

Description

Title of Invention: ELECTROPHORESIS SYSTEM, ELECTROPHORESIS DATA PROCESSING DEVICE, AND ELECTROPHORESIS DATA PROCESSING METHOD

Technical Field

[0001]

The present invention relates to technology for an electrophoresis system, an electrophoresis data processing device, and an electrophoresis data processing method.

Background Art

[0002]

The multi-capillary electrophoresis system has been widely used for analyzing biological samples. The multi-capillary electrophoresis system is configured to fill a plurality of capillaries with electrophoresis separation media such as electrolytic solutions, high polymer gels, polymer-containing electrolytic solutions, and the like to allow parallel processing of electrophoretic analysis. An analysis object for electrophoresis widely ranges from a low molecule to a high molecule such as protein, DNA (Deoxyribonucleic Acid), and the like.

[0003]

Especially, when detecting DNA or the like, a sample obtained by adding fluorescence labeling to the DNA is irradiated with the exciting light so that a fluorescence signal generated by the fluorescence labeling is detected. Based on the detected fluorescence signal, the DNA base sequence and the length thereof are analyzed. The fluorescence signal may be detected by an image sensor such as a CCD (Charge Coupled Device) image sensor, a CMOS

(Complementary Metal Oxide Semiconductor) image sensor, and the like. The multi-capillary electrophoresis system detects the signal intensity for each wavelength based on the detected fluorescence signal.

[0004]

In the multi-capillary electrophoresis system, the signal intensity varies in accordance with the sample concentration. In order to detect a minute signal, it is essential to improve the detection sensitivity of the image sensor. Furthermore, it is also essential to expand the dynamic range for detecting the strong signal intensity as well.

[0005]

A binning processing has been known for expanding the dynamic range of the image sensor. In the processing, a plurality of light receiving surfaces (corresponding to pixels) that constitute the image sensor are pseudoly combined into a single pixel. It is known that the binning processing includes hardware binning and software binning. The software binning can deal with stronger fluorescence compared with the hardware binning.

[0006]

Concerning the binning, Patent Literature 1 discloses "the fluorescence detection device configured to select the software binning to acquire the fluorescence signal intensity when the fluorescence signal intensity acquired by executing the hardware binning exceeds a first threshold, and to select the hardware binning to acquire the fluorescence signal intensity when the fluorescence signal intensity acquired by executing the software binning becomes equal to or lower than the first threshold" (see claim 2).

[0007]

The multi-capillary electrophoresis system outputs the generated data as a file called a primary analysis file. Analysis of a nucleic acid base sequence and the length thereof from data of the output primary analysis file is called a secondary analysis. The secondary analysis is executed by inputting the primary analysis file output from the multi-capillary electrophoresis system to the secondary analysis software for performing the secondary analysis. This makes it possible to analyze the DNA base sequence and the length thereof.

[0008]

The signal intensity range that can be input to the secondary analysis software is fixed. Meanwhile, a range of the signal intensity that can be output from the multi-capillary electrophoresis system is wider than the range of the signal intensity that can be input to the secondary analysis software.

[0009]

Compression of the fluorescence signal data by a fixed compression ratio has been conventionally practiced to bring the fluorescence signal data output from the multi-capillary electrophoresis system into the range of the value that can be input to the secondary analysis software. Non-patent Literature 1 discloses the description as below. "The CCD detector and computer software in the ABI Genetic Analyzers use a 2-byte system for data storage, which enables fluorescence values to be encoded with 16 bits(each bit holding a value of 0 or 1). This 2-byte storage format enables the data collection software to provide a range of 0 to 65,535 in decimal(base-10) digits, or 0000000000000000 to

1111111111111111 in binary(base-2) digits. If both positive and negative values are permitted, then the maxima of a 2-byte storage system are +32,767 and_-32,767."

[0010]

The analysis by the multi-capillary electrophoresis system uses the reagent called a primer for DNA amplification. As the primer is added by an excessive amount compared with the analysis object DNA. The primer-derived signal intensity becomes higher than the DNA-derived signal intensity. As the primer is shorter than the analysis object DNA, the primer can be detected at a timing earlier than the analysis object DNA.

[0011]

Upon execution of the software binning, under the influence of the primer-derived fluorescence signal, the signal intensity of the primary analysis file may become significantly higher to deviate from the range of the signal intensity that can be input to the secondary analysis software. The signal intensity of the primary analysis file may be compressed to be usable for the secondary analysis software. As a result, the compression ratio in the signal intensity direction becomes high. This may cause the loss of information of the analysis object DNA with minute signal intensity.

[0012]

The method for compressing the data size in the time axis direction may be implemented by selecting the data point. Patent Literature 2 discloses "the clutter rejection method including a step for selecting the data point of the first set from the data point of the set filtered using the initial threshold reference, a step for selecting the data point of a plurality of duplicated subsets from

the data point of the first set, a step for executing a plurality of linear mapping operations to the data points of the plurality of duplicated subsets, a step for determining a plurality of error values as a result of executing the plurality of linear mapping operations to the data points of the plurality of duplicated subsets, and a step for selecting the duplicated data points of the first final subset having the minimum error value from the data points of the first set while bringing the plurality of normalized data points of the first final subset within the range, and excluding deviating data points" (see Claim 9).

Citation List

Patent Literature

[0013]

Patent Literature 1: Japanese Unexamined Patent Application

Publication No. 2015-49179

Patent Literature 2: Japanese Unexamined Patent Application

Publication (Translation of PCT Application) No. 2003-500662

Non-patent Literature

[0014]

Non-patent Literature 1: John M. Butler, "Advanced Topics in FORENSIC DNA TYPING: INTERPRETATION", p32

Summary of Invention

Technical Problem

[0015]

Patent Literature 1 discloses the fluorescence detector that executes the software binning. In Patent Literature 1, however, there is no description relating to the processing for converting the high signal intensity acquired by the software binning into the value

in the range that can be input to the secondary analysis software.

