

**TITLE OF INVENTION: IMAGE COMPRESSION APPARATUS, IMAGE
DECOMPRESSION APPARATUS, IMAGE COMPRESSION PROGRAM,
IMAGE DECOMPRESSION PROGRAM, AND DATA STRUCTURE**

[Technical Field]

[0001] The invention relates to an image compression apparatus, an image decompression apparatus, an image compression program, an image decompression program, and a data structure.

[Background of the Invention]

[0002] Conventionally, high-speed compression of an image is required to store and transmit medical image data such as a radiographic image and a computed tomography (CT) image efficiently. For example, in Patent Document 1, a method for compressing image data which shows an image captured by using radiation is disclosed. Further, a method for compressing block data, which is a portion of a plurality of pieces of image data with a plurality of processors in order to increase the speed of compression of the image data, is known. For example, in Patent Document 2, a system that encodes each of a plurality of pieces of block data with a Huffman code is disclosed.

[Prior Art]

[Patent Document]

[0003]

Patent Document 1: Japanese Unexamined Patent Application Publication No. 2011-130880

Patent Document 2: Japanese Unexamined Patent Application Publication No. 2004-104677

[Summary of Invention]

[Problems to be solved by the Invention]

[0004] There has been a problem that the compression processing by using a Huffman code takes a long processing time because a process of tallying frequency of a pixel value in image data is conducted. In image data whose background region is large like medical image data, the same pixel value often continues both in a vertical direction and in a horizontal direction. For example, a lot of medical image data is characterized in that the pixel values in many of the pixels of the image data are 0 because the pixel values of positions without images of a portion of a body are 0. Accordingly, an image compression apparatus that can compress image data at a high speed by using such characteristics of image data is desired.

[0005] The present invention is created in view of the aforementioned circumstances and is to provide an image compression apparatus, an image compression program, and a data structure that can compress image data at a high speed. Further, the present invention is to provide an image decompression apparatus and an image decompression program that can restore compressed image data generated by the image compression apparatus and the image compression program.

[Means for solving the problems]

[0006] In the first aspect of the present invention, an image compression apparatus comprising an image data acquiring section that acquires image data, a dividing section that divides block data that is a portion of the image data into a plurality of pieces of sub-block data that contains a plurality of pieces of pixel information indicating pixel values of pixels in the image data, a compressing section that generates compressed sub-block data by compressing the sub-block data, and a combining section that

generates compressed image data by combining the compressed sub-block data, wherein the compressing section includes an identifying section that identifies a minimum value from the pixel values of the plurality of pieces of pixel information, a subtracting section that subtracts the minimum value from the pixel values of the plurality of pieces of pixel information, and a generating section that generates the compressed sub-block data that contains i) the compressed pixel information in which (a) the pixel value of the valid pixel information, which is pixel information with a pixel value other than a predetermined value, after the minimum value is subtracted by the subtracting section and (b) information that identifies the position of the pixel having the pixel value are associated with each other and ii) information indicating the minimum value is provided.

[0007] In the above-mentioned image compression apparatus, each of the plurality of pieces of pixel information may have a predetermined data length, the identifying section may identify a maximum value from the pixel values of the plurality of pieces of pixel information, the generating section may generate the compressed sub-block data by changing the predetermined data length to a data length corresponding to the pixel value obtained by subtracting the minimum value from the maximum value.

[0008] In the above-mentioned image compression apparatus, the identifying section may identify the number of pieces of the valid pixel information on the basis of the pixel values of the plurality of pieces of pixel information, the generating section may generate the compressed sub-block data that contains i) map data that stores information, indicating whether each of the plurality of pieces of pixel information is the valid pixel information or not, in an order of the plurality of pieces of pixel information in the sub-block data when the number of pieces of the valid pixel information is within a

predetermined range and ii) the pixel value of the valid pixel information after the minimum value is subtracted by the subtracting section. In the above-identified image compression apparatus, a plurality of the compressing sections may compress the plurality of pieces of sub-block data in parallel.

[0009] In the second aspect of the present invention, an image compression program that causes a computer to operate as an image data acquiring section that acquires image data, a dividing section that divides block data that is a portion of the image data into a plurality of pieces of sub-block data that contains a plurality of pieces of pixel information indicating pixel values of pixels in the image data, a compressing section that generates compressed sub-block data by compressing the sub-block data, and a combining section that generates compressed image data by combining the compressed sub-block data, wherein the compressing section includes an identifying section that identifies a minimum value from the pixel values of the plurality of pieces of pixel information, a subtracting section that subtracts the minimum value from the pixel values of the plurality of pieces of pixel information, and a generating section that generates the compressed sub-block data that contains i) the compressed pixel information in which (a) the pixel value of the valid pixel information, which is pixel information with a pixel value other than a predetermined value after the minimum value is subtracted by the subtracting section and (b) information that identifies the position of the pixel having the pixel value are associated with each other and ii) information indicating the minimum value is provided.

[0010] In the third aspect of the present invention, an image decompression apparatus comprising an image data acquiring section that acquires compressed image data generated by compressing image data, a dividing section that divides the compressed

image data and acquires compressed sub-block data that constitutes compressed block data that is a portion of the compressed image data, a decompressing section that restores sub-block data that contains a plurality of pieces of pixel information indicating pixel values of pixels in the image data that constitutes block data that is a portion of the image data by decompressing the compressed sub-block data, and a combining section that restores the image data by combining the plurality of pieces of sub-block data restored by the decompressing section, wherein the compressed sub-block data contains i) a minimum value of a plurality of pixel values contained in the sub-block data and ii) compressed pixel information in which (a) the pixel value of the valid pixel information with a pixel value in the image data other than a predetermined value after the minimum value is subtracted and (b) information that identifies the position of the pixel having the pixel value are associated with each other, wherein the decompressing section includes a minimum value acquiring section that acquires a minimum value from the compressed image data, a pixel restoring section that restores the pixel information contained in sub-block data on the basis of the compressed pixel information contained in the compressed sub-block data, and a pixel value restoring section that restores a pixel value before compression by adding the minimum value to each of the pixel values of the pixel information restored by the pixel restoring section is provided.

