adaptively setting a resolution of each block during encoding according to a predetermined criterion for each of said luminance element image data and said two types of chrominance element image data, and creating resolution information;
a step (S54 to S56) creating data having each block reduced and creating data having each block unreduced based on said resolution information for each of said luminance element image data and said two types of chrominance element image data; and
a step (S58) of encoding said resolution information and said created data,

wherein
said step (S8 to S53, S108 to S130) of creating the resolution information comprises:

a step (S42, S48, S53) of obtaining the number of colors included in each block based on said two types of chrominance element image data; and
a step (S42, S49 to S53) of creating said resolution information on each of said two types of chrominance element image data based said number of colors.

7. A computer readable recording medium having stored thereon a program-for allowing a computer to execute an image expansion method for decoding the resolution information and the encoded data encoded by executing the program recorded on the computer readable recording medium according to claim 5, and restoring luminance element image data and two types of chrominance element image data, wherein
said image expansion method comprises:

a step (S78) of decoding said encoded resolution information;
a step (S82) of decoding said encoded data; and
a step (S86) of enlarging said encoded data to have a resolution

before reduction based on said resolution information, and creating the luminance element image data and the two types of chrominance element image data.

Patentansprüche

1. Bildkompressionsvorrichtung zum Komprimieren von Luminanzelementbilddaten und von zwei Typen von Chrominanzelementbilddaten, welche jeweils von einer Mehrzahl von Blöcken gebildet werden, mit:

einem Auflösungsbestimmungsverarbeitungsbereich (38, 142), welcher während eines Codierens eine Auflösung jedes Blocks adaptiv einstellt gemäß einem vorbestimmten Kriterium für jede der Luminanzelementbilddaten und der zwei Typen von Chrominanzelementbilddaten und welcher Auflösungsinformation erzeugt,
einem Datenerzeugungsverarbeitungsbereich (44), welcher mit dem Auflösungsbestimmungsverarbeitungsbereich (38, 142) verbunden ist und welcher Daten, bei welchen jeder Block auf der Grundlage der Auflösungsinformation für jede der Luminanzelementbilddaten und der zwei Typen von Chrominanzelementbilddaten reduziert ist, sowie Daten erzeugt, bei welchen jeder Block nicht reduziert ist, und
einem Codierer (42, 48A, 48B), welcher mit dem Auflösungsbestimmungsverarbeitungsbereich (38, 142) und mit dem Datenerzeugungsverarbeitungsbereich (44) verbunden ist und welcher die Auflösungsinformation und eine Ausgabe des Datenerzeugungsverarbeitungsbereichs (44) codiert,
wobei der Auflösungsbestimmungsverarbeitungsbereich (38, 142) aufweist:
einen Luminanzelementkantendetektionsverarbeitungsbereich (78), welcher Kantenelemente von den Luminanzelementbilddaten detektiert,
eine Kantendichteberechnungseinrichtung (80), welche mit dem Luminanzelementkantendetektionsverarbeitungsbereich (78) verbunden ist, zum Berechnen einer Dichte der Kantenelemente in jedem Block für jeden der Mehrzahl von Blöcken der Luminanzelementbilddaten und
eine Auflösungserzeugungseinrichtung (80), welche mit der Kantendichteberechnungseinrichtung (80) verbunden ist, zum Erzeugen von Auflösungsinformation auf den Luminanzelementbilddaten auf der Grundlage der Dichte.

2. Bildkompressionsvorrichtung zum Komprimieren von Luminanzelementbilddaten und von zwei Typen von Chrominanzelementbilddaten, welche jeweils von einer Mehrzahl von Blöcken gebildet werden, mit:

einem Auflösungsbestimmungsverarbeitungsbereich (38, 142), welcher während eines Codierens eine Auflösung jedes Blocks adaptiv einstellt gemäß einem vorbestimmten Kriterium für jede der Luminanzelementbilddaten und der zwei Typen von Chrominanzelementbilddaten und welcher Auflösungsinformation erzeugt,
einem Datenerzeugungsverarbeitungsbereich (44), welcher mit dem Auflösungsbestimmungsverarbeitungsbereich (38, 142) verbunden ist und welcher Daten, bei welchen jeder Block auf der Grundlage der Auflösungsinformation für jede der Luminanzelementbilddaten und der zwei Typen von Chrominanzelementbilddaten reduziert ist, sowie Daten erzeugt, bei welchen jeder Block nicht reduziert ist, und
einem Codierer (42, 48A, 48B), welcher mit dem Auflösungsbestimmungsverarbeitungsbereich (38, 142) und mit dem Datenerzeugungsverarbeitungsbereich (44) verbunden ist und welcher die Auflösungsinformation und eine Ausgabe des Datenerzeugungsverarbeitungsbereichs (44) codiert,

wobei der Auflösungsbestimmungsverarbeitungsbereich (38, 142) aufweist:

eine Berechnungseinrichtung (82, 84) für eine Anzahl von Farben zum Erhalten der Anzahl von Farben, die in jedem Block enthalten sind, auf der Grundlage der zwei Typen von Chrominanzelementbilddaten und
eine Auflösungserzeugungseinrichtung (84), die mit der Berechnungseinrichtung (82, 84) für die Anzahl von Farben verbunden ist, zum Erzeugen der Auflösungsinformation auf jedem der zwei Typen von Chrominanzelementbilddaten auf der Grundlage einer Ausgabe der Berechnungseinrichtung (82, 84) für die Anzahl von Farben.

3. Bildkompressionsvorrichtung nach Anspruch 1,
wobei der Auflösungsbestimmungsverarbeitungsbereich (38, 142) die Auflösung jedes der Mehrzahl von Blöcken gemäß einem Grad der Beeinflussung einstellt, wenn die Luminanzelementbilddaten und die zwei Typen von Chrominanzelementbilddaten in Bilddaten für ein rotes Element, Bilddaten für ein grünes Element bzw. Bilddaten für ein blaues Element für jeden Block gewandelt werden, und die Auflösungsinformation (144 bis 148) erzeugt.

4. Bildexpansionsvorrichtung zum Decodieren der Auflösungsinformation und der codierten Daten, welche mittels der Bildkompressionsvorrichtung nach Anspruch 1 komprimiert wurden, und zum Wiedergewinnen von Luminanzelementbilddaten und von zwei Typen von Chrominanzelementbilddaten, mit:

einem Auflösungsinformationsdatendecodierer (110), welcher codierte Auflösungsinformation decodiert,
einem Datendecodierer, welcher die codierten Daten decodiert, und
einem Bilderzeugungsverarbeitungsbereich (116A, 116B, 118A, 118B, 119, 121, 120), welcher mit dem Auflösungsinformationsdatendecodierer und dem Datendecodierer verbunden ist, und welcher die codierten Daten aufweitet, um eine Auflösung vor der Reduktion zu besitzen auf der Grundlage der Auflösungsinformation, und welcher die Luminanzelementbilddaten und die zwei Typen von Chrominanzelementbilddaten erzeugt.

5. Computerlesbares Aufzeichnungsmedium mit einem darauf gespeicherten Programm, welches einem Computer ermöglicht, ein Bildkompressionsverfahren auszuführen zum Komprimieren von Luminanzelementbilddaten und von zwei Typen von Chrominanzelementbilddaten, welche jeweils von einer Mehrzahl von Blöcken gebildet werden, wobei das Bildkompressionsverfahren aufweist:

einen Schritt (S8 bis S53, S108 bis S130) des adaptiven Einstellens einer Auflösung jedes Blocks während eines Codierens gemäß einem vorbestimmten Kriterium für jedes der Luminanzelementbilddaten und der zwei Typen von Chrominanzelementbilddaten sowie des Erzeugens von Auflösungsinformation,
einen Schritt (S54 bis S56) des Erzeugens von Daten, bei welchen jeder Block reduziert ist, und des Erzeugens von Daten, bei welchen jeder Block nicht reduziert ist, auf der Grundlage der Auflösungsinformation für jedes der Luminanzelementbilddaten und der zwei Typen von Chrominanzelementbilddaten, und
einen Schritt (S58) des Codierens der Auflösungsinformation und der erzeugten Daten,
wobei der Schritt (S8 bis S53, S108 bis S130) des Erzeugens der Auflösungsinformation aufweist:
einen Schritt (S40) des Detektierens von Kantenelementen von den Luminanzelementbilddaten,
einen Schritt (S42, S44, S53) des Berechnens einer Dichte der Kantenelemente in jedem Block für jeden der Mehrzahl von Blöcken der Luminanzelementbilddaten und
einen Schritt (S42, S44, S46, S53) des Erzeugens der Auflösungsinformation auf den Luminanzelementbilddaten auf der Grundlage der Dichte.

6. Computerlesbares Aufzeichnungsmedium mit einem darauf gespeicherten Programm, welches einem Computer ermöglicht, ein Bildkompressionsverfahren auszuführen zum Komprimieren von Luminanzelementbilddaten und von zwei Typen von Chrominanzelementbilddaten, welche jeweils von einer Mehrzahl von Blöcken gebildet werden, wobei das Bildkompressionsverfahren aufweist:

einen Schritt (S8 bis S53, S108 bis S130) des adaptiven Einstellens einer Auflösung jedes Blocks während eines Codierens gemäß einem vorbestimmten Kriterium für jedes der Luminanzelementbilddaten und der zwei Typen von Chrominanzelementbilddaten sowie des Erzeugens von Auflösungsinformation,
einen Schritt (S54 bis S56) des Erzeugens von Daten, bei welchen jeder Block reduziert ist, und des Erzeugens von Daten, bei welchen jeder Block nicht reduziert ist, auf der Grundlage der Auflösungsinformation für jedes der Luminanzelementbilddaten und der zwei Typen von Chrominanzelementbilddaten, und
einen Schritt (S58) des Codierens der Auflösungsinformation und der erzeugten Daten,
wobei der Schritt (S8 bis S53, S108 bis S130) des Erzeugens der Auflösungsinformation aufweist:

einen Schritt (S42, S48, S53) des Erhaltens der Anzahl von Farben, die in jedem Block enthalten sind, auf der Grundlage der zwei Typen von Chrominanzelementbilddaten und
einen Schritt (S42, S48 bis S53) des Erzeugens der Auflösungsinformation auf jedem der zwei Typen von Chrominanzelementbilddaten auf der Grundlage der Anzahl von Farben.