[0016]

Non-patent Literature 1 discloses that the signal intensity that can be acquired by the CCD image sensor ranges from "0" to "65,535", and the use of software for converting the signal intensity into the value in the range from "-32,767" to "32,767". However, as described above, execution of the software binning makes the compression ratio in the signal intensity direction high because of increase in the acquirable signal intensity. This may cause the loss of the information of the analysis object DNA with minute signal intensity. It is therefore necessary to minimize (optimize) the compression ratio in the signal intensity direction. Non-patent Literature 1 does not disclose the compression method when executing the software binning.

[0017]

The method for minimizing the compression ratio in the signal intensity direction may be implemented by selecting the data point as the analysis object. Patent Literature 2 discloses the method for decreasing the data points by clutter rejection, but does not disclose the method for removing the primer-derived fluorescence that causes high signal intensity of data output by the multi-capillary electrophoresis system.

[0018]

In the multi-capillary electrophoresis system, if the software binning is executed, and the primer-derived fluorescence signal is not removed, the signal intensity becomes high under the influence of the primer. Accordingly, the compression ratio becomes excessively high. In this case, as the compression ratio in the signal intensity

direction becomes high, there may cause the risk of losing information of the analysis object DNA with minute signal intensity.

[0019]

In light of the above-described circumstances, an object of the present invention is to attain appropriate compression of the fluorescence signal data.

Solution to Problem

[0020]

As the solution for the above-described problem, the present invention provides an electrophoresis apparatus, a software binning processing unit which acquires an analysis object sample signal as a signal relating to a hardware binned analysis object sample, and a matrix standard signal as a signal relating to a hardware binned matrix standard from the electrophoresis apparatus, and executes a software binning to the analysis object sample signal and the matrix standard signal, a fluorescence signal data generation unit which generates fluorescence signal data as data relating to fluorescence signal intensity for each frame based on the software binned analysis object sample signal, and the software binned matrix standard signal, a compression range set unit which detects a first fluorescence signal derived from an analysis object and a second fluorescence signal derived from an analysis exclusion object distinguishingly from fluorescence signals contained in the fluorescence signal data, and sets a compression range for frames of the fluorescence signal data based on a result of the detection, a compression ratio calculation unit which calculates a compression ratio based on a maximum value of the fluorescence signal intensity included in the compression range and a maximum value of the signal intensity usable

for a secondary analysis, and a compression unit which generates fluorescence signal compressed data by compressing the fluorescence signal data based on the compression ratio, and outputs the generated fluorescence signal compressed data. Other solutions will be appropriately described in the embodiments.

Advantageous Effects of Invention

[0021]

The present invention allows appropriate compression of the fluorescence signal data.

Brief Description of Drawings

[0022]

Fig. 1 schematically illustrates a configuration example of an electrophoresis system according to an embodiment 1-1.

Fig. 2 schematically illustrates a configuration of a fluorescence detection device according to the embodiment 1-1.

Fig. 3 schematically illustrates a configuration of a CCD image sensor according to the embodiment 1-1.

Fig. 4 illustrates a configuration of a processing device according to the embodiment 1-1.

Fig. 5 illustrates an example of a hardware configuration of the processing device.

Fig. 6 is an explanatory view (part 1) of an operation for converting the diffracted fluorescence into a digital signal.

Fig. 7 is an explanatory view (part 2) of an operation for converting the diffracted fluorescence into the digital signal.

Fig. 8 is an explanatory view (part 3) of an operation for converting the diffracted fluorescence into the digital signal.

Fig. 9 is an explanatory view (part 4) of an operation for

converting the diffracted fluorescence into the digital signal.

Fig. 10 is an explanatory view (part 5) of an operation for converting the diffracted fluorescence into the digital signal.

Fig. 11 is a timing chart of pulse application by a control device.

Fig. 12 is a view representing generation of soft bins.

Fig. 13 illustrates a configuration example of generalized bins and soft bins.

Fig. 14 represents an example of correlation between the soft bins and the bins.

Fig. 15 is a flowchart representing a procedure of a compression range determination processing executed by a compression range set unit according to the embodiment 1-1.

Fig. 16 illustrates an example of an electrophoresis image (part 1).

Fig. 17 is a flowchart representing a procedure of a compression ratio calculation processing executed by a compression ratio calculation unit according to the embodiment 1-1.

Fig. 18 is a flowchart representing a procedure of a compression processing executed by a compression unit according to the embodiment 1-1.

Fig. 19 illustrates an example of the electrophoresis image (part 2).

Fig. 20 illustrates an example of the electrophoresis image (part 3).

Fig. 21 illustrates an example of the electrophoresis image (part 4).

Fig. 22 illustrates an example of the electrophoresis image

(part 5).

Fig. 23 illustrates an example of the electrophoresis image (part 6).

Fig. 24 illustrates a configuration of a processing device according to an embodiment 2-1.

Fig. 25 is a flowchart representing a procedure of a compression range determination processing executed by the compression range set unit according to the embodiment 2-1.

Fig. 26 illustrates an example of the electrophoresis image (part 7).

Fig. 27 illustrates an example of the electrophoresis image (part 8).

Fig. 28 illustrates an example of the electrophoresis image (part 9).

Fig. 29 illustrates an example of the electrophoresis image (part 10).

Fig. 30 illustrates an example of the electrophoresis image (part 11).

Fig. 31 illustrates an example of a secondary analysis screen to be displayed according to the present embodiment.

Description of Embodiments

[0023]

A mode for carrying out the present invention (referred to as an "embodiment") will be described in detail with reference to the drawings.

Based on the drawings, embodiments of the present invention will be described in detail. In all the drawings for descriptions of the embodiments, basically, identical reference numerals designate

the identical elements, and descriptions of those elements, thus, will be omitted.