[0011] In the fourth aspect of the present invention, an image decompression program that causes a computer to operate as an image data acquiring section that acquires compressed image data that is generated by compressing image data, a dividing section that acquires compressed sub-block data that constitutes compressed block data that is a portion of the compressed image data by dividing the compressed image data, a decompressing section that restores sub-block data that contains a plurality of pieces of

pixel information indicating pixel values of pixels in the image data that constitutes block data that is a portion of the image data by decompressing the compressed sub-block data, and a combining section that restores the image data by combining the plurality of pieces of sub-block data restored by the decompressing section, wherein the compressed sub-block data contains i) a minimum value of a plurality of pixel values contained in the sub-block data and ii) compressed pixel information in which (a) the pixel value of the valid pixel information with a pixel value in the image data other than a predetermined value after the minimum value is subtracted and (b) information that identifies the position of pixel having the pixel value are associated with each other, wherein the decompressing section includes a minimum value acquiring section that acquires a minimum value from the compressed image data, a pixel restoring section that restores the pixel information contained in sub-block data on the basis of the compressed pixel information contained in the compressed sub-block data, and a pixel value restoring section that restores a pixel value before compression by adding the minimum value to each of the pixel values of the pixel information restored by the pixel restoring section is provided.

[0012] In the fifth aspect of the present invention, a data structure of compressed sub-block data constituting compressed image data that is generated by compressing image data, the data structure comprising a minimum value of a pixel value in pixel information indicating a pixel value of a pixel contained in the image data, and compressed pixel information in which a pixel value after the minimum value is subtracted from the pixel value of the pixel information and information that identifies the position of the pixel having the pixel value are associated with each other is provided.

[Effects of the Invention]

[0013] According to the present invention, image data can be compressed at a high speed.

[Brief Description of the Drawings]

[0014]

FIG. 1 shows an outline of an image processing system according to the present exemplary embodiment.

FIG. 2 shows a block diagram showing a function configuration of an image compression apparatus according to the present exemplary embodiment.

FIG. 3 shows a flowchart of image compression processing of the image compression apparatus according to the present exemplary embodiment.

FIG. 4 shows a flowchart of sub-block data compression processing according to the present exemplary embodiment.

FIG. 5 shows a flowchart of sub-block data generating processing according to the present exemplary embodiment.

FIG. 6A shows a configuration of compressed image data according to the present exemplary embodiment.

FIG. 6B shows a configuration of compressed sub-block data according to the present exemplary embodiment.

FIG. 7A shows a state of sub-block data before compression according to the present exemplary embodiment.

FIG. 7B shows an example where a minimum value is subtracted by a subtracting section according to the present exemplary embodiment.

FIG. 8A shows a body section of the sub-block data generated by processing of a

processing pattern 1 according to the present exemplary embodiment.

FIG. 8B shows the body section of the sub-block data generated by the processing of a processing pattern 2 according to the present exemplary embodiment.

FIG. 8C shows the body section of the sub-block data generated by the processing of a processing pattern 3 according to the present exemplary embodiment.

FIG. 8D shows the body section of the sub-block data generated by the processing of a processing pattern 4 according to the present exemplary embodiment.

FIG. 9 shows a block diagram showing a function configuration of an image decompression apparatus according to the present exemplary embodiment.

FIG. 10 shows a flowchart of a flow of decompression processing of the image decompression apparatus according to the present exemplary embodiment.

FIG. 11 shows a flowchart of the decompression processing by a decompressing section according to the present exemplary embodiment.

[Description of Embodiments]

[0015] FIG. 1 shows an outline of an image processing system S according to the present exemplary embodiment. The image processing system S includes an image compression apparatus 1 that generates compressed image data by compressing image data and an image decompression apparatus 2 that restores medical image data from the compressed image data generated by the image compression apparatus 1.

[0016] The image compression apparatus 1 divides the image data into a plurality of pieces of block data, and divides the block data into sub-block data containing a plurality of pieces of pixel information indicating pixel values of pixels in the image data. Also, the image compression apparatus 1 generates the compressed image data by compressing the sub-block data. Here, the image data is medical image data such

as Computed Tomography (CT) image data and Magnetic Resonance Imaging (MRI) image data.

[0017] Hereinafter, details of the image compression apparatus 1 are described. FIG. 2 shows a block diagram showing a function configuration of the image compression apparatus 1 according to the present exemplary embodiment. As shown in FIG. 2, the image compression apparatus 1 includes a display section 11, an inputting section 12, a storage section 13, a control section 14, and a plurality of compressing sections 15.

[0018] The display section 11 contains, for example, a liquid crystal display, an organic Electro-Luminescence (EL) display, or the like. The display section 11 displays, for example, an operation screen for the compression processing of image data and the like in response to control by the control section 14. The inputting section 12 contains, for example, a keyboard, a mouse, and the like. The inputting section 12 accepts an operation input of a user of the image compression apparatus 1.

[0019] The storage section 13 contains, for example, a Read Only Memory (ROM), a Random Access Memory (RAM), a hard disk, an external memory connected to the image compression apparatus 1, and the like. Here, the external memory may be connected directly to the image compression apparatus 1 or connected through a communication network (not shown in the figure) so as to communicate with it. The storage section 13 stores, for example, medical image data as the image data to be compressed. Further, the storage part 13 stores an image compression program which makes a computer operate as an image data acquiring section 141, a size-adjusting section 142, a dividing section 143, a combining section 144, an outputting section 145, and a compressing section 15, which are described further below.

[0020] The control section 14 contains, for example, a Central Processor Unit (CPU).

The control section 14 controls functions of the image compression apparatus 1 by executing various programs for operating the image compression apparatus 1 stored in the storage section 13. The control section 14 includes the image data acquiring section 141, the size-adjusting section 142, the dividing section 143, the combining section 144, and the outputting section 145. Hereinafter, each function is described by referring to a flowchart as necessary. FIG. 3 shows the flowchart of a flow of image compression processing of the image compression apparatus 1 according to the present exemplary embodiment. FIG. 4 shows the flowchart of sub-block data compression processing according to the present exemplary embodiment. FIG. 5 shows the flowchart of compressed sub-block data generating processing according to the present exemplary embodiment.

[0021] First, an entire flow of the image compression processing is described by referring to FIG. 3. The image data acquiring section 141 acquires the image data (S1). Specifically, the image data acquiring section 141 acquires the image data stored in the storage section 13 in response to an acceptance of an operation of acquiring the image data in the inputting section 12. Further, the image data acquiring section 141 may acquire the image data by receiving the image data from the external memory connected to the image compression apparatus 1 through a communication network.