7. Computerlesbares Aufzeichnungsmedium mit einem darauf gespeicherten Programm, welches einem Computer ermöglicht, ein Bildexpansionsverfahren auszuführen zum Decodieren der codierten Auflösungsinformation und der codierten Daten, welche codiert wurden durch Ausführen des Programms, welches auf dem computerlesbaren Aufzeichnungsmedium nach Anspruch 5 aufgezeichnet ist, und zum Wiedergewinnen von Luminanzelementbilddaten und von zwei Typen von Chrominanzelementbilddaten,
wobei das Bildexpansionsverfahren aufweist:

einen Schritt (S78) des Decodierens der codierten Auflösungsinformation,
einen Schritt (S82) des Decodierens der codierten Daten und
einen Schritt (S86) des Aufweitens der codierten Daten, um eine Auflösung vor der Reduktion auf der Grundlage der Auflösungsinformation zu erhalten, und des Erzeugens der Luminanzelementbilddaten und der zwei Typen von Chrominanzelementbilddaten.

Revendications

1. Dispositif de compression d'image destiné à compresser des données d'image d'élément de luminance et deux types de données d'image d'élément de chrominance constituées chacune de plusieurs blocs, comportant :

une section de traitement de détermination de résolution (38, 142) destinée à déterminer de manière adaptative une résolution de chaque bloc au cours du codage, en fonction d'un critère prédéterminé pour chacune desdites données d'image d'élément de luminance et chacun desdits deux types de données d'image d'élément de chrominance, et créer des informations de résolution ;
une section de traitement de création de données (44) reliée à ladite section de traitement de détermination de résolution (38, 142) et destinée à créer des données contenant chacun des blocs réduits en fonctions desdites informations de résolution pour chacune desdites données d'image d'élément de luminance et chacun desdits deux types de données d'image d'élément de chrominance ; et des données contenant chacun des blocs non réduits ; et
un codeur (42, 48A, 48B) relié à ladite section de traitement de détermination de résolution (38, 142) et à ladite section de traitement de création de données (44), et destiné à coder lesdites informations de résolution et une sortie de ladite section de traitement de création de données (44) ;
ladite section de traitement de détermination de résolution (38,142) comportant :
une section de traitement de détection de contour d'élément de luminance (78) destinée à détecter des éléments de contour à partir desdites données d'image d'élément de luminance ;
un moyen de calcul de densité de contour (80), relié à ladite section de traitement de détection de contour d'élément de luminance (78), destiné à calculer une densité des éléments de contour de chacun des blocs appartenant auxdits plusieurs blocs desdites données d'image d'élément de luminance ; et
un moyen de création de résolution (80), relié audit moyen de calcul de densité de contour (80), destiné à créer lesdites informations de résolution sur lesdites données d'image d'élément de luminance en fonction de ladite densité.

2. Dispositif de compression d'image destiné à compresser des données d'image d'élément de luminance et deux types de données d'image d'élément de chrominance constituées chacune de plusieurs blocs, comportant :

une section de traitement de détermination de résolution (38, 142) destinée à déterminer de manière adaptative une résolution de chaque bloc au cours du codage, en fonction d'un critère prédéterminé pour chacune desdites données d'image d'élément de luminance et chacun desdits deux types de données d'image d'élément de chrominance, et créer des informations de résolution ;
une section de traitement de création de données (44) reliée à ladite section de traitement de détermination de résolution (38, 142) et destinée à créer des données contenant chacun des blocs réduits en fonction desdites informations de résolution pour chacune desdites données d'image d'élément de luminance et chacun desdits deux types de données d'image d'élément de chrominance ; et des données contenant chacun des blocs non réduits ; et

un codeur (42, 48A, 48B) relié à ladite section de traitement de détermination de résolution (38, 142) et à ladite section de traitement de création de données (44), et destiné à coder lesdites informations de résolution et une sortie de ladite section de traitement de création de données (44) ;
dans lequel ladite section de traitement de détermination de résolution (38, 142) comporte :
un moyen de calcul de nombre de couleurs (82, 84) destiné à obtenir le nombre de couleurs contenues dans chaque bloc en fonction desdits deux types de données d'image d'élément de chrominance ; et
un moyen de création de résolution (84), relié audit moyen de calcul de nombre de couleurs (82, 84), destiné à créer lesdites informations de résolution sur chacun desdits deux types de données d'image d'élément de chrominance en fonction d'une sortie dudit moyen de calcul de nombre de couleurs (82, 84).

3. Dispositif de compression d'image selon la revendication 1, dans lequel
ladite section de traitement de détermination de résolution (38, 142) détermine ladite résolution de chacun desdits plusieurs blocs en fonction d'un degré d'influence lorsque lesdites données d'image d'élément de luminance et lesdits deux types de données d'image d'élément de chrominance sont convertis, respectivement, en données d'image d'élément rouge, en données d'image d'élément vert et en données d'images d'élément bleu, pour chaque bloc, et crée lesdites informations de résolution (144 à 148).

4. Dispositif d'expansion d'image destinée à décoder les informations de résolution et les données codées par le dispositif de compression d'image selon la revendication 1, et destiné à restaurer des données d'image d'élément de luminance et deux types de données d'image d'élément de chrominance, comportant :

un décodeur de données d'informations de résolution (110) destiné à décoder lesdites informations de résolution codées ;
un décodeur de données destiné à décoder lesdites données codées ; et
une section de traitement de création d'image (116A, 116B, 118A, 118B, 119, 121, 120) reliée audit décodeur de données d'informations de résolution et audit décodeur de données, destiné à agrandir lesdites données codées pour disposer d'une résolution avant réduction basée sur lesdites informations de résolution, et à créer les données d'image d'élément de luminance et les deux types de données d'image d'élément de chrominance.

5. Support d'enregistrement lisible par ordinateur contenant un programme destiné à permettre à un ordinateur d'exécuter un procédé de compression d'image servant à compresser des données d'image d'élément de luminance et deux types de données d'image d'élément de chrominance constituées à partir de plusieurs blocs, dans lequel ledit procédé de compression d'image comporte :

une étape (S8 à S53, S108 à S130) consistant à fixer de manière adaptative une résolution de chacun des blocs au cours du codage en fonction d'un critère prédéterminé pour chacune desdites données d'image d'élément de luminance et chacun desdits deux types de données d'image d'élément de chrominance, et à créer des informations de résolution ;
une étape (S54 à S56) consistant à créer des données avec réduction de chacun des blocs et à créer des données avec non réduction de chacun des blocs, en fonction desdites informations de résolution pour chacune desdites données d'image d'élément de luminance et chacun des deux types de données d'image d'élément de chrominance ; et
une étape (S58) consistant à coder lesdites informations de résolution et lesdites données créées ;
ladite étape (S8 à 553, S108 à S130) de création d'informations de résolution comprenant :
une étape (S40) de détection d'éléments de contour à partir desdites données d'image d'élément de luminance
une étape (S42, S44, S53) de calcul de densité des éléments de contour desdites données d'image d'élément de contour dans chaque bloc pour chacun desdits blocs ; et
une étape (S42, S44, S46, S53) de création de ladite information de résolution sur lesdites données d'image d'élément de luminance basées sur ladite densité.

6. Support d'enregistrement lisible par ordinateur contenant un programme destiné à permettre à un ordinateur d'exécuter un procédé de compression d'image servant à compresser des données d'images d'élément de luminance et deux types de données d'image d'élément de chrominance constituées à partir de plusieurs blocs, dans lequel ledit procédé de compression d'image comporte :

une étape (S8 à S53, S108 à S130) consistant à fixer de manière adaptative une résolution de chacun des blocs au cours du codage en fonction d'un critère prédéterminé pour chacune desdites données d'image d'élément de luminance et chacun desdits deux types de données d'image d'élément de chrominance, et à créer

des informations de résolution ;
une étape (S54 à S56) consistant à créer des données avec réduction de chacun des blocs et à créer des données avec non réduction de chacun des blocs, en fonction desdites informations de résolution pour chacune desdites données d'image d'élément de luminance et chacun des deux types de données d'image d'élément de chrominance ; et
une étape (S58) consistant à coder lesdites informations de résolution et lesdites données créées ;
ladite étape (S8 à S53, S108 à S130) de création d'information de résolution comprenant :
une étape (S42, S48, S53) d'obtention d'un nombre de couleurs incluses dans chaque bloc basées sur lesdits deux types de données d'image d'élément de chrominance ; et
une étape (S42, S48, S53) de création de ladite information de résolution sur chacun desdits deux types de données d'image d'élément de chrominance basées sur ledit nombre de couleurs.

7. Support d'enregistrement lisible par ordinateur contenant un programme destiné à permettre un ordinateur d'exécuter un procédé d'expansion d'image, servant à décoder les informations de résolution et les données encodées en exécutant le programme enregistré sur le support d'enregistrement lisible par ordinateur selon la revendication 5, et à restaurer des données d'image d'élément de luminance et deux types de données d'image d'élément de chrominance, dans lequel
ledit procédé d'expansion d'image comporte :

une étape (S78) consistant à décoder lesdites informations de résolution codées ;
une étape (S82) consistant à décoder lesdites données codées ; et
une étape (S86) consistant à agrandir lesdites données codées pour qu'elles possèdent une résolution avant réduction basée sur lesdites informations de résolution, et à créer les données d'image d'élément de luminance et les deux types de données d'image d'élément de chrominance.