[0024]

<<Embodiment 1>>

<Embodiment 1-1>

[System Configuration]

Fig. 1 schematically illustrates a configuration example of an electrophoresis system 1 according to an embodiment 1-1.

As illustrated in Fig. 1, the electrophoresis system 1 includes a processing device 10 as an electrophoresis data processing device, an electrophoresis apparatus 20, and an external memory 30. The external memory 30 denotes a USB (Universal Serial Bus) memory, an external HD (Hard Disk), and the like.

[0025]

(Electrophoresis Apparatus 20)

The electrophoresis apparatus 20 is a multi-capillary electrophoresis apparatus, and includes a pump unit 21, a high voltage power supply 22, a thermostatic bath 23, a fluorescence detection device 200, and a capillary array 240. The electrophoresis apparatus 20 includes a sample tray 250 and a transport unit 260.

[0026]

The sample tray 250 stores a plurality of sample containers 251. Each of the sample containers 251 contains a sample prepared by adding a fluorescence labeling to a measurement object DNA. The samples respectively contained in the sample containers 251 are different from one another.

[0027]

The transport unit 260 transports the sample tray 250 so that

the sample containers 251 are positioned at the leading end positions of the capillaries 241, respectively.

[0028]

The capillary array 240 is composed of a plurality of capillaries 241. Each of the capillaries 241 has a hollow structure. The capillaries 241 are inserted into the sample containers 251, respectively.

[0029]

The thermostatic bath 23 keeps the inner temperature of the capillary array 240 at the fixed temperature.

The pump unit 21 injects an electrophoresis medium M (for example, polymer) into each of the capillaries 241. This allows the inside of the capillary 241 to be filled with the electrophoresis medium M.

[0030]

The high voltage power supply 22 applies high voltage to both ends of the capillaries 241 each filled with the electrophoresis media M, respectively.

A fluorescence detection position 24 is set on a path on which the sample is electrophoresed. The sample is irradiated with an excitation light R1 (see Fig. 2) at the fluorescence detection position 24.

[0031]

The sample is electrophoresed through the voltage application by the high voltage power supply 22, and moves inside the capillary 241. As illustrated in Fig. 1, a moving direction of the sample is indicated by an arrow mark. The sample moving inside the capillary 241 is irradiated with the excitation light R1 (see Fig. 2) at the

fluorescence detection position 24, and emits a fluorescence R2 (see Fig. 2). Thereafter, the sample is discharged into a discharge container 25. The fluorescence detection device 200 detects the fluorescence R2 emitted from the sample. The detailed configuration of the fluorescence detection device 200 will be described later. The above-configured electrophoresis apparatus 20 allows simultaneous measurement of the electrophoresed samples inside the plurality of capillaries 241, respectively.

[0032]

In the present embodiment, the fluorescence-labeled DNA fragment is intended to be used as the sample that passes inside the capillary 241. It is possible, however, to use the sample except the DNA fragment.

[0033]

(Processing Device 10)

Fig. 1 schematically illustrates the processing device 10. The processing device 10 includes a signal integration unit 101 as a software binning processing unit, a fluorescence calibration unit 102, a color conversion unit 104, a compression range set unit 105, a compression ratio calculation unit 106, a compression unit 107, and the like. The detailed configuration of the processing device 10 will be described later.

[0034]

(External Memory 30)

Processing executed to the external memory 30 will be described later.

[0035]

(Fluorescence Detection Device 200)

Fig. 2 schematically illustrates a configuration of a fluorescence detection device 200 according to the embodiment 1-1.

As illustrated in Fig. 2, the fluorescence detection device 200 includes an excitation light source 201, a shutter 202, and an excitation light lens 203. The fluorescence detection device 200 includes an optical filter 204, fluorescence lens 205, a diffraction grating 206 and a CCD image sensor 210. Additionally, the fluorescence detection device 200 includes a control device 220 and a conversion device 230.

[0036]

The excitation light source 201 continuously emits the excitation light R1. The excitation light source 201 is placed so that all the capillaries 241 of the capillary array 240 passing over the fluorescence detection position 24 are irradiated with the emitted excitation light R1.

The shutter 202 is opened and closed at predetermined time intervals repeatedly. In other words, while the shutter 202 is opened, the capillary 241 is irradiated with the excitation light R1 from the excitation light source 201. When the shutter 202 is closed, irradiation of the excitation light R1 to the capillary 241 is shut off. A frame denotes the time period from when the shutter 202 is opened from its closed state until the shutter 202 is closed again.

[0037]

The excitation light lens 203 concentrates the excitation light R1 passing through the shutter 202. The excitation light R1 concentrated by the excitation light lens 203 is irradiated toward the fluorescence detection position 24.

[0038]

As described above, the fluorescence-labeled DNA fragment is used as the sample passing through the inside of each of the respective capillaries 241. The fluorescence labeling added to the DNA fragment electrophoresing inside the respective capillaries 241 is excited through irradiation of the excitation light R1 to emit the fluorescence R2.

[0039]

The optical filter 204 cuts the light except the fluorescence R2 emitted from the fluorescence labeling. For example, a color filter may be used for the optical filter 204.

The fluorescence lens 205 concentrates the fluorescence R2 passing through the optical filter 204.

The diffraction grating 206 diffracts the fluorescence R2 concentrated by the fluorescence lens 205 for each wavelength.

The CCD image sensor 210 receives the fluorescence R2 diffracted by the diffraction grating 206, and outputs an electric charge in accordance with the intensity of the fluorescence R2.

[0040]

The control device 220 instructs the CCD image sensor 210 to output the electric charge based on the fluorescence R2.

[0041]

The conversion device 230 includes a charge conversion unit 231 and a digital conversion unit 232 as an ADC (Analog digital converter).

[0042]

The charge conversion unit 231 converts the electric charge output from the CCD image sensor 210, and outputs the converted

voltage as an analog signal.

The digital conversion unit 232 converts the analog signal output from the charge conversion unit 231 into a digital signal. The digital conversion unit 232 outputs the converted digital signal to the processing device 10.