[0022] The size-adjusting section 142 adjusts a size of the image data acquired by the image data acquiring part 141 (S2). Specifically, the size-adjusting section 142 adds pixels with a pixel value of 0 to the image data so that each of the number of pixels in a row direction and the number of pixels in a column direction of the acquired image data becomes a multiple of 4.

[0023] The dividing section 143 divides the block data that is a portion of the acquired

image data into a plurality of pieces of sub-block data that contains a plurality of pieces of pixel information indicating the pixel values of the pixels in the image data (S3). Specifically, the image data acquiring section 141 initially determines the number of pieces of the block data that constitutes the image data and divides the block data. Here, the number of pieces of block data in the row direction is bh and the number of lines in the column direction is bw . Next, the image data acquiring section 141 determines the number of pieces of the sub-block data that constitutes the block data. When, for example, the number of pixels of the sub-block data in the row direction is sh and the number of pixels in the column direction is sw , the dividing section 143 determines the number of pieces of the sub-block data so that $sw \times sh$ is from 16 to 128 and divides the sub-block data into this number.

[0024] Next, the dividing section 143 obtains a buffer area of each piece of data (S4). Specifically, the dividing section 143 obtains the buffer area of the compressed block data, which is compressed data of each piece of the block data, in the storage section 13. A capacity of the buffer area is, for example, $sh \times sw \times 396 + 4$. Further, the dividing section 143 determines the size of the buffer area of the compressed image data according to the number of pieces of the compressed block data and obtains the buffer area of the compressed image data.

[0025] Here, the configuration of the compressed image data is described. FIG. 6A shows the configuration of the compressed image data. FIG. 6B shows the configuration of the compressed sub-block data contained in the compressed image data.

[0026] As shown in FIG. 6A, the compressed image data consists of a header section and a body section. The header section of the compressed image data stores the

number of pieces of the compressed block data contained in the body section, the number of pieces of the compressed sub-block data, and the number of pixels in the row direction and the number of pixels in the column direction of the image data before the size is adjusted by the size-adjusting section 142. For example, the 1st to 8th bytes of the header section of the compressed image data store the number of pieces of the block data in the row direction bh , the number of pieces of the block data in the column direction bw , the number of pixels of the sub-block data in the row direction sh , and the number of pixels of the sub-block data in the column direction sw . Further, the 9th to 12th bytes of the header section store “width” which is the number of pixels of the image data in the column direction and “height” which is the number of pixels in the row direction before the size of the image data is adjusted. The body section of the compressed image data stores one or more pieces of block data.

[0027] As shown in FIG. 6A, the compressed block data consists of the header section and the body section. The header section of the compressed block data stores an address indicating a position of the block data in the image data and a size of the body section. The body section of the compressed block data stores one or more pieces of compressed sub-block data.

[0028] As shown in FIG. 6B, the compressed sub-block data consists of the header section and the body section. The header section of the compressed sub-block data is divided into a plurality of areas. Specifically, the address indicating the position of the sub-block data in the block data and a data length of the compressed sub-block data are stored in the 1st to 16th bits. More specifically, the address of the sub-block data is stored in the 1st to 7th bits. The data length of the compressed sub-block data is stored in the 8th to 16th bits. Information indicating the minimum value among the pixel

values of the pixel information contained in the sub-block data is stored in the 17th to 29th bits.

[0029] Pattern information indicating the data length of the pixel information after compression is stored in the 30th to 32nd bits. The data length after the compression is, for example, any of 0 bits, 4 bits, 6 bits, 8 bits, 10 bits, and 12 bits. That is, binary pattern information for distinguishing these bit lengths is stored in the 30th to 32th bits.

[0030] *The number of pieces of valid pixel information is stored in the 33rd to 41st bits.*

The number of pieces of valid unit data is stored in the 42nd to 48th bits. The valid pixel information and the valid unit data are described below. The pixel value of invalid pixel information is stored in the 49th to 64th bits. Unit data or the valid pixel information is stored in the body section of the compressed sub-block data.

[0031] The dividing section 143 inputs the sub-block data into the compressing section 15. Here, the pixel values of the plurality of pieces of pixel information contained in the sub-block data are represented, for example, in binary. Each of these pluralities of pieces of pixel information has a predetermined data length (for example, 12 bits).

[0032] The plurality of compressing sections 15 contains, for example, a Graphics Processing Unit (GPU) including a plurality of cores. Each of the plurality of compressing sections 15 corresponds to any of the plurality of cores that constitute the GPU. Each of the plurality of compressing sections 15 executes sub-block data compression processing that is processing for generating the compressed sub-block data by compressing the sub-block data (S5). The plurality of compressing sections 15 generates the compressed sub-block data by compressing the plurality of pieces of sub-block data inputted by the control section 14 in parallel. The processing of the compressing section 15 is described below.

[0033] The combining section 144 generates the compressed image data by combining the compressed sub-block data. Specifically, the combining section 144 calculates the size of the compressed block data on the basis of the size of the compressed sub-block data generated by the compressing sections 15 (S6). The combining section 144 stores the calculated size of the compressed block data and the plurality of pieces of compressed sub-block data in a buffer of the compressed block data and generates the compressed block data (S7). Here, the combining section 144 stores the compressed sub-block data in the buffer on the basis of the position of the sub-block data before compression of the compressed sub-block data.

[0034] Next, the combining section 144 generates the compressed image data by combining the plurality of pieces of compressed block data (S8).

[0035] The outputting section 145 outputs the compressed image data generated by the combining section 144. The outputting section 145, for example, transmits the compressed image data to the image decompression apparatus 2 through a communication line or stores the compressed image data in a storage medium.

[0036] Next, details of the processing of the compressing section 15 are described. Each of the plurality of compressing sections 15 includes an identifying section 151, a subtracting section 152, and a generating section 153. FIG. 7A and FIG. 7B show a process of generating the sub-block data. FIG. 7A shows a state of the sub-block data before compression. Further, in order to simplify explanations, it is assumed that the sub-block data contains the pixel information of 16 pixels p1-p16 in FIG. 7A and FIG. 7B. Further, a total length of white bars and black bars shown in FIG. 7A and FIG. 7B indicates the data length of the pixel information (a predetermined data length) and the black bars indicate the pixel value of the pixels. For example, when the black bars are

short, the pixel values are small and when the black bars are long, the pixel values are big.