FIG. 1

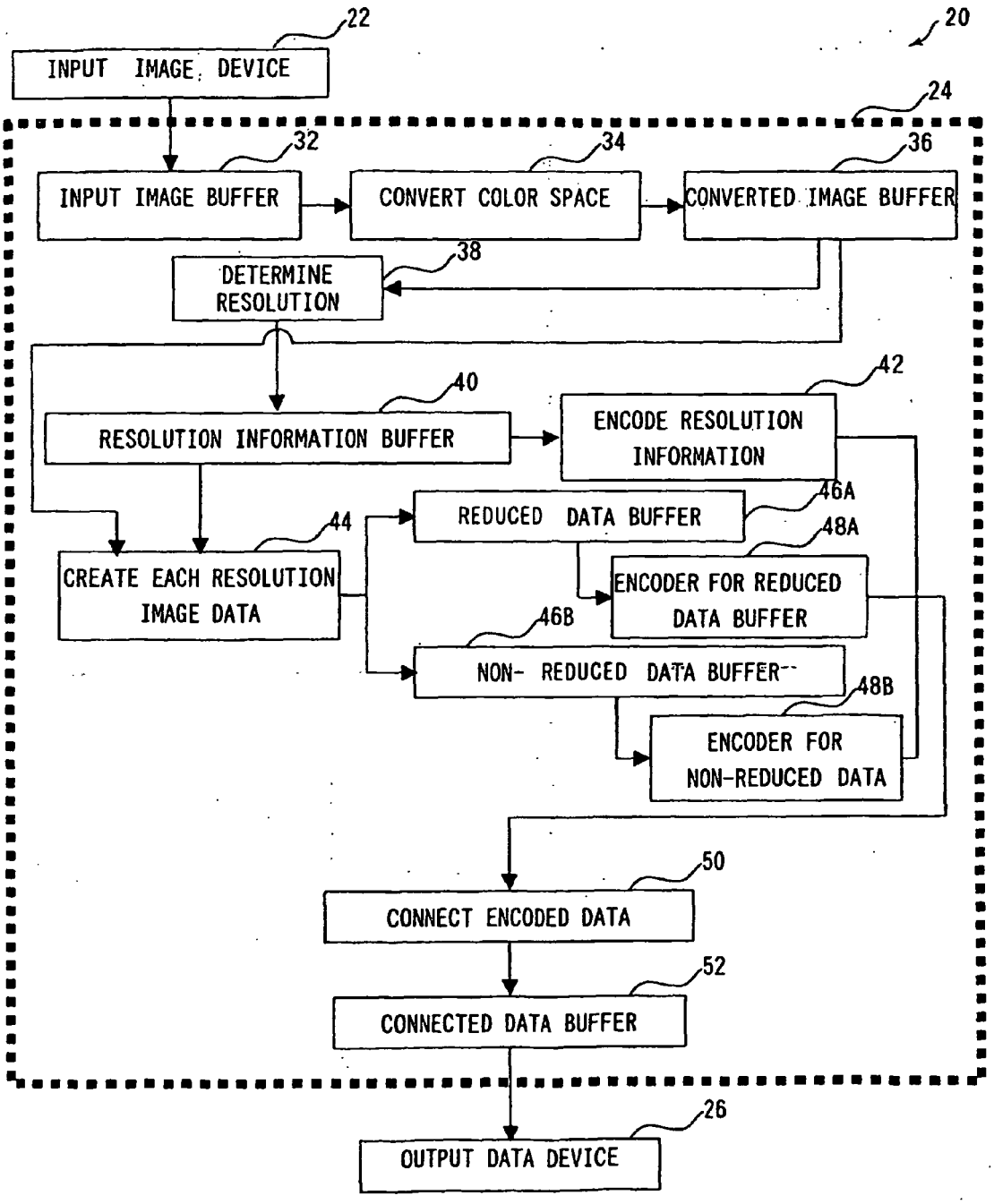

22
20
INPUT IMAGE DEVICE
24
32
34
36
INPUT IMAGE BUFFER
CONVERT COLOR SPACE
CONVERTED IMAGE BUFFER
38
DETERMINE RESOLUTION
42
40
RESOLUTION INFORMATION BUFFER
ENCODE RESOLUTION INFORMATION
46A
REDUCED DATA BUFFER
44
48A
CREATE EACH RESOLUTION IMAGE DATA
ENCODER FOR REDUCED DATA BUFFER
46B
NON- REDUCED DATA BUFFER
48B
ENCODER FOR NON-REDUCED DATA
50
CONNECT ENCODED DATA
52
CONNECTED DATA BUFFER
26
OUTPUT DATA DEVICE

FIG. 2

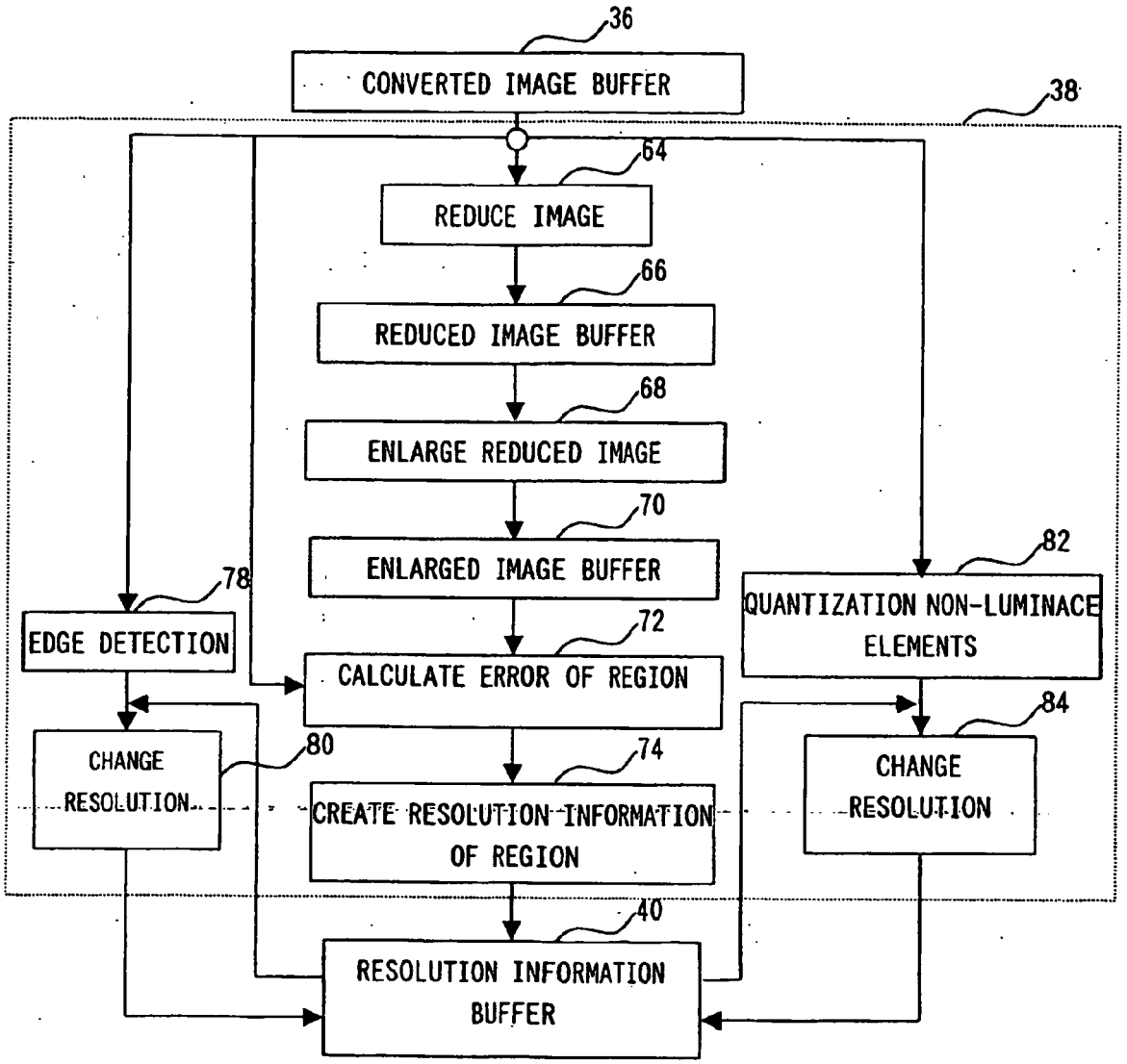

36
CONVERTED IMAGE BUFFER
38
64
REDUCE IMAGE
66
REDUCED IMAGE BUFFER
68
ENLARGE REDUCED IMAGE
70
ENLARGED IMAGE BUFFER
72
CALCULATE ERROR OF REGION
74
CREATE RESOLUTION INFORMATION OF REGION
78
EDGE DETECTION
80
CHANGE RESOLUTION
82
QUANTIZATION NON-LUMINACE ELEMENTS
84
CHANGE RESOLUTION
40
RESOLUTION INFORMATION BUFFER

FIG. 3

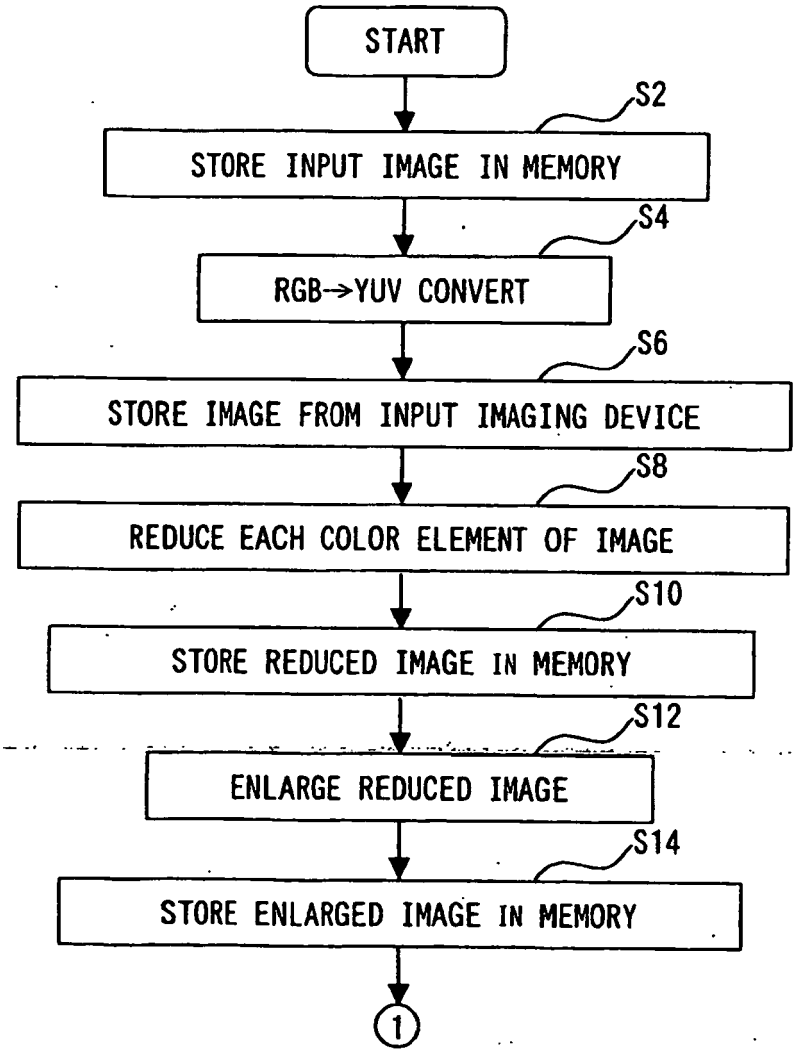

START
S2
STORE INPUT IMAGE IN MEMORY
S4
RGB→YUV CONVERT
S6
STORE IMAGE FROM INPUT IMAGING DEVICE
S8
REDUCE EACH COLOR ELEMENT OF IMAGE
S10
STORE REDUCED IMAGE IN MEMORY
S12
ENLARGE REDUCED IMAGE
S14
STORE ENLARGED IMAGE IN MEMORY
1