[0043]

A sample measurement processing will be described with reference to Fig. 1 and Fig. 2.

Firstly, the sample is stored in the sample container 251. The high voltage power supply 22 applies high voltage to both ends of the respective capillaries 241. The sample then moves to the inside of the capillary 241 from the sample container 251. This allows the sample to move inside the capillary 241 toward the discharge container 25 through the fluorescence detection position 24 (arrow mark in Fig. 1: electrophoresis). Upon electrophoresis of the sample, the moving speed differs in accordance with the base length of the DNA fragment as the sample. Accordingly, the DNA fragments reach the fluorescence detection position 24 in order from the shorter base length. The excitation light R1 that is emitted from the excitation light source 201, passing through the shutter 202, and concentrated by the excitation light lens 203 is irradiated to the sample that has reached the fluorescence detection position 24. The fluorescence labeling added to the DNA fragment is excited through irradiation of the excitation light R1 to emit the fluorescence R2. The fluorescence R2 passing through the optical filter 204 is concentrated by the fluorescence lens 205, and diffracted for each wavelength by the diffraction grating 206.

[0044]

(CCD Image Sensor 210)

Fig. 3 schematically illustrates a configuration of a CCD image sensor 210 according to the embodiment 1-1. Fig. 2 is appropriately referred.

As illustrated in Fig. 3, the CCD image sensor 210 includes a light receiving unit 211, a horizontal register unit 212, and a summing gate 213.

The light receiving unit 211 includes a plurality of light receiving elements 211A arranged into a grating-like form. Each of the light receiving elements 211A constitutes a surface that receives the fluorescence R2 diffracted for each wavelength by the diffraction grating 206. The fluorescence R2 emitted from the capillary 241 of the electrophoresis system 1 is diffracted by the diffraction grating 206. The light receiving element 211A receives the diffracted light. Upon reception of the fluorescence R2, the light receiving element 211A accumulates the signal charge in accordance with the intensity of the fluorescence R2. The light receiving unit 211 is connected to the control device 220 through a pulse line L1. The signal charges accumulated in the respective light receiving elements 211A that constitute the light receiving unit 211 are output in response to an instruction of the control device 220 through the pulse line L1. Operations of the light receiving elements 211A for outputting the signal charge will be described later in detail.

[0045]

The horizontal register unit 212 includes a plurality of horizontal registers 212A. The horizontal register 212A integrates the signal charges accumulated in the light receiving elements 211A in the vertical direction. In the present embodiment, the direction

from the light receiving element 211A to the horizontal register 212A is defined as the vertical direction. In the present embodiment, the direction from the horizontal register unit 212 to the summing gate 213 is defined as the horizontal direction. The horizontal register unit 212 is connected to the control device 220 through a pulse line L2. The respective horizontal registers 212A which constitute the horizontal register unit 212 output the signal charges in response to the instruction of the control device 220 through the pulse line L2. Operations of the respective horizontal registers 212A for outputting the signal charge will be described later in detail.

[0046]

The summing gate 213 further integrates the signal charges integrated by the horizontal register unit 212. The summing gate 213 is connected to the control device 220 through a pulse line L3. The summing gate 213 outputs the integrated signal charge in response to an instruction of the control device 220 through the pulse line L3.

[0047]

It is possible to use the CCD image sensor 210 of either frame transfer type, full-frame transfer type, interline transfer type, or frame interline transfer type. If the CCD image sensor of either frame transfer type, interline transfer type, or frame interline transfer type is applied, the shutter 202 (see Fig. 2) does not have to be provided. If the CCD image sensor of full-frame transfer type is applied, the number of the light receiving elements 211A and an area of the light receiving element 211A are increased to allow detection of the minute signal.

[0048]

It is possible to apply a CMOS (Complementary Metal Oxide

Semiconductor) image sensor for detection of the fluorescence R2 (see Fig. 2) instead of the CCD image sensor 210. If the CMOS image sensor is applied, it is possible to directly acquire digital signals from the respective light receiving elements 211A.

[0049]

[Configuration of Processing Device 10]

Fig. 4 illustrates a configuration of the processing device 10 according to the embodiment 1-1. Fig. 1 and Fig. 2 are appropriately referred.

The processing device 10 includes the signal integration unit 101, the fluorescence calibration unit 102, a pseudo inverse matrix generation unit 103 and the color conversion unit 104. The processing device 10 includes the compression range set unit 105, the compression ratio calculation unit 106 and the compression unit 107. As described above, the signal integration unit 101 constitutes the software binning processing unit. The fluorescence calibration unit 102, the pseudo inverse matrix generation unit 103, and the color conversion unit 104 constitute a fluorescence signal data generation unit.

[0050]

The electrophoresis system 1 uses a matrix standard D20 for obtaining the signal intensity of a sample as the analysis object (hereinafter referred to as an analysis object sample D10) separately from the analysis object sample D10. The matrix standard D20 is a sample for fluorescence calibration. In the present embodiment, as described above, the analysis object sample D10 is a mixture liquid of the fluorescence-labeled DNA fragment and the primer. The primer as a reagent used for DNA amplification is added to the analysis

object sample D10.

[0051]

The electrophoresis apparatus 20 outputs an analysis object sample signal D11 as the digital signal (signal) of the analysis object sample D10 by the procedure as illustrated in Fig. 6 to Fig. 11. The analysis object sample signal D11 to be output is composed of the signal intensity relating to each bin B. The output analysis object sample signal D11 is input to the signal integration unit 101 of the processing device 10. The analysis object sample signal D11 is a signal relating to the hardware binned analysis object sample D10.