[0037] Hereinafter, details of the sub-block data compression processing in the compressing section 15 are described by referring to FIG. 4. The identifying section 151 identifies the minimum value and the maximum value from the pixel values contained in the plurality of pieces of pixel information contained in the sub-block data (S51). In the example shown in FIG. 7A, the identifying section 151 identifies the pixel values of the pixels p1-p6 as the minimum value and identifies the pixel value of the pixel p9 as the maximum value. The identifying section 151 stores information indicating the minimum value from the minimum value and the maximum value in the 17th to 29th bits, which is a portion of the header section of the sub-block data.

[0038] Next, the identifying section 151 identifies the valid pixel information from the plurality of pieces of pixel information contained in the sub-block data (S52). The valid pixel information is pixel information with a pixel value other than a predetermined value. Further, the invalid pixel information is pixel information whose pixel value is the predetermined value. Here, the predetermined value is the minimum value identified by the identifying section 151. For example, in FIG. 7A, the identifying section 151 identifies the pixels p1-p6 as the pixels of the invalid pixel information and identifies the pixels p7-p16 as the pixels of the valid pixel information. The identifying section 151 stores the number of pieces of the valid pixel information in the 33rd to 41st bits of the header section of the compressed sub-block data. Further, the predetermined value is the minimum value in the present exemplary embodiment, but it is not necessarily so limited. For example, the predetermined value may be the pixel value whose appearance frequency is the highest among the plurality of pieces of

pixel information, instead of the minimum value.

[0039] Next, the identifying section 151 identifies the data length of the pixel information after compression contained in the sub-block data (S53). Specifically, the identifying section 151 identifies the data length after compression of the data length of the pixel information (the predetermined data length) as the data length that corresponds to the pixel value obtained by subtracting the minimum value from the maximum value. For example, the identifying section 151 identifies the data length corresponding to the smallest number of bits among the predetermined numbers of bits that are larger than the number of bits required when the pixel value is represented in binary and that are previously stored in the storage section 13 in association with the pixel value. Here, the predetermined numbers of bits are 0 bits or 4 bits, 6 bits, 8 bits, 10 bits, or 12 bits.

[0040] The identifying section 151 stores the pattern information indicating the data length after compression in the 30th to 32nd bits in the header section of the sub-block data. Further, the identifying section 151 may identify a first data length obtained by subtracting the data length corresponding to the minimum value from the data length of the pixel information as the data length after compression.

[0041] Next, the number of pieces of the valid unit data contained in the sub-block data is identified (S54). Here, the valid unit data is data that constitutes the sub-block data and contains the valid pixel information after the minimum value is subtracted by the undermentioned subtracting section 152. Further, when the data length after the compression is 8 bits or when the number of pieces of the valid pixel information contained in the compressed sub-block data is 32 or more, the valid unit data is not generated. Next, the identifying section 151 calculates the number of pieces of the valid pixel information in each piece of the valid unit data (S55).

[0042] The subtracting section 152 subtracts the minimum value identified by the identifying section 151 from the pixel contained in the plurality of pieces of pixel information contained in the sub-block data (S56). For example, FIG. 7B shows an example where the minimum value is subtracted from the pixel values of the pixels p1-p16 by the subtracting section 152.

[0043] The generating section 153 generates the compressed sub-block data by executing compressed sub-block data generating processing (S57). Specifically, by executing the compressed sub-block data generating processing, the generating section 153 generates the compressed sub-block data that contains i) the compressed pixel information in which the pixel value of the valid pixel information that is pixel information with a pixel value other than the predetermined value after a subtraction by the subtracting section 152 and information that identifies the position of the pixel having this pixel value are associated with each other and ii) the information indicating the minimum value. Hereinafter, the information that identifies the position of the pixel having this pixel value after the subtraction is also called “index information.”

[0044] Here, the generating section 153 generates the compressed sub-block data by changing the data length of the pixel information (the predetermined data length) to the data length identified by the identifying section 151 (the data length after compression). Further, the generating section 153 may generate the compressed sub-block data by changing the data length by subtracting the data length corresponding to the minimum value identified by the identifying section 151 from the predetermined data length.

[0045] Hereinafter, details of the compressed sub-block data generating processing are described by referring to FIG. 5. First, the generating section 153 determines a value of the data length after compression identified by the identifying section 151, performs

branching processing (S571), and generates the compressed sub-block data.

[0046] When the data length after the compression is 0 bits or 4 bits, the generating section 153 performs processing of a processing pattern 1 (S572). FIG. 8A shows the body section of the compressed sub-block data generated with the processing of the processing pattern 1. The generating section 153 performs different processing when the number of pieces of the valid pixel information is from 0 to 31, when the number of pieces of the valid pixel information is from 32 to 191, and when the number of pieces of the valid pixel information is from 192 to 256, and generates the body section of the compressed sub-block data.

[0047] Specifically, the generating section 153 generates valid unit data when the number of pieces of the valid pixel information is from 0 to 31, and stores the generated valid unit data in the body section of the compressed sub-block data. A piece of valid unit data contains the pixel information of 4 rows and 4 columns. This data length of the header section of this valid unit data is 8 bits. The generating section 153 stores the information that identifies the position of the valid unit data in the sub-block data in the 1st to 4th bits of the header section of the valid unit data and stores the number of pieces of the valid pixel information in the 5th to 8th bits.

[0048] The generating section 153 stores the address that indicates the position of the pixel information in the valid unit data in the 1st to 4th bits of the plurality of pieces of valid pixel information contained in the body section of this valid unit data and stores the pixel value after a subtraction by the subtracting section 152 in the 5th to 8th bits. Here, the invalid pixel information, that is, pixel information whose pixel value after the subtraction by the subtracting section 152 is 0, is not stored in the body section of the valid unit data.

[0049] For example, the pixels p1-p16 shown in FIG. 7B are stored in 4 pieces of unit data containing the pixel information of 2 rows and 2 columns in order. Here, the body section of first unit data can store the pixels p1-p4, but the first unit data is not the valid unit data and is not stored in the compressed sub-block data because the pixels p1-p4 are not the valid pixel information. Similarly, the body section of second unit data can store the pixels p5-p8, but the pixel values of the pixels p7 and p8 and the index information are stored in the body section of the second unit data because the pixels p5 and p6 are not the valid pixel information. When the number of pieces of the pixel information contained in the unit data is 4, the index information is, for example, the information of 2 bits.