FIG. 4

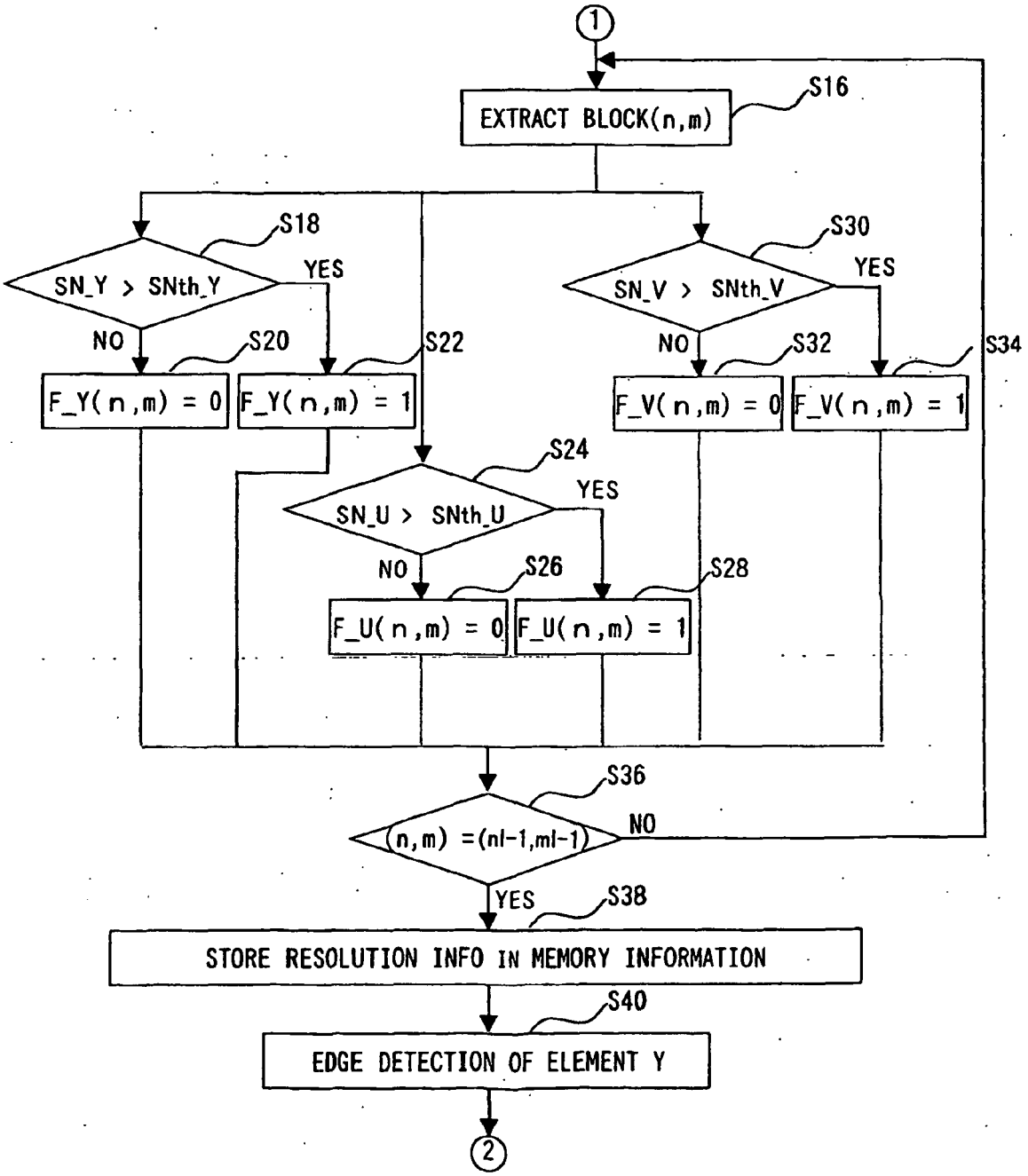

1
EXTRACT BLOCK(n,m)
S16
S18
SN_Y > SNth_Y
YES
NO
S20
S22
F_Y(n,m) = 0
F_Y(n,m) = 1
S30
SN_V > SNth_V
YES
NO
S32
S34
F_V(n,m) = 0
F_V(n,m) = 1
S24
SN_U > SNth_U
YES
NO
S26
S28
F_U(n,m) = 0
F_U(n,m) = 1
S36
(n,m) =(nl-1,ml-1)
NO
YES
S38
STORE RESOLUTION INFO IN MEMORY INFORMATION
S40
EDGE DETECTION OF ELEMENT Y
2

FIG. 5

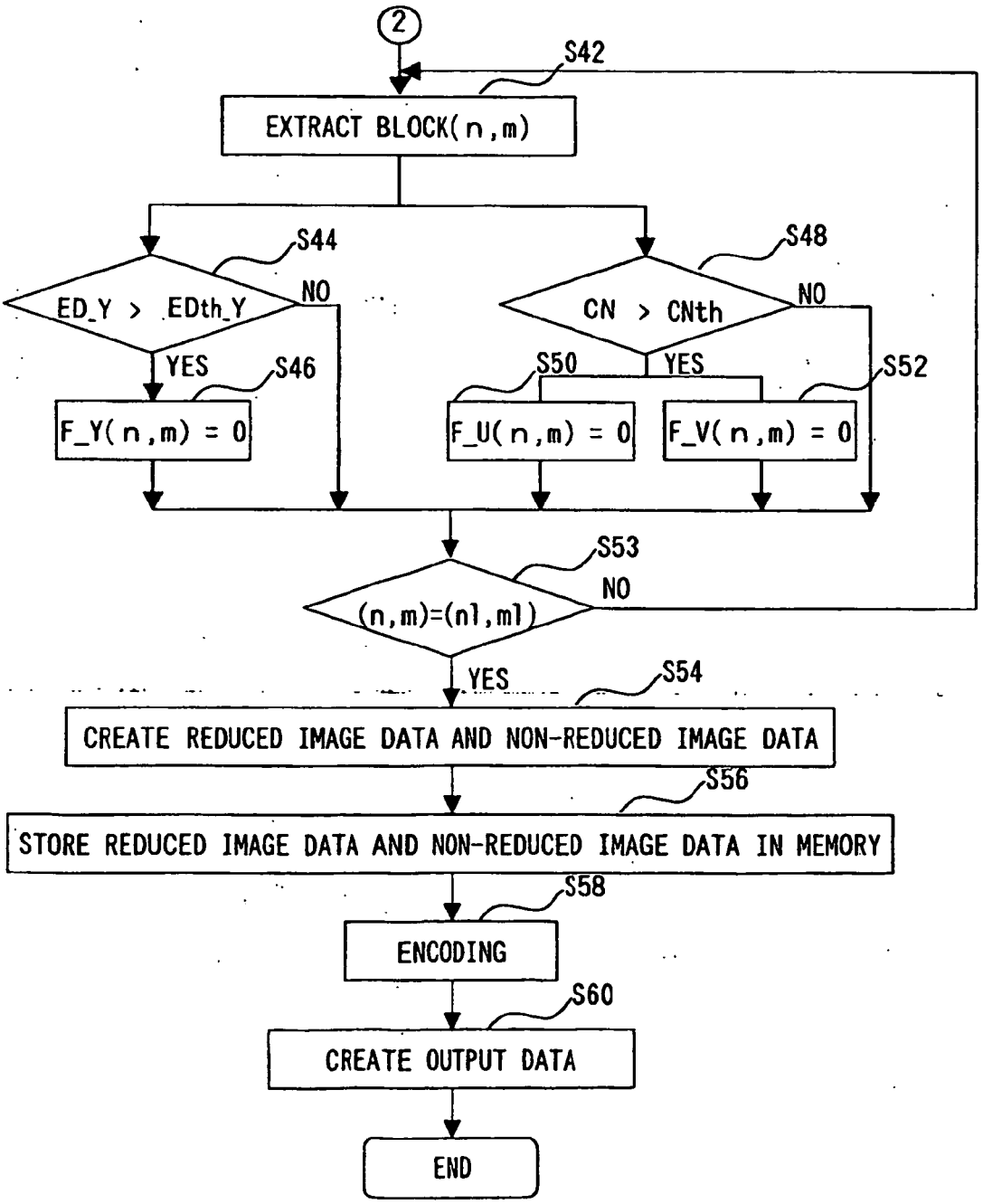

2
S42
EXTRACT BLOCK(n,m)
S44
ED_Y > EDth_Y
NO
YES
S46
F_Y(n,m) = 0
S48
CN > CNth
NO
YES
S50
F_U(n,m) = 0
S52
F_V(n,m) = 0
S53
(n,m)=(n1,m1)
NO
YES
S54
CREATE REDUCED IMAGE DATA AND NON-REDUCED IMAGE DATA
S56
STORE REDUCED IMAGE DATA AND NON-REDUCED IMAGE DATA IN MEMORY
S58
ENCODING
S60
CREATE OUTPUT DATA
END