[0052]

The electrophoresis apparatus 20 measures the matrix standard D20 separately from the analysis object sample D10. The electrophoresis apparatus 20 outputs a matrix standard signal D21 as the digital signal of the matrix standard D20 by the procedure as illustrated in Fig. 6 to Fig. 11. The matrix standard signal D21 to be output is composed of the signal intensity relating to each bin B. The output matrix standard signal D21 to be output is input to the signal integration unit 101 of the processing device 10. The analysis object sample D10 and the matrix standard D20 are measured separately. The matrix standard signal D21 is a signal relating to the hardware binned matrix standard D20.

[0053]

The signal integration unit 101 acquires the analysis object sample signal D11 and the matrix standard signal D21 from the electrophoresis apparatus 20.

[0054]

The signal integration unit 101 integrates the analysis object sample signal D11 as the digital signal relating to the bin B of the analysis object sample D10 for each bin B. The signal integration unit executes the software binning by the integration. The software binning to be described later is executed by further binning results of the hardware binning executed by the horizontal register unit 212 and the summing gate 213 as illustrated in Fig. 3. The signal integration unit 101 outputs an analysis object sample integration signal D12 as a result of integrating the analysis object sample signals D11 for each bin B to the color conversion unit 104. The signal integration unit 101 integrates, for each bin, the input matrix standard signal D21 of the matrix standard D20 as the digital signal relating to the bin B. The signal integration unit 101 outputs a matrix standard integration signal D22 as a result of integrating the matrix standard signal D21 for each bin B to the fluorescence calibration unit 102. In other words, the signal integration unit 101 executes the software binning to the matrix standard signal D21.

[0055]

As described above, the signal integration unit 101 executes the software binning to the analysis object sample signal D11 and the matrix standard signal D21.

[0056]

The fluorescence calibration unit 102 normalizes the matrix standard integration signal D22 output from the signal integration unit 101 for each frame, and outputs the signal to the pseudo inverse matrix generation unit 103 so that the maximum signal intensity becomes "1". The matrix standard integration signal D22 normalized

by the fluorescence calibration unit 102 is referred to as fluorescence spectrum data D23.

[0057]

Then, the pseudo inverse matrix generation unit 103 acquires the fluorescence spectrum data D23 output from the fluorescence calibration unit 102, and generates a pseudo inverse matrix D24 of the fluorescence spectrum data D23. Generated pseudo inverse matrix D24 is output to the color conversion unit 104.

[0058]

The color conversion unit 104 acquires the analysis object sample integration signal D12 from the signal integration unit 101, and further acquires the pseudo inverse matrix D24 from the pseudo inverse matrix generation unit 103. Then, the color conversion unit 104 multiplies the analysis object sample integration signal D12 acquired from the signal integration unit 101 by the acquired pseudo inverse matrix D24. As a result, fluorescence signal data D25 are generated. The color conversion unit 104 outputs the generated fluorescence signal data D25 to the compression range set unit 105, the compression ratio calculation unit 106, and the compression unit 107.

[0059]

The fluorescence calibration unit 102, the pseudo inverse matrix generation unit 103, and the color conversion unit 104 generate the fluorescence signal data D25 relating to the fluorescence signal intensity for each frame. At this time, based on the software binned analysis object sample signal D11 and the software binned matrix standard signal D21, the fluorescence signal data D25 are generated.

[0060]

Upon acquisition of the fluorescence signal data D25 from the color conversion unit 104, the compression range set unit 105 generates an electrophoresis image EP (see Fig. 16). Based on the generated electrophoresis image EP, the compression range set unit 105 sets a compression range H (see Fig. 20). The method for setting the compression range H will be described later. Thereafter, the compression range set unit 105 outputs the set compression range H to the compression ratio calculation unit 106 and the compression unit 107.

[0061]

The compression ratio calculation unit 106 acquires the compression range H from the compression range set unit 105, and further acquires the fluorescence signal data D25 from the color conversion unit 104. Based on the acquired compression range H and the fluorescence signal data D25, the compression ratio calculation unit 106 calculates a compression ratio D27 of the fluorescence signal data D25. The method for calculating the compression ratio D27 by the compression ratio calculation unit 106 will be described later. The compression ratio calculation unit 106 outputs the calculated compression ratio D27 to the compression unit 107, the external memory 30, and the like.

[0062]

The compression unit 107 acquires the compression ratio D27 from the compression ratio calculation unit 106, the fluorescence signal data D25 from the color conversion unit 104, and the compression range H from the compression range set unit 105. The compression unit 107 compresses the fluorescence signal data D25

based on the compression range H and the compression ratio D27 to generate fluorescence signal compressed data D28. The method for generating the fluorescence signal compressed data D28 will be described later. The compression unit 107 outputs the fluorescence signal compressed data D28 to the external memory 30, and the like. [0063]

[Hardware Configuration]

Fig. 5 illustrates an example of a hardware configuration of the processing device 10.

As illustrated in Fig. 5, the processing device 10 includes a memory 151, a computing device 152, a storage device 153, an input device 154, an output device 155, a communication device 156 and the like.

The memory 151 is constituted by a RAM (Random Access Memory), and the like. The computing device 152 is constituted by a CPU (Central Processing Unit), a GPU (Graphic Processing Unit) and the like. The storage device 153 is constituted by a HD (Hard Disk), a SSD (Solid State Drive) and the like. The input device 154 is constituted by a keyboard, a bottom and the like. The output device 155 is constituted by a display and the like. The input device 154 and the output device 155 may be integrated into a single unit such as a touch panel display, and the like.

[0064]

The program stored in the storage device 153 is loaded into the memory 151. The loaded program is executed by the computing device 152. This embodies the signal integration unit 101, the fluorescence calibration unit 102, the pseudo inverse matrix generation unit 103, the color conversion unit 104, the compression range set unit 105,

the compression ratio calculation unit 106, and the compression unit 107 as illustrated in Fig. 4.

[0065]

The processing device 10 and the electrophoresis apparatus 20 may be formed either integrally or separately. If the processing device 10 and the electrophoresis apparatus 20 are integrated into a single structure, the control device 220, the conversion device 230, and the like as illustrated in Fig. 2 may be installed in the processing device 10.