[0050] When the number of pieces of the valid pixel information is from 32 to 191, the generating section 153 generates the compressed sub-block data containing map data and the pixel value of the valid pixel information after the minimum value is subtracted by the subtracting section 152. That is, when the number of pieces of the valid pixel information is in a predetermined range, the generating section 153 generates the compressed sub-block data containing the map data and the pixel value of the valid pixel information after the minimum value is subtracted by the subtracting section 152.

[0051] The map data stores information indicating whether each of the plurality of pieces of pixel information is the valid pixel information or not in an arrangement order of the plurality of pieces of pixel information in the sub-block, and consists of a number of bits equal to the number of pieces of the pixel information contained in the sub-block data. For example, when the sub-block data contains the pixel information of 16×16, the map data is binary information of 256 bits. Each bit of the map data shows a state of the pixel value at the position of the pixel information contained in the body section

of the sub-block data. The bit whose bit value is 0 in the map data shows the invalid pixel information and the bit whose bit value is 1 shows the valid pixel information.

[0052] The generating section 153 stores the map data and the pixel value of the valid pixel information (4 bits) in the body section of the compressed sub-block data. Here, when n is an odd number, the generating section 153 inserts 4 bits of dummy data (the pixel information whose pixel value is 0) into the body section of the compressed sub-block data. When the number of pieces of the valid pixel information is from 192 to 256, the generating section 153 stores the pixel values of all pixel information (4 bits) in the body section of the compressed sub-block data in the order of positions of the pixel information.

[0053] The description now refers to FIG. 5. When the data length after the compression is 6 bits, the generating section 153 performs the processing of a processing pattern 2 (S573).

FIG. 8B shows the body section of the compressed sub-block data generated by the processing of the processing pattern 2. The generating section 153 performs different processing when the number of pieces of the valid pixel information is from 0 to 31, when the number of pieces of the valid pixel information is from 32 to 212, and when the number of pieces of the valid pixel information is from 213 to 256 and generates the body section of the compressed sub-block data.

[0054] Specifically, the generating section 153 generates the valid unit data when the number of pieces of the valid pixel information is from 0 to 31, and stores the generated valid unit data in the body section of the compressed sub-block data. A piece of valid unit data contains the pixel information of 2 rows and 2 columns. The data length of the header section of this valid unit data is 8 bits. The generating section 153 stores

the address indicating the position of the valid unit data in the sub-block data in the 1st to 6th bits of the header section of the valid unit data and stores the number of pieces of the valid pixel information in the 7th to 8th bits.

[0055] The generating section 153 stores the address indicating the position of the pixel information in the valid unit data in the 1st to 2nd bit of the plurality of pieces of valid pixel information contained in the body section of this valid unit data and stores the pixel value after a subtraction by the subtracting section 152 in the 3rd to 8th bits. Here, the invalid pixel information is not stored in the body section.

[0056] When the number of pieces of the valid pixel information is from 32 to 212, the generating section 153 generates the map data in a way similar to the above. The generating section 153 stores the map data and the pixel value of the valid pixel information (6 bits) in the body section of the compressed sub-block data. Here, the generating section 153 inserts k bits of dummy data (the pixel information whose pixel value is 0) into the body section so that $n \times 6 + k = 24$ is satisfied. When the number of pieces of the valid pixel information is from 213 to 256, the generating section 153 stores the pixel values of all pixel information (6 bits) in the body section of the compressed sub-block data in the order of positions of the pixel information.

[0057] The description now refers to FIG. 5. When the data length is 8 bits, the generating section 153 performs the processing of a processing pattern 3 (S574).

FIG. 8C shows the body section of the compressed sub-block data generated by the processing of the processing pattern 3. The generating section 153 performs different processing when the number of pieces of the valid pixel information is from 0 to 31, when the number of pieces of the valid pixel information is from 32 to 223, and when the number of pieces of the valid pixel information is from 224 to 256 and generates the

body section of the compressed sub-block data.

[0058] Specifically, when the number of pieces of the valid pixel information is from 0 to 31, the generating section 153 stores the pixel information of the valid pixel in the body section of the compressed sub-block data. The generating section 153 stores the address indicating the position of the pixel information in the sub-block data in the 1st to 8th bits of this body section and stores the pixel value of the valid pixel information after a subtraction by the subtracting section 152 in the 9th to 16th bits.

[0059] When the number of pieces of the valid pixel information is from 32 to 223, the generating section 153 generates the map data in a way similar to the above. The generating section 153 stores the map data and the pixel value of the valid pixel information (8 bits) in the body section of the compressed sub-block data. When the number of pieces of the valid pixel information is from 224 to 256, the generating section 153 stores the pixel values of all pixel information (8 bits) in the body section of the compressed sub-block data in the order of positions of the pixel information.

[0060] The description now refers to FIG. 5. When the data length is 10 bits or 12 bits, the generating section 153 performs the processing of a processing pattern 4 (S575).

FIG. 8D shows the body section of the compressed sub-block data generated by the processing of the processing pattern 4. The generating section 153 performs different processing when the number of pieces of the valid pixel information is from 0 to 31, when the number of pieces of the valid pixel information is from 32 to 234, and when the number of pieces of the valid pixel information is from 235 to 256 and generates the body section of the compressed sub-block data.

[0061] Specifically, the generating section 153 generates the valid unit data when the number of pieces of the valid pixel information is from 0 to 31, and stores the generated

valid unit data in the body section of the compressed sub-block data. A piece of valid unit data contains the pixel information of 4 rows and 4 columns. The data length of the header section of the valid unit data is 8 bits. The generating section 153 stores the address indicating the position of the valid unit data in the sub-block data in the 1st to 4th bits of the header section of the valid unit data and stores the number of pieces of the valid pixel information in the 5th to 8th bits. The generating section 153 stores the address indicating the position of the pixel information in the valid unit data in the 1st to 4th bits of the plurality of pieces of valid pixel information contained in the body section of this valid unit data and stores the pixel value of the valid pixel information after a subtraction by the subtracting section 152 in the 5th to 16th bits.