FIG. 6

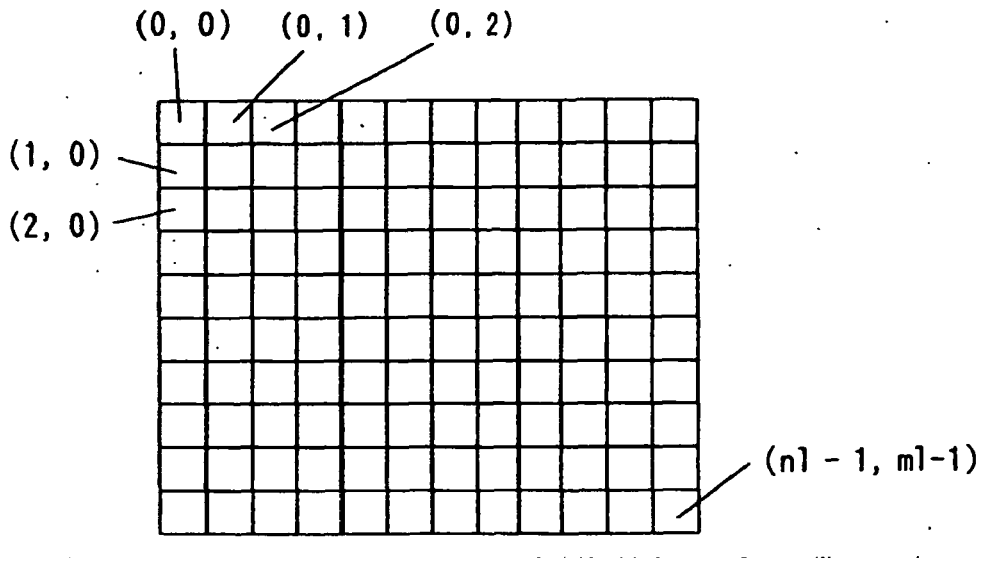


FIG. 7

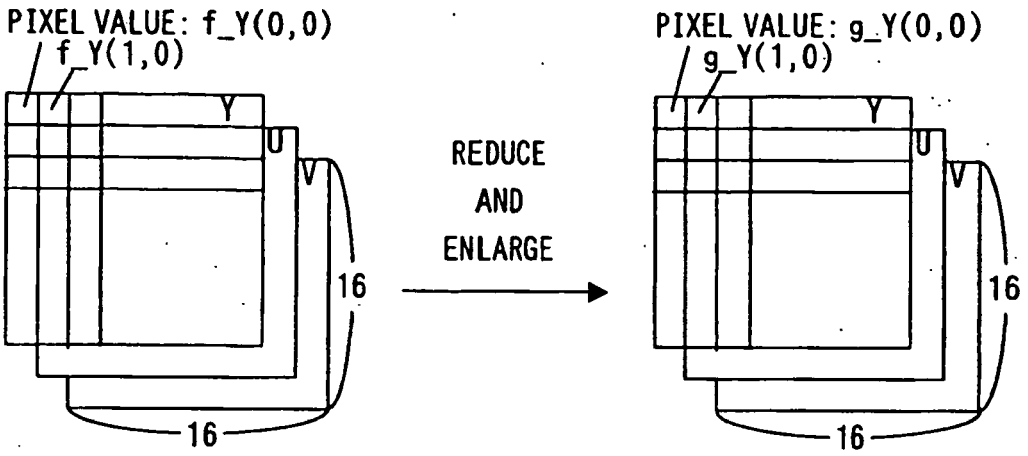

PIXEL VALUE: f_Y(0,0)
f_Y(1,0)
Y
U
V
16
16
REDUCE
AND
ENLARGE
PIXEL VALUE: g_Y(0,0)
g_Y(1,0)
Y
U
V
16
16

FIG. 8

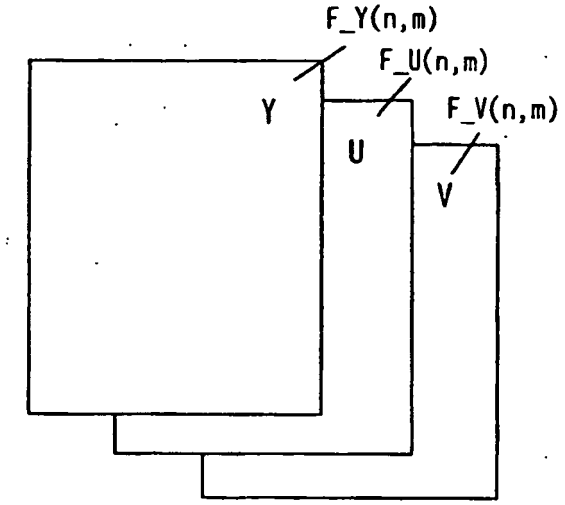


FIG. 9

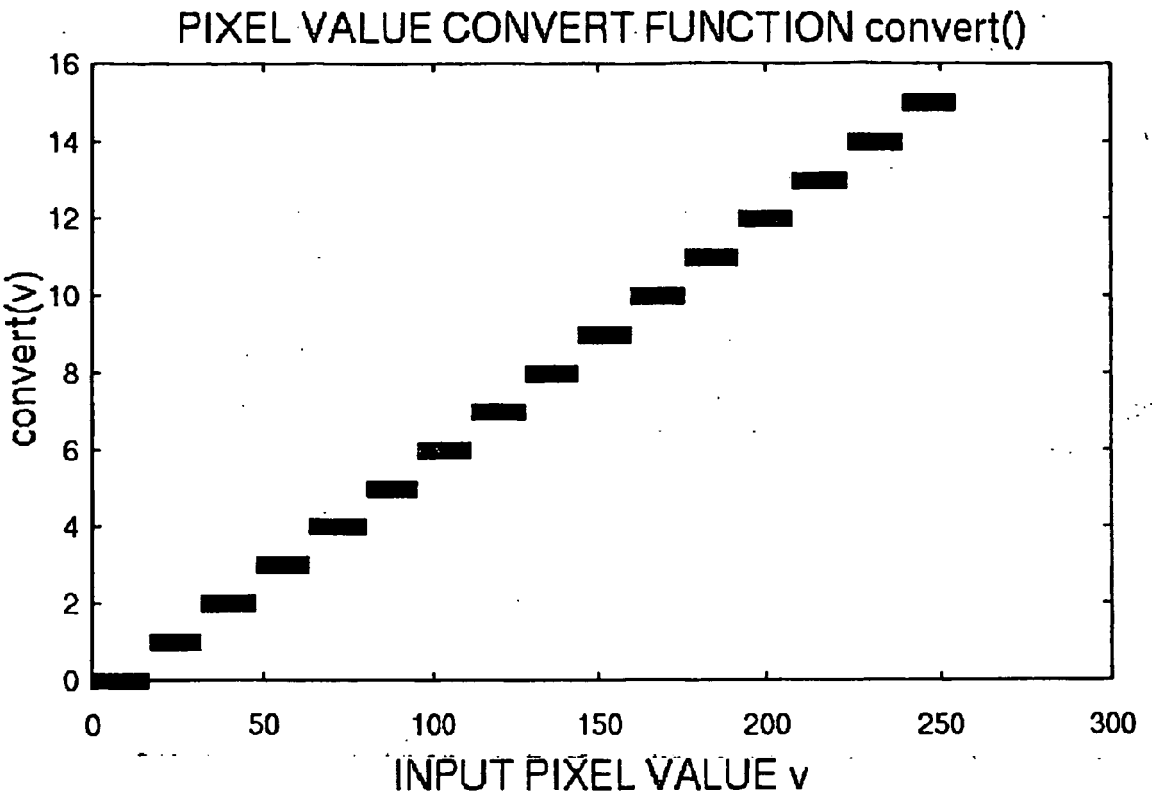

PIXEL VALUE CONVERT FUNCTION convert()
convert(v)
INPUT PIXEL VALUE v
0
2
4
6
8
10
12
14
16
0
50
100
150
200
250
300

FIG. 10

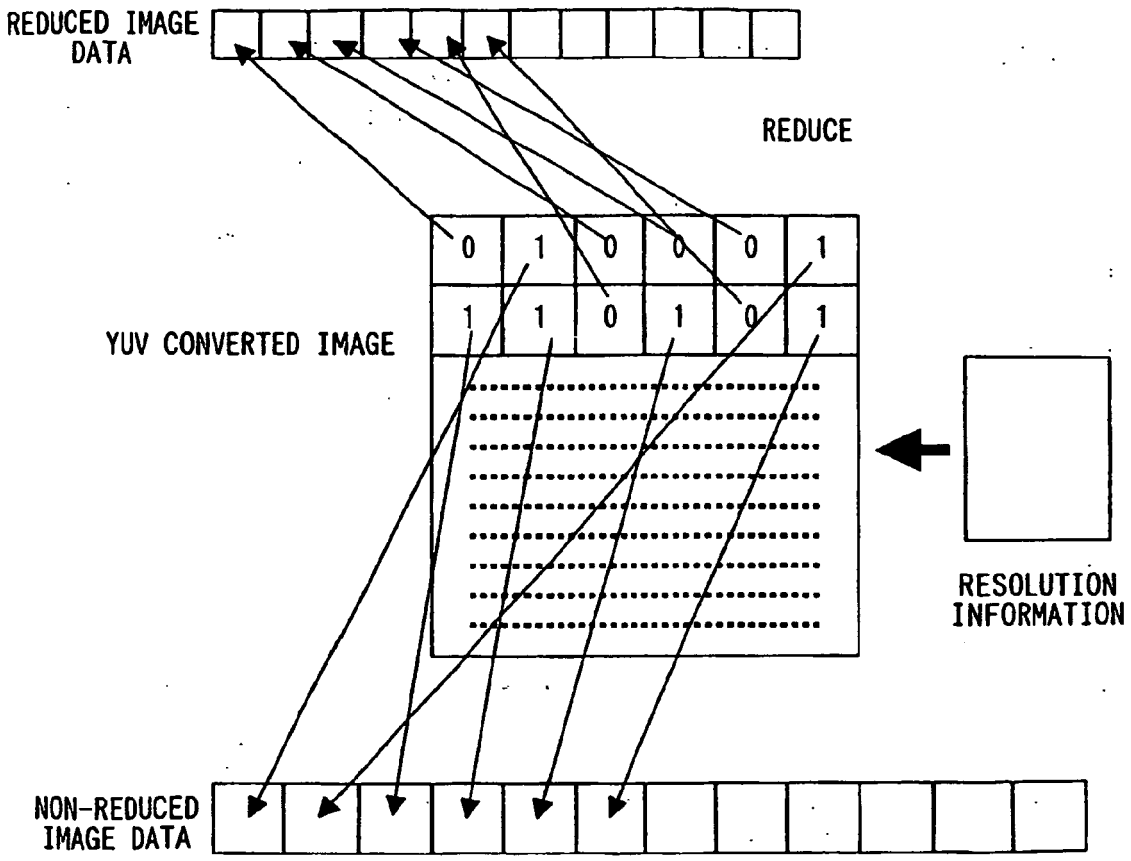

REDUCED IMAGE DATA
REDUCE
0 1 0 0 0 1
1 1 0 1 0 1
YUV CONVERTED IMAGE
RESOLUTION INFORMATION
NON-REDUCED IMAGE DATA

FIG. 11

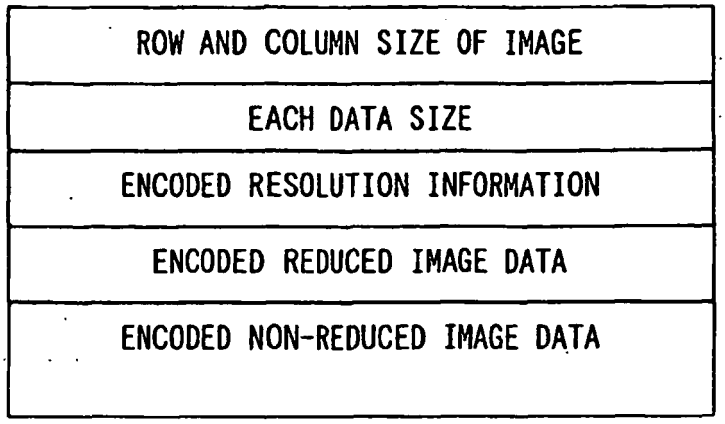

ROW AND COLUMN SIZE OF IMAGE
EACH DATA SIZE
ENCODED RESOLUTION INFORMATION
ENCODED REDUCED IMAGE DATA
ENCODED NON-REDUCED IMAGE DATA