[0066]

(Hardware Binning)

Fig. 6 to Fig. 10 are explanatory views of an operation for converting the diffracted fluorescence R2 (see Fig. 2) into the digital signal. Fig. 2 is appropriately referred. As illustrated in Fig. 6 to Fig. 8 (additionally, Fig. 3), a broken line for the light receiving element 211A indicates the bin B. The bin B to be described later denotes a group of a plurality of light receiving elements 21A, which is pseudoly regarded as a single light receiving element 211A.

[0067]

The fluorescence R2 diffracted for each wavelength is received by the light receiving element 211A of the electrophoresis apparatus 20 as illustrated in Fig. 2, and the signal charge is accumulated as illustrated in Fig. 6. Each pattern for the respective light receiving elements 211A as illustrated in Fig. 6 denotes the signal charge accumulated in each of the respective light receiving elements 211A.

[0068]

The control device 220 applies pulses for vertically transferring the signal charges accumulated in the respective light receiving elements 211A to the pulse line L1. Upon application of the pulse to the pulse line L1, each signal charge accumulated in the respective light receiving elements 211A is transferred one by one in the vertical direction.

[0069]

The charge accumulated in the light receiving element 211A at the tail end in the vertical direction is transferred to the horizontal register 212A. In this way, the electric charges accumulated at the positions as illustrated in Fig. 6 are transferred to positions as illustrated in Fig. 7, respectively.

[0070]

The control device 220 applies the pulse for vertically transferring the signal charges accumulated in the respective light receiving elements 211A to the pulse line L1 again. Upon application of the pulse to the pulse line L1, the signal charges accumulated in the light receiving elements 211A are sequentially transferred in the vertical direction.

[0071]

The signal charge accumulated in the light receiving element 211A at the tail end in the vertical direction is transferred to the horizontal register 212A. In this way, the signal charges transferred last time, and the signal charges transferred at the present time are accumulated in the respective horizontal registers 212A. The signal charges accumulated at the positions as illustrated in Fig. 7 are respectively transferred to positions as illustrated in Fig. 8.

[0072]

The control device 220 further applies the pulse for vertically transferring the signal charges accumulated in the respective light receiving elements 211A to the pulse line L1. Upon application of the pulse to the pulse line L1, each signal charge accumulated in the respective light receiving elements 211A is transferred one by one sequentially in the vertical direction.

[0073]

The signal charge accumulated in the light receiving element 211A at the tail end in the vertical direction is transferred to the horizontal register 212A. In this way, the signal charges transferred before the last time, the signal charges transferred last time, and the signal charges transferred at the present time are accumulated in the respective horizontal registers 212A. In other words, every time the pulse is applied to the pulse line L1, the signal charges accumulated in the light receiving elements 211A are sequentially transferred to the horizontal registers 212A. In an example of the present embodiment, the pulse is applied to the pulse line L1 three times. Accordingly, the signal charges are accumulated in the horizontal registers 212A as illustrated in Fig. 9.

[0074]

The control device 220 applies the pulse for horizontally transferring the signal charges accumulated in the horizontal registers 212A to the pulse line L2. Upon application of the pulse to the pulse line L2, the signal charges accumulated in the respective horizontal registers 212A are sequentially transferred in the horizontal direction. The timing at which the pulse is applied to the pulse line L2 will be described later.

[0075]

The signal charges accumulated in the horizontal register 212A at the side end in the horizontal direction are transferred to the summing gate 213. In this way, the signal charges are transferred to the position as illustrated in Fig. 10.

[0076]

Thereafter, the control device 220 applies the pulse to the summing gate 213 via the pulse line L3 so that the signal charges are output to the conversion device 230 (see Fig. 3) from the summing gate 213.

[0077]

[Timing for Pulse Application]

Fig. 11 is a timing chart of pulse application by the control device 220.

Fig. 11 shows the timing for pulse application to the light receiving unit 211, the timing for pulse application to the horizontal register unit 212, and the timing for pulse application to the summing gate 213 in order from the top of the drawing.

[0078]

The signal charges corresponding to the plurality of light receiving elements 211A are integrated by the summing gate 213 through the operations as described with reference to Fig. 6 to Fig. 10. This makes it possible to pseudoly handle those elements as a single light receiving element 211A. The operation for handling the plurality of light receiving elements 211A pseudoly as the single light receiving element 211A is referred to as the hardware binning. A group of the pseudoly combined light receiving elements 211A is referred to as the bin B (see Fig. 3).

[0079]

In an example as illustrated in Fig. 6 to Fig. 11, three light receiving elements 211A in total, that is, three in the vertical direction and one in the horizontal direction, are subjected to the hardware binning into the single bin B. Signal charges of the light receiving elements 211A corresponding to the bin B are integrated in the horizontal register 212A and the summing gate 213. In other words, each example as illustrated in Fig. 6 to Fig. 11 illustrates that the pulse is consecutively applied to the light receiving unit 211 three times, and the pulse is applied to the horizontal register unit 212 once as illustrated in Fig. 11. The pulse is then applied to the summing gate 213 once. The bin B generated by the hardware binning is illustrated in Fig. 3. A region where the hardware binning is executed is not necessarily limited to the example as illustrated in Fig. 6 to Fig. 11. Change of the hardware binning region (made changeable) makes sensitivity of the CCD image sensor 210 variable. In other words, the size of the bin B is changeable. That is, the size of the bin B can be changed for each electrophoresis.

[0080]

Referring to the example of Fig. 11, a cycle of the pulse application to the light receiving unit 211 three times, the pulse application to the horizontal register unit 212 once, and the pulse application to the summing gate 213 once is defined as one set (time interval T). The above-described set is executed a plurality of times. The set is executed repeatedly until all the signal charges accumulated in the light receiving units 211 are transferred to the summing gate 213.