[0062] When the number of pieces of the valid pixel information is from 32 to 234, the subtracting section 153 generates the map data in a way similar to the above. The generating section 153 stores the map data and the pixel value of the valid pixel information (12 bits) in the body section of the compressed sub-block data. Here, when n is an odd number, the generating section 153 inserts 12 bits of dummy data (the pixel information whose pixel value is 0) into the body section. When the number of pieces of the valid pixel information is from 235 to 256, the generating section 153 stores the pixel values of all pixel information (12 bits) in the body section of the compressed sub-block data.

[0063] Next, details of the image decompression apparatus 2 are described. FIG. 9 shows a block diagram showing a function configuration of the image decompression apparatus 2 according to the present exemplary embodiment.

As shown in FIG. 9, the image decompression apparatus 2 includes a display section 21, an inputting section 22, a storage section 23, a control section 24, and a plurality of

decompressing sections 25.

[0064] The display part 21 contains, for example, a liquid crystal display, an organic EL display, or the like. The display section 21 displays, for example, an operation screen for the decompression processing and the like in response to control by the control section 24. The inputting section 22 contains, for example, a keyboard, a mouse, and the like. The inputting section 22 accepts an operation input of a user of the image decompression apparatus 2.

[0065] The storage section 23 contains, for example, a ROM, a RAM, a hard disk, an external memory connected to the image decompression apparatus 2, and the like. Here, the external memory may be connected directly to the image decompression apparatus 2 or connected through a communication network so as to communicate with it. The storage section 23 may store the compressed image data generated by compressing the image data. Further, the storage part 23 stores an image decompression program which makes a computer operate as an image data acquiring section 241, a dividing section 242, a combining section 243, a size-adjusting section 244, an outputting section 245, and a decompressing section 25, which are described further below.

[0066] The control section 24 contains, for example, a CPU. The control section 24 controls functions of the image decompression apparatus 2 by executing various programs for operating the image decompression apparatus 2 stored in the storage section 23.

The control section 24 includes the image data acquiring section 241, the dividing section 242, the combining section 243, the size-adjusting section 244, and the outputting section 245. Hereinafter, each function is described by referring to a

flowchart as necessary. FIG. 10 shows the flowchart of a flow of decompression processing of the image decompression apparatus 2 according to the present exemplary embodiment.

[0067] The image data acquiring section 241 acquires the compressed image data generated by compressing the image data (S11). Specifically, the image data acquiring section 241 acquires the compressed image data by receiving the compressed image data from the external apparatus such as the image compression apparatus 1 that is connected to the image decompression apparatus 2 through a communication network. Further, the image data acquiring section 241 may receive the compressed image data from the image compression apparatus 1 and store it in the storage section 23, and may acquire the compressed image data stored in the storage section 23 in response to an acceptance of an operation of acquiring the compressed image data in the inputting section 22.

[0068] The dividing section 242 divides the compressed image data received by the image data acquiring section 241 into a plurality of pieces of compressed block data. Then, the dividing section 242 further divides the compressed image data and acquires a plurality of pieces of compressed sub-block data that constitutes the compressed block data that is a portion of the compressed image data (S12). The dividing section 242 inputs the plurality of pieces of acquired compressed sub-block data into the plurality of decompressing sections 25.

[0069] The plurality of decompressing sections 25 contains, for example, a GPU. The plurality of decompressing sections 25 decompresses the compressed sub-block data by executing the decompression processing and restores the sub-block data that contains a plurality of pieces of pixel information indicating the pixel values of the pixels in the

image data that constitutes the block data that is a portion of the compressed image data (S13).

Further, the plurality of decompressing sections 25 decompresses the plurality of pieces of compressed sub-block data inputted by the control section 24 in parallel. The processing of the decompressing sections 25 is described below.

[0070] The combining section 243 restores the image data by combining the plurality of pieces of sub-block data restored by the decompressing sections 25 (S14). Specifically, the combining section 243 combines the plurality of pieces of restored sub-block data on the basis of an address of the sub-block data stored in the header section of the compressed sub-block data and restores the block data. Then, the combining section 243 restores the image data by combining the plurality of pieces of restored block data on the basis of an address of the block data stored in the header section of the compressed block data.

[0071] The size-adjusting section 244 adjusts the size of the restored image data (S15). Specifically, the size-adjusting section 244 adjusts the size of the restored image data on the basis of “width” which is the number of pixels of the image data in the column direction and “height” which is the number of pixels in the row direction before adjusting the size of the image data stored in the header section of the compressed image data. The outputting section 245 outputs the image data after the size adjustment by the size-adjusting section 244. The outputting section 245 displays the image data, for example, on the display section 21.

[0072] Next, details of the processing of the decompressing sections 25 are described. Each of the plurality of decompressing sections 25 includes a minimum value acquiring section 251, a pixel restoring section 252, and a pixel value restoring section 253. FIG.

11 shows the flowchart of the decompression processing of the decompressing section 25 according to the present exemplary embodiment. Hereinafter, the processing of the decompressing section 25 for decompressing the compressed sub-block data compressed in the image compression apparatus 1 is described by referring to FIG. 11.

[0073] First, the minimum value acquiring section 251 acquires information indicating the minimum value stored in the header section of the compressed sub-block data (S131). The pixel restoring section 252 restores the pixel information contained in the sub-block data on the basis of the compressed pixel information contained in the compressed sub-block data. Next, the pixel restoring section 252 changes the data length of the pixel information to a predetermined data length (S132). Because a storage format of the compressed pixel information varies depending on the data length after compression and the number of pieces of the valid pixel information, the pixel restoring section 252 performs different processing on the basis of the data length after compression and the number of pieces of the valid pixel information, and restores the pixel information contained in the sub-block data.

[0074] Specifically, when the data length after the compression is 0 bits or 4 bits and the number of pieces of the valid pixel information is from 0 to 31, the pixel restoring section 252 identifies the position of the pixel of the valid pixel information contained in the unit data on the basis of the body section of the unit data stored in the compressed sub-block data. The pixel restoring section 252 identifies the pixel value of the pixel information whose position of the pixel cannot be identified as 0.

[0075] Further, when the data length after the compression is 0 bits or 4 bits and the number of pieces of the valid pixel information is from 32 to 191, the pixel restoring section 252 restores the pixel information on the basis of the map data. When the bit

value is 0 in the map data, the pixel information of the position corresponding to the bit value is restored on the basis of the pixel value of the invalid pixel information contained in the header section of the compressed sub-block data. Further, when the bit value is 1 in the map data, the pixel information of the position corresponding to the bit value is restored on the basis of the pixel value of the valid pixel information contained in the body section of the compressed sub-block data.