FIG. 12

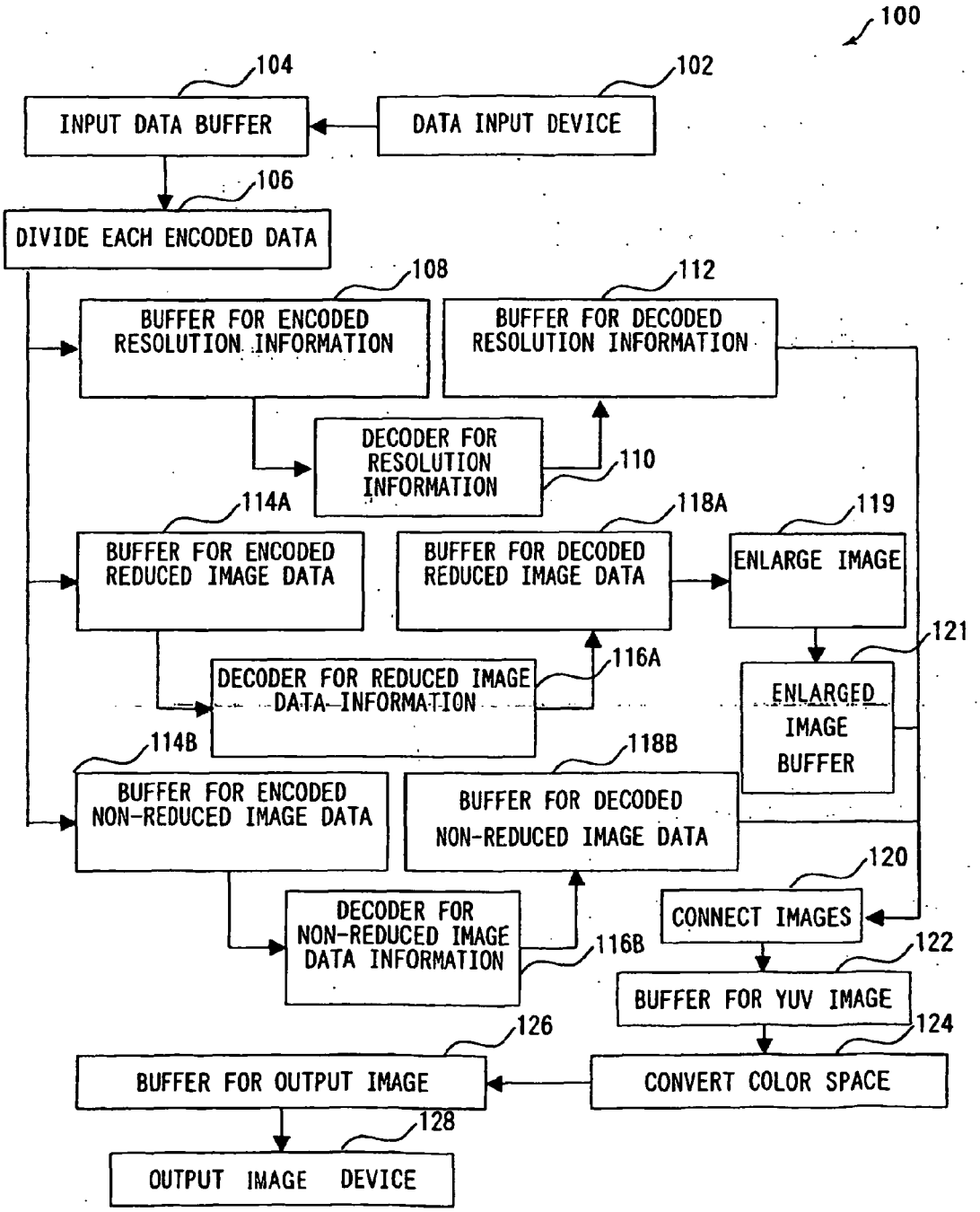

100
104
INPUT DATA BUFFER
102
DATA INPUT DEVICE
106
DIVIDE EACH ENCODED DATA
108
BUFFER FOR ENCODED RESOLUTION INFORMATION
112
BUFFER FOR DECODED RESOLUTION INFORMATION
DECODER FOR RESOLUTION INFORMATION
110
114A
BUFFER FOR ENCODED REDUCED IMAGE DATA
118A
BUFFER FOR DECODED REDUCED IMAGE DATA
119
ENLARGE IMAGE
121
DECODER FOR REDUCED IMAGE DATA INFORMATION
116A
ENLARGED IMAGE BUFFER
114B
BUFFER FOR ENCODED NON-REDUCED IMAGE DATA
118B
BUFFER FOR DECODED NON-REDUCED IMAGE DATA
120
DECODER FOR NON-REDUCED IMAGE DATA INFORMATION
116B
CONNECT IMAGES
122
BUFFER FOR YUV IMAGE
126
124
BUFFER FOR OUTPUT IMAGE
CONVERT COLOR SPACE
128
OUTPUT IMAGE DEVICE

FIG. 13

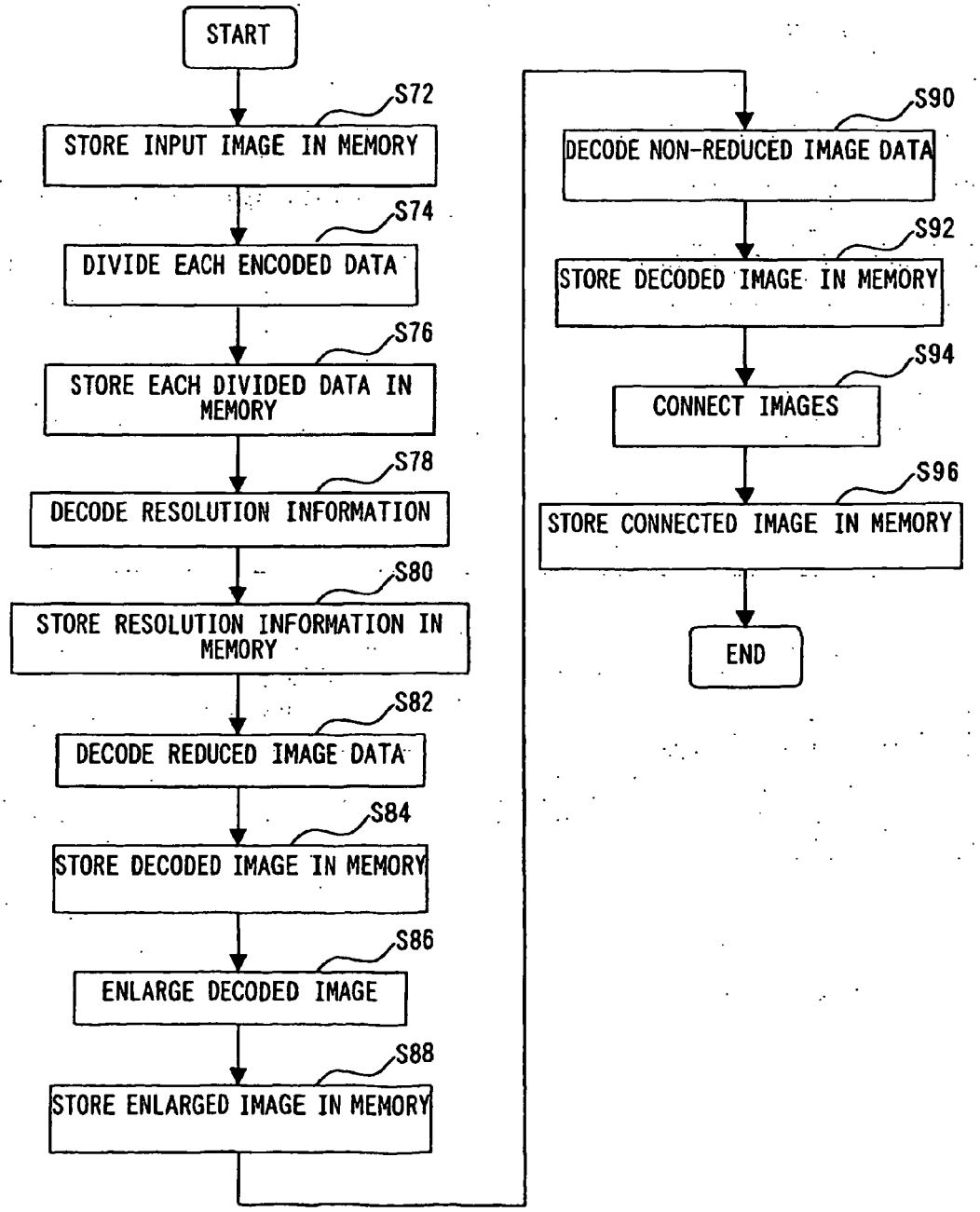

START
S72
STORE INPUT IMAGE IN MEMORY
S74
DIVIDE EACH ENCODED DATA
S76
STORE EACH DIVIDED DATA IN MEMORY
S78
DECODE RESOLUTION INFORMATION
S80
STORE RESOLUTION INFORMATION IN MEMORY
S82
DECODE REDUCED IMAGE DATA
S84
STORE DECODED IMAGE IN MEMORY
S86
ENLARGE DECODED IMAGE
S88
STORE ENLARGED IMAGE IN MEMORY
S90
DECODE NON-REDUCED IMAGE DATA
S92
STORE DECODED IMAGE IN MEMORY
S94
CONNECT IMAGES
S96
STORE CONNECTED IMAGE IN MEMORY
END