[0081]

Those operations are performed synchronously with the timing for opening the shutter 202. As described above, the time interval T from opening of the shutter 202 from its closed state to closing of the shutter 202 again is referred to as a frame. The shutter 202 is kept closed during transfer of the signal charge from the light receiving element 211A to the processing device 10. After transferring the signal charges accumulated in all the light receiving elements 211A to the summing gate 213, the shutter is ready for opening.

[0082]

Fig. 3 is appropriately referred again. The signal charge accumulated in the summing gate 213 is converted by the charge conversion unit 231 into the voltage in accordance with the number of signal charges transferred from the summing gate 213. As a result, the charge conversion unit 231 outputs the converted voltage, as an analog signal, to the digital conversion unit 232. In other words, in the set (time interval T) as illustrated in Fig. 11, the charge conversion unit 231 to which the signal charge has been finally transferred from the summing gate 213 outputs the voltage corresponding to the transferred signal charge amount as the analog signal.

[0083]

The analog signal output from the charge conversion unit 231 is converted into the digital signal by the digital conversion unit 232. The converted digital signal is output to the processing device 10, the external memory 30, and the like. In the present embodiment, the digital signal will be referred to as a "signal", and the digital

signal intensity as the intensity of the digital signal will be referred to as "signal intensity" hereinafter.

[0084]

The present embodiment will be described on the assumption that when the summing gate 213 is saturated, the digital conversion unit 232 converts an analog signal value into the digital signal value "65535" (ADU).

[0085]

(Software Binning)

Fig. 12 is a view representing generation of soft bins C.

Fig. 12 illustrates that a soft bin C is generated in a single frame by integrating the digital signals for each bin B. The signal integration unit 101 integrates the digital signals relating to the input bin B so that the plurality of bins B can be further pseudoly handled as the single bin B. In this way, handling of the plurality of bins B pseudoly as the single bin B is referred to as the software binning. The pseudoly combined bins B will be referred to as the soft bin C. Fig. 14 is a table showing an example of bins B that constitute the soft bin C. A software binning region is not necessarily limited to the example as illustrated in Fig. 12 and Fig. 14. Change of the software binning region (made changeable) makes sensitivity of the CCD image sensor 210 variable. In other words, the size of the soft bin C is changeable.

[0086]

As illustrated in Fig. 12, among 240 bins B1 to B240 (B) output as a result of the hardware binning, software binning is executed in units of 12 bins to generate the soft bins C1 to C20 (C). Each numerical value "30000" for the respective bins B denotes each signal

intensity output by the bins B. As illustrated in Fig. 12, each bin B outputs the signal intensity of "30000" uniformly. Each numerical value "360000" for the respective soft bins C denotes each signal intensity output by the respective soft bins C. In the present embodiment, as one soft bin C is composed of 12 bins B, a value of the signal intensity output by each of the soft bins C is obtained by calculating $30000 \times 12 = 360000$.

[0087]

Fig. 13 illustrates a configuration example of generalized bins B and soft bins C. Fig. 14 represents an example of correlation between the soft bins C and the bins B. Generally, it can be considered that the single bin B is composed of m light receiving elements 211A in the vertical direction, and n light receiving elements 211A in the horizontal direction. Each definition of the vertical direction and the horizontal direction in Fig. 13 applies to the case as illustrated in Fig. 3. In the examples of Fig. 3, Fig. 6 to Fig. 11, the bin B includes the light receiving elements of $m=3$ and $n=1$. The bins B1 to BN as illustrated in Fig. 13 are not overlapped with one another. As the control device 220 changes the pulse application timing, the size of the bin B can be changed.

[0088]

Generally, it can be considered that the soft bin C is composed of k bins B in the horizontal direction. In other words, examples of Fig. 12 and Fig. 14 show that the soft bin C is composed of $k = 12$ bins B. The respective soft bins C1 to CL as illustrated in Fig. 13 are not overlapped with one another. Similar to Fig. 12, Fig. 14 shows that each group of 12 bins among 240 bins B1 to B240 (B) is subjected to the software binning so that the soft bins C1 to C20 (C)

are generated.

[0089]

Referring to Fig. 15 to Fig. 18, the following describes procedures of the electrophoresis data processing method according to the embodiment 1-1, which is implemented by the compression range set unit 105, the compression ratio calculation unit 106, and the compression unit 107. The processing as illustrated in Fig. 15, Fig. 17, Fig. 18 may be executed for each electrophoresis, or executed collectively after completion of all the electrophoresis operations.

[0090]

(Compression Range Determination Processing)

Fig. 15 is a flowchart of compression range determination processing as a compression range setting step executed by the compression range set unit 105 according to the embodiment 1-1. Fig. 16 illustrates an example of the electrophoresis image EP. Fig. 4 is appropriately referred.

The compression range determination processing is intended to distinguish between a primer-derived fluorescence signal P and a DNA-derived fluorescence signal P for appropriate compression of the DNA-derived fluorescence signal P.

[0091]

Firstly, the compression range set unit 105 acquires the fluorescence signal data D25 from the color conversion unit 104 (S101). In step S101, the compression range set unit 105 acquires the fluorescence signal data D25 relating to all the frames. In the subsequent processing, the fluorescence signal data D25 relating to all the frames are acquired in the processing similar to step S101. The fluorescence signal data D25 are acquired as a result of

executing the software binning.