[0076] Furthermore, when the data length after the compression is 0 bits or 4 bits and the number of pieces of the valid pixel information is from 192 to 256, the pixel restoring section 252 restores the pixel information of the sub-block data on the basis of the pixel value of the pixel information contained in the body section of the compressed sub-block data.

[0077] Moreover, when the data length after the compression is 6 bits and the number of pieces of the valid pixel information is from 0 to 31, the pixel restoring section 252 identifies the position of the pixel of the valid pixel information contained in the unit data on the basis of the body section of the unit data stored in the compressed sub-block data. Further, the pixel restoring section 252 identifies the pixel value of the pixel information whose position of the pixel cannot be identified as 0.

[0078] Furthermore, when the data length after the compression is 6 bits and the number of pieces of the valid pixel information is from 32 to 212, the pixel restoring section 252 restores the pixel information on the basis of the map data. Moreover, when the data length after the compression is 6 bits and the number of pieces of the valid pixel information is from 213 to 256, the pixel restoring section 252 restores the pixel information of the sub-block data on the basis of the pixel value of the pixel information contained in the body section of the compressed sub-block data.

[0079] Moreover, when the data length after the compression is 8 bits and the number of pieces of the valid pixel information is from 0 to 31, the pixel restoring section 252 restores on the basis of the valid pixel information stored in the body section of the compressed sub-block data. Further, the pixel restoring section 252 identifies the pixel value of the pixel information whose position of the pixel cannot be identified as 0. Furthermore, when the data length after the compression is 8 bits and the number of pieces of the valid pixel information is from 32 to 223, the pixel restoring section 252 restores the pixel information on the basis of the map data. Moreover, when the data length after the compression is 8 bits and the number of pieces of the valid pixel information is from 224 to 256, the pixel restoring section 252 restores the pixel information of the sub-block data on the basis of the pixel value of the pixel information contained in the body section of the compressed sub-block data.

[0080] Further, when the data length after the compression is 10 bits or 12 bits and the number of pieces of the valid pixel information is from 0 to 31, the pixel restoring section 252 identifies the position of the pixel of the valid pixel information contained in the unit data on the basis of the body section of the unit data stored in the compressed sub-block data. Furthermore, the pixel restoring section 252 identifies the pixel value of the pixel information whose position of the pixel cannot be identified as 0. Moreover, when the data length after the compression is 10 bits or 12 bits and the number of pieces of the valid pixel information is from 32 to 234, the pixel restoring section 252 restores the pixel information on the basis of the map data. Further, when the data length after the compression is 10 bits or 12 bits and the number of pieces of the valid pixel information is from 235 to 256, the pixel restoring section 252 restores the pixel information of the sub-block data on the basis of the pixel value of the pixel

information contained in the body section of the compressed sub-block data.

[0081] The pixel value restoring section 253 restores the pixel value before the compression by adding the minimum value on the basis of the information indicating the minimum value acquired by the minimum value acquiring section 251 to each of the pixel values of the pixel information restored by the pixel restoring section 252 (S133).

[0082] According to the present exemplary embodiment, the compressing section 15 of the image compression apparatus 1 includes the identifying section 151 that identifies the minimum value from the plurality of pieces of pixel information, the subtracting section 152 that subtracts the minimum value from the pixel values of the plurality of pieces of pixel information, and the generating section 153 that generates the compressed sub-block data that contains i) the compressed pixel information in which the pixel value of the valid pixel information that is pixel information with a pixel value other than the predetermined value after the minimum value is subtracted by the subtracting section 152 and information that identifies the position of the pixel having this pixel value are associated with each other and ii) the information indicating the minimum value.

[0083] Consequently, the image compression apparatus 1 can reduce conditional branching processing in the processing and reduce the amount of processing in the image compression processing as compared with other compression systems such as Huffman coding. Accordingly, the image compression apparatus 1 can compress the medical image at a high speed. Further, the block data of the medical image data has little gradations and the minimum value and the maximum value of the pixel value of the pixel information contained in the sub-block data tend to be close. Therefore, the image compression apparatus 1 can compress the medical image data efficiently.

[0084] Furthermore, the compressing section 15 of the image compression apparatus 1 generates the compressed sub-block data by changing the predetermined data length that is the data length of the plurality of pieces of pixel information to the data length corresponding to the pixel value obtained by subtracting the minimum value from the maximum value using the generating section 153. Consequently, the image compression apparatus 1 can eliminate the unnecessary data length and compress efficiently. Moreover, because a plurality of compressing sections 15 of the image compression apparatus 1 is provided and they compress the plurality of pieces of sub-block data in parallel, they can compress at a high speed.

[0085] Further, when the number of pieces of the valid pixel information is within a predetermined range, the compressing section 15 of the image compression apparatus 1 generates the compressed sub-block data that contains i) the map data that stores the information indicating whether each of the plurality of pieces of pixel information is the valid pixel information or not in an order of the plurality of pieces of pixel information in the sub-block and ii) the pixel value of the valid pixel information after the minimum value is subtracted by the subtracting section 152 using the generating section 153. Consequently, the image compression apparatus 1 can represent whether or not there is valid pixel information in the map data with the minimum data number and compress the pixel information contained in the sub-block data efficiently.

[0086] Furthermore, the decompressing section 25 of the image decompression apparatus 2 acquires the minimum value from the compressed image data using the minimum value acquiring section 251, restores the pixel information contained in the sub-block data on the basis of the compressed pixel information contained in the compressed sub-block data using the pixel restoring section 252, and restores the pixel

value before compression by adding the minimum value to each piece of the restored pixel information using the pixel value restoring section 253. Also, the image data is restored by combining the plurality of pieces of restored sub-block data using the combining section 243. Consequently, the decompression apparatus 2 can restore the compressed image that is compressed by the image compression apparatus 1 to the image data at a high speed.

[0087] The present invention is described with the exemplary embodiments of the present invention but the technical scope of the present invention is not limited to the scope described in the above embodiment. It is apparent for those skilled in the art that it is possible to make various changes and modifications to the embodiment. It is apparent from the description of the scope of the claims that the forms added with such changes and modifications are included in the technical scope of the present invention. For example, in the present exemplary embodiment can be applied to other kinds of image data that is different from the medical image.