FIG. 14

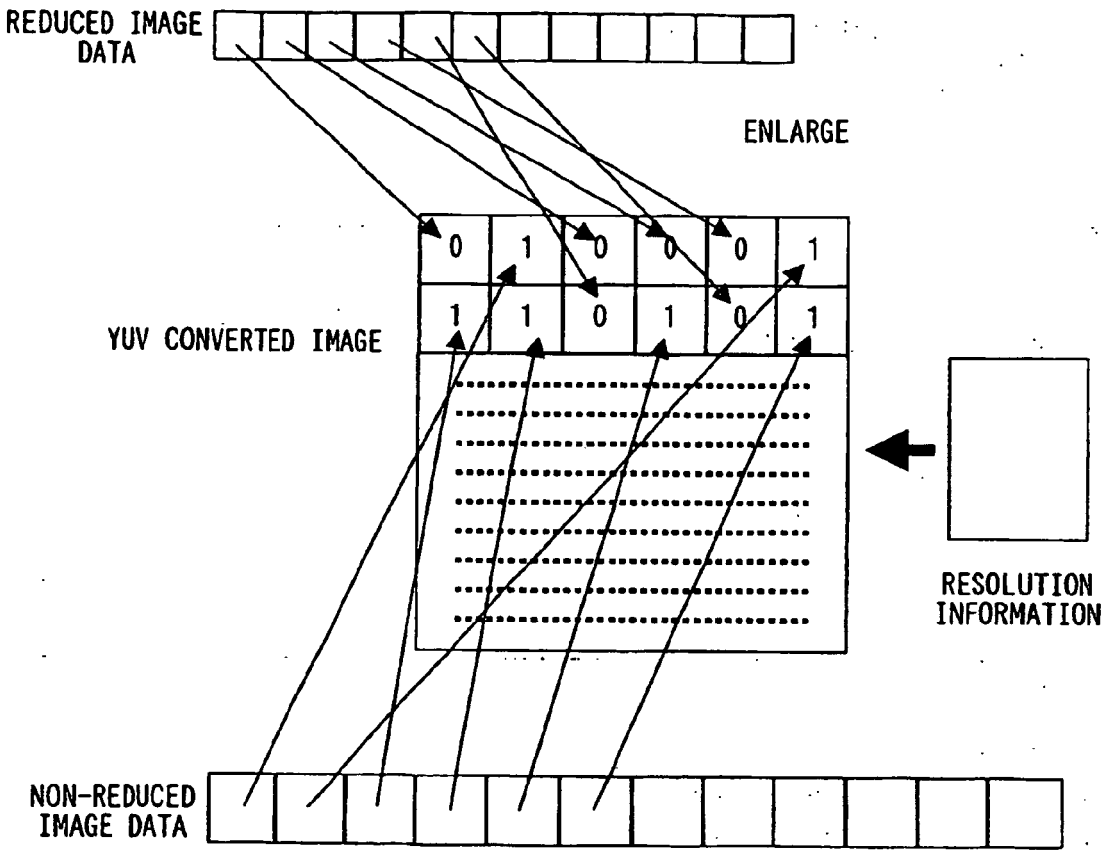

REDUCED IMAGE DATA
ENLARGE
0 1 0 0 0 1
1 1 0 1 0 1
YUV CONVERTED IMAGE
RESOLUTION INFORMATION
NON-REDUCED IMAGE DATA

FIG. 15

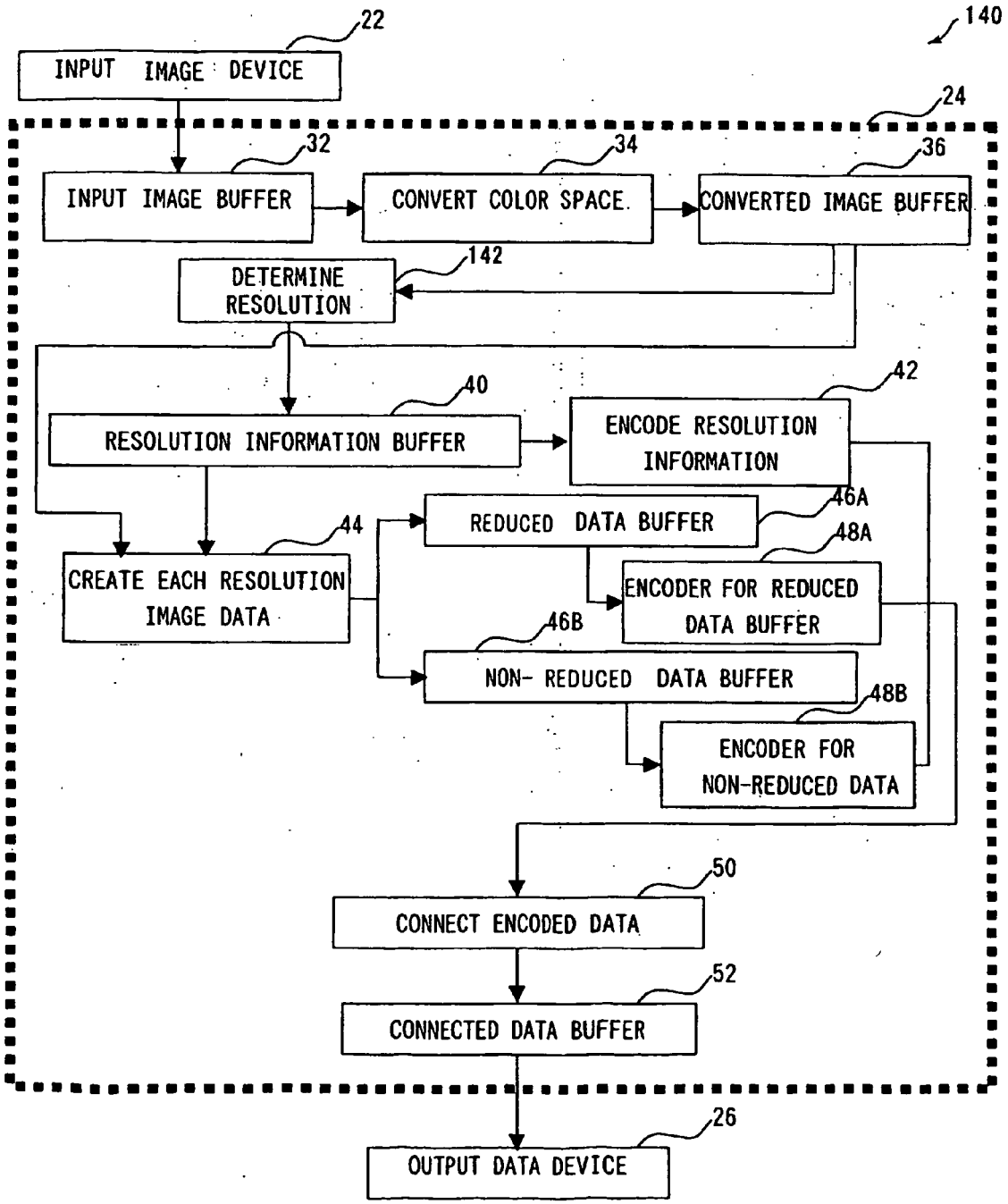

22
140
INPUT IMAGE DEVICE
24
32
34
36
INPUT IMAGE BUFFER
CONVERT COLOR SPACE
CONVERTED IMAGE BUFFER
142
DETERMINE RESOLUTION
40
42
RESOLUTION INFORMATION BUFFER
ENCODE RESOLUTION INFORMATION
46A
REDUCED DATA BUFFER
44
48A
CREATE EACH RESOLUTION IMAGE DATA
ENCODER FOR REDUCED DATA BUFFER
46B
NON- REDUCED DATA BUFFER
48B
ENCODER FOR NON-REDUCED DATA
50
CONNECT ENCODED DATA
52
CONNECTED DATA BUFFER
26
OUTPUT DATA DEVICE

FIG. 16

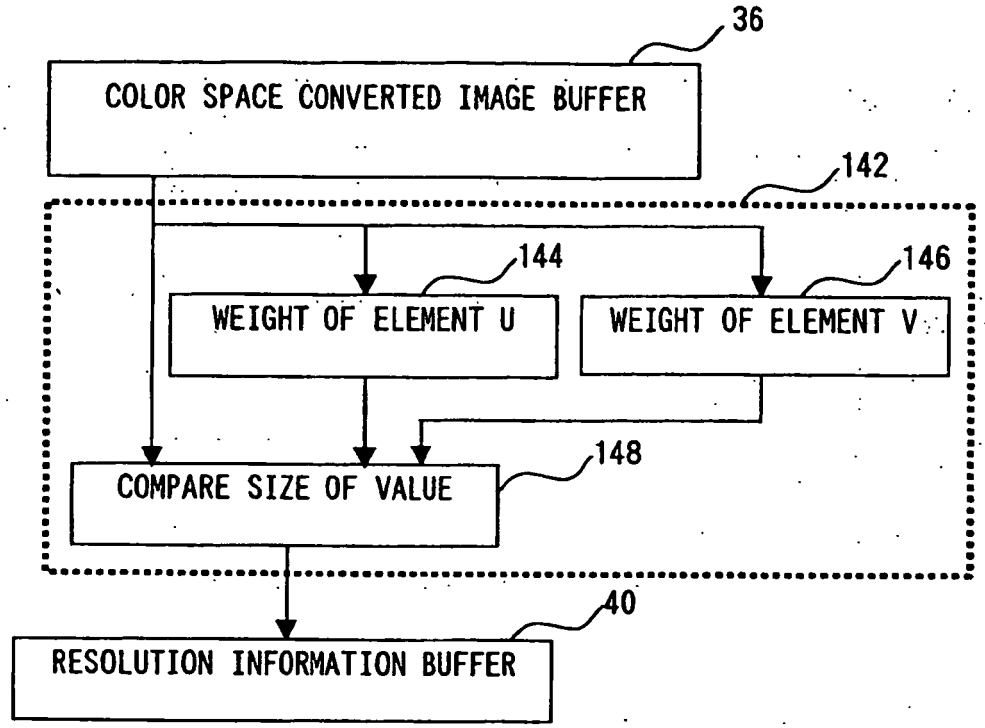

36
COLOR SPACE CONVERTED IMAGE BUFFER
142
144
WEIGHT OF ELEMENT U
146
WEIGHT OF ELEMENT V
148
COMPARE SIZE OF VALUE
40
RESOLUTION INFORMATION BUFFER

FIG. 17

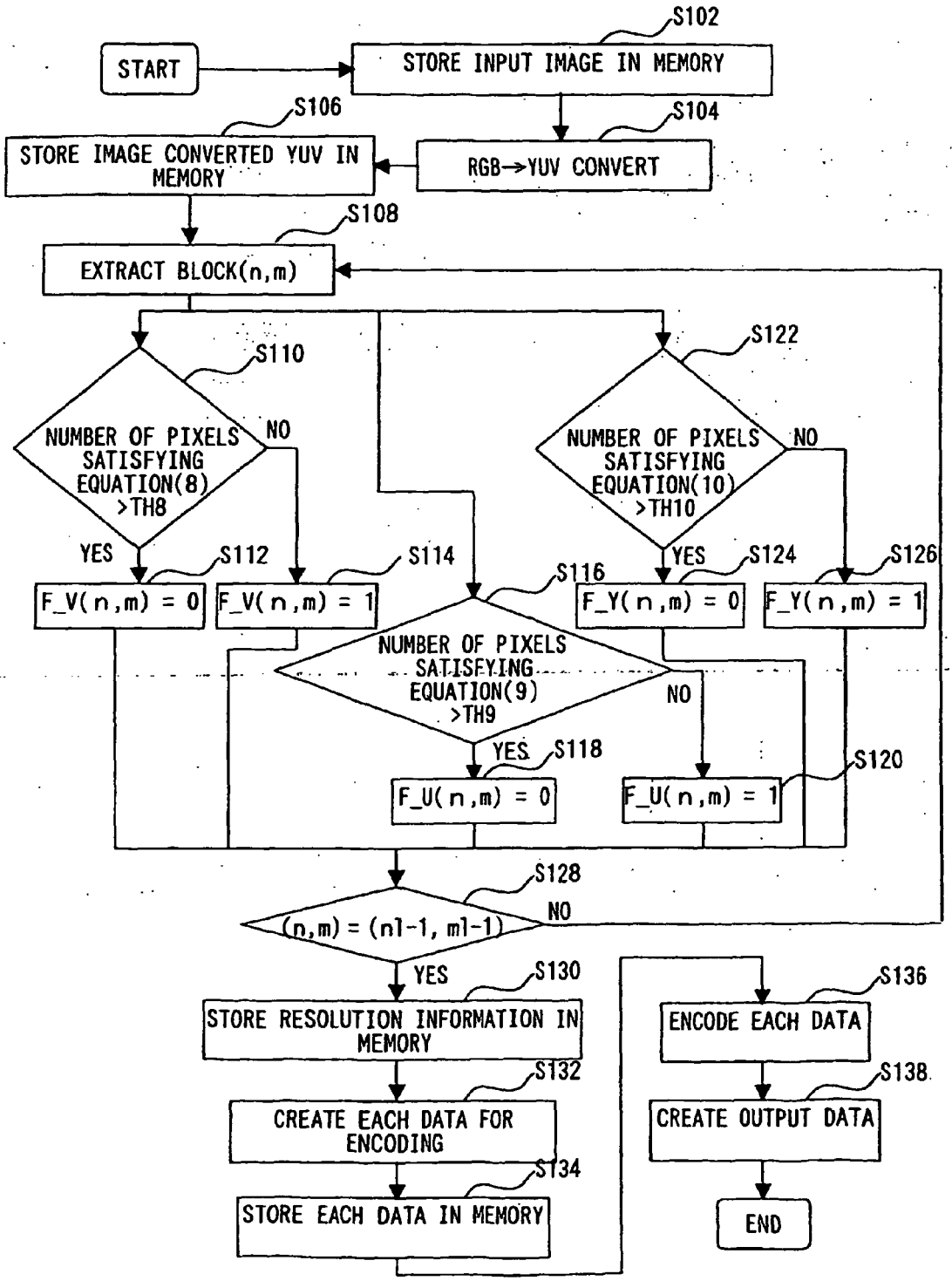

START
S102
STORE INPUT IMAGE IN MEMORY
S104
RGB→YUV CONVERT
S106
STORE IMAGE CONVERTED YUV IN MEMORY
S108
EXTRACT BLOCK(n,m)
S110
NUMBER OF PIXELS SATISFYING EQUATION(8) >TH8
NO
YES
S112
F_V(n,m) = 0
S114
F_V(n,m) = 1
S116
NUMBER OF PIXELS SATISFYING EQUATION(9) >TH9
NO
YES
S118
F_U(n,m) = 0
S120
F_U(n,m) = 1
S122
NUMBER OF PIXELS SATISFYING EQUATION(10) >TH10
NO
YES
S124
F_Y(n,m) = 0
S126
F_Y(n,m) = 1
S128
(n,m) = (n1-1, m1-1)
NO
YES
S130
STORE RESOLUTION INFORMATION IN MEMORY
S132
CREATE EACH DATA FOR ENCODING
S134
STORE EACH DATA IN MEMORY
S136
ENCODE EACH DATA
S138
CREATE OUTPUT DATA
END

FIG. 18

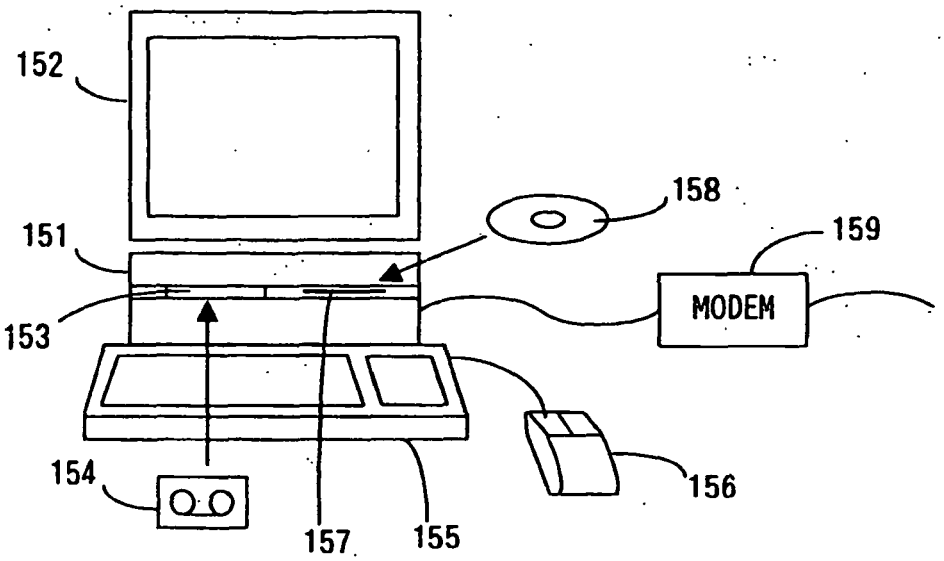


FIG. 19

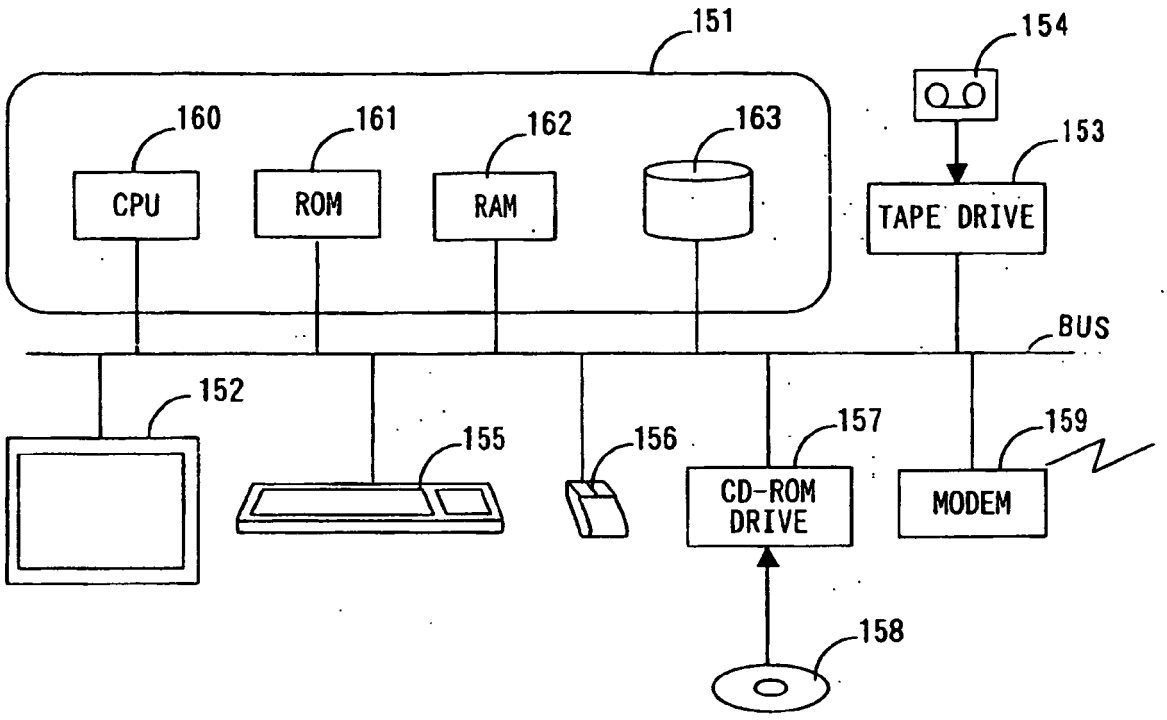

151
154
160
161
162
163
153
CPU
ROM
RAM
TAPE DRIVE
BUS
152
155
156
157
159
CD-ROM DRIVE
MODEM
158

FIG. 20A

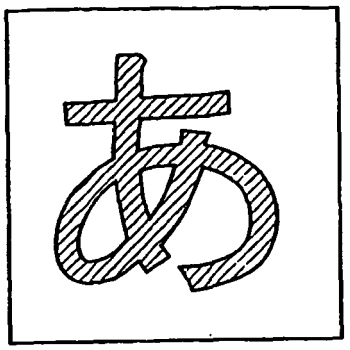
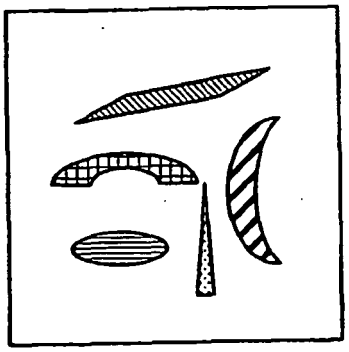


FIG. 20B



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 7221993 A **[0002]**
- EP 0608618 A2 **[0005]**
- US 4319267 A **[0006]**
- JP 63296583 A **[0007]**