[0088]

[Explanations of the reference numerals]

1 image compression apparatus

2 image decompression apparatus

11, 21 display section

12, 22 inputting section

13, 23 storage section

14, 24 control section

15 compressing section

25 decompressing section

141, 241 image data acquiring section

142, 244 size-adjusting section

143, 242 dividing section

144, 243 combining section

145, 245 outputting section

151 identifying section

152 subtracting section

153 generating section

251 minimum value acquiring section

252 pixel restoring section

253 pixel value restoring section

S image processing system

CLAIMS

1. An image compression apparatus comprising:
 - an image data acquiring section that acquires image data;
 - a dividing section that divides block data that is a portion of the image data into a plurality of pieces of sub-block data that contains a plurality of pieces of pixel information indicating pixel values of pixels in the image data;
 - a compressing section that generates compressed sub-block data by compressing the sub-block data; and
 - a combining section that generates compressed image data by combining the compressed sub-block data, wherein
 - the compressing section includes:
 - an identifying section that identifies a minimum value from the pixel values of the plurality of pieces of pixel information,
 - a subtracting section that subtracts the minimum value from the pixel values of the plurality of pieces of pixel information, and
 - a generating section that generates the compressed sub-block data that contains
 - i) the compressed pixel information in which (a) the pixel value of the valid pixel information, which is pixel information with a pixel value other than a predetermined value, after the minimum value is subtracted by the subtracting section and (b) information that identifies the position of the pixel having the pixel value are associated with each other and ii) information indicating the minimum value.
2. The image compression apparatus according to Claim 1, wherein
 - each of the plurality of pieces of pixel information has a predetermined data

length, wherein

the identifying section identifies a maximum value from the pixel values of the plurality of pieces of pixel information, wherein

the generating section generates the compressed sub-block data by changing the predetermined data length to a data length corresponding to the pixel value obtained by subtracting the minimum value from the maximum value.

3. The image compression apparatus according to Claim 1 or 2, wherein

the identifying section identifies the number of pieces of the valid pixel information on the basis of the pixel values of the plurality of pieces of pixel information, wherein

the generating section generates the compressed sub-block data that contains i) map data that stores information, indicating whether each of the plurality of pieces of pixel information is the valid pixel information or not, in an order of the plurality of pieces of pixel information in the sub-block data when the number of pieces of the valid pixel information is within a predetermined range and ii) the pixel value of the valid pixel information after the minimum value is subtracted by the subtracting section.

4. The image compression apparatus according to any one of Claims 1 to 3, wherein

a plurality of the compressing sections compresses the plurality of pieces of sub-block data in parallel.

5. An image compression program that causes a computer to operate as:

an image data acquiring section that acquires image data,
 a dividing section that divides block data that is a portion of the image data into
 a plurality of pieces of sub-block data that contains a plurality of pieces of
 pixel information indicating pixel values of pixels in the image data,
 a compressing section that generates compressed sub-block data by
 compressing the sub-block data, and
 a combining section that generates compressed image data by combining the
 compressed sub-block data, wherein
 the compressing section includes:
 an identifying section that identifies a minimum value from the pixel values of
 the plurality of pieces of pixel information,
 a subtracting section that subtracts the minimum value from the pixel values of
 the plurality of pieces of pixel information, and
 a generating section that generates the compressed sub-block data that contains
 i) the compressed pixel information in which (a) the pixel value of the valid pixel
 information, which is pixel information with a pixel value other than a predetermined
 value, after the minimum value is subtracted by the subtracting section and (b)
 information that identifies the position of the pixel having the pixel value are associated
 with each other and ii) information indicating the minimum value.

6. *An image decompression apparatus comprising:*

an image data acquiring section that acquires compressed image data generated
 by compressing image data;
 a dividing section that divides the compressed image data and acquires

compressed sub-block data that constitutes compressed block data that is a portion of the compressed image data;

a decompressing section that restores sub-block data that contains a plurality of pieces of pixel information indicating pixel values of pixels in the image data that constitutes block data that is a portion of the image data by decompressing the compressed sub-block data; and

a combining section that restores the image data by combining the plurality of pieces of sub-block data restored by the decompressing section, wherein

the compressed sub-block data contains i) a minimum value of a plurality of pixel values contained in the sub-block data and ii) compressed pixel information in which (a) the pixel value of the valid pixel information with a pixel value in the image data other than a predetermined value after the minimum value is subtracted and (b) information that identifies the position of the pixel having the pixel value are associated with each other, wherein

the decompressing section includes:

a minimum value acquiring section that acquires a minimum value from the compressed image data,

a pixel restoring section that restores the pixel information contained in sub-block data on the basis of the compressed pixel information contained in the compressed sub-block data, and

a pixel value restoring section that restores a pixel value before compression by adding the minimum value to each of the pixel values of the pixel information restored by the pixel restoring section.

7. An image decompression program that causes a computer to operate as
 - an image data acquiring section that acquires compressed image data that is generated by compressing image data,
 - a dividing section that acquires compressed sub-block data that constitutes compressed block data that is a portion of the compressed image data by dividing the compressed image data,
 - a decompressing section that restores sub-block data that contains a plurality of pieces of pixel information indicating pixel values of pixels in the image data that constitutes block data that is a portion of the image data by decompressing the compressed sub-block data, and
 - a combining section that restores the image data by combining the plurality of pieces of sub-block data restored by the decompressing section, wherein
 - the compressed sub-block data contains i) a minimum value of a plurality of pixel values contained in the sub-block data and ii) compressed pixel information in which (a) the pixel value of the valid pixel information with a pixel value in the image data other than a predetermined value after the minimum value is subtracted and (b) information that identifies the position of pixel having the pixel value are associated with each other, wherein

the decompressing section includes:

- a minimum value acquiring section that acquires a minimum value from the compressed image data,

- a pixel restoring section that restores the pixel information contained in sub-block data on the basis of the compressed pixel information contained in the compressed sub-block data, and

a pixel value restoring section that restores a pixel value before compression by adding the minimum value to each of the pixel values of the pixel information restored by the pixel restoring section.

8. A data structure of compressed sub-block data constituting compressed image data that is generated by compressing image data, the data structure comprising:

a minimum value of a pixel value in pixel information indicating a pixel value of a pixel contained in the image data, and compressed pixel information in which a pixel value after the minimum value is subtracted from the pixel value of the pixel information and information that identifies the position of the pixel having the pixel value are associated with each other.