[0092]

Then the compression range set unit 105 draws (generates) the electrophoresis image EP (see Fig. 16) of the fluorescence signal data D25 (S102). The electrophoresis image EP is expressed as a graph of the fluorescence signal data D25. As illustrated in Fig. 16, the compression range set unit 105 draws the graph of the fluorescence signal data D25, having its abscissa as the frame number, and its ordinate as the fluorescence signal intensity corresponding to the frame number. The frame number is defined as the number applied to the frame in order from the earlier time. The drawn graph having its abscissa as the frame number and its ordinate as the fluorescence signal intensity corresponding to the frame is referred to as the electrophoresis image EP. The electrophoresis image EP is drawn for each electrophoresis. Referring to the electrophoresis image EP, while the CCD image sensor 210 is not irradiated with the fluorescence R, the signal intensity of the fluorescence signal data D25 is kept constant. The signal intensity of the fluorescence signal data D25 is referred to as the fluorescence signal intensity. There may be cases where the fluorescence signal intensity takes a negative value owing to the influence of noise or the like. For this reason, conventionally, a predetermined value is added to the calculated fluorescence signal intensity. Even if the CCD image sensor 210 is not irradiated with the fluorescence R, the fluorescence signal intensity set to the predetermined value is generally accepted.

[0093]

Meanwhile, if the CCD image sensor 210 is irradiated with the

strong fluorescence R2, the fluorescence signal intensity as the signal intensity of the fluorescence signal data D25 becomes high. The CCD image sensor 210 is irradiated with the fluorescence R2 over a plurality of frames. Accordingly, each fluorescence signal intensity of the electrophoresis image EP differs depending on the frame number. Therefore, the electrophoresis image EP includes a plurality of cone-like shapes as illustrated in Fig. 16. Each of the cone-like shapes is referred to as the fluorescence signal P. As illustrated in Fig. 16, in the present embodiment, the electrophoresis image EP has frame numbers "1" to "5000".

[0094]

The following is a description with reference back to Fig. 15. The following description will be made with reference to Fig. 16 hereinafter.

The compression range set unit 105 selects one fluorescence signal P from those contained in the generated electrophoresis image EP. At this time, the compression range set unit 105 searches the electrophoresis image EP as illustrated in Fig. 16 in the direction of the frame number from "1" to "5000", and acquires the frame numbers in the range where the fluorescence signal intensity is equal to or higher than the predetermined value. The compression range set unit 105 selects the fluorescence signal intensity corresponding to the frame number in the range as one fluorescence signal P.

[0095]

The compression range set unit 105 determines whether or not a width (the number of frames) of the fluorescence signal P is equal to or larger than a first threshold (S103). The first threshold is set to a value sufficiently smaller than the width of the primer-derived

fluorescence signal P, and sufficiently larger than the width of the fluorescence signal P derived from the analysis object DNA. Compared with the analysis object DNA, the primer is excessively added. This makes the fluorescence signal intensity higher. In other words, the width of the primer-derived fluorescence signal P becomes larger than the width of the DNA-derived fluorescence signal P.

[0096]

The width of the fluorescence signal P which is obvious to be derived from the primer is preliminarily set to the first threshold. In the present embodiment, the first threshold is set to "50" frames. The width of the fluorescence signal P is defined by a starting frame number and an end frame number of the fluorescence signal P. The starting frame number is defined as the first frame number at which the value of the fluorescence signal P becomes equal to or larger than the predetermined value. The end frame number is defined as the one after the starting frame number, and as the first frame number at which the value of the fluorescence signal P becomes equal to or smaller than the predetermined value. The value of the first threshold is not necessarily limited to "50". It is possible to use a full width at half maximum for the width of the fluorescence signal P. The use of the full width at half maximum makes less susceptible to the influence of the base line.

[0097]

If the width of the fluorescence signal P is equal to or larger than the first threshold (S103 → Yes), the compression range set unit 105 determines whether or not an area of the fluorescence signal P is equal to or larger than a second threshold (S104). The second threshold is set to a value sufficiently smaller than the area of the

primer-derived fluorescence signal P, and sufficiently larger than the area of the fluorescence signal P derived from the analysis object DNA. This is attributable to the characteristic that the area of the primer-derived fluorescence signal P is larger than the area of the DNA-derived fluorescence signal P.

[0098]

The area of the fluorescence signal P which is obvious to be derived from the primer is preliminarily set to the second threshold. In the present embodiment, the second threshold is set to "10000000".

[0099]

If the area of the fluorescence signal P is equal to or larger than the second threshold (S104 → Yes), the compression range set unit 105 determines whether or not the end frame number of the fluorescence signal P is smaller than a third threshold (S105). The third threshold is set to the value that is sufficiently larger than the end frame number of the primer-derived fluorescence signal P, and sufficiently smaller than the end frame number of the fluorescence signal P derived from the analysis object DNA. In other words, the end frame number of the fluorescence signal P which is obvious to be derived from the primer is preliminarily set as the third threshold. This is attributable to the characteristic that the primer-derived fluorescence signal P is detected before detection of the DNA-derived fluorescence signal P. In the present embodiment, the third threshold is set to the frame number "2500".

[0100]

If the end frame number of the fluorescence signal P is smaller than the third threshold (S105 → Yes), the compression range set unit 105 determines that the object fluorescence signal P is derived from

the primer. The compression range set unit 105 applies an analysis exclusion mark JN (see Fig. 19) to the object fluorescence signal P (S106).

[0101]

In step S103, if the width of the fluorescence signal P is smaller than the first threshold (S103 → No), the compression range set unit 105 determines that the object fluorescence signal P is derived from the analysis object DNA. The compression range set unit 105 applies an analysis object mark JY (see Fig. 19) to the object fluorescence signal P (S107).

[0102]

In step S104, if the area of the fluorescence signal P is smaller than the second threshold (S104 → No), the compression range set unit 105 determines that the object fluorescence signal P is derived from the analysis object DNA. The compression range set unit 105 applies the analysis object mark JY (see Fig. 19) to the object fluorescence signal P (S107).

[0103]

Similarly, in step S105, if the end frame number of the fluorescence signal P is equal to or larger than the third threshold (S105→No), the compression range set unit 105 determines that the fluorescence signal P is derived from the analysis object DNA. The compression range set unit 105 applies the analysis object mark JY (see Fig. 19) to the object fluorescence signal P (S107).

[0104]

The fluorescence signal P with the analysis object mark JY is a first fluorescence signal derived from the analysis object. In other words, in the embodiment 1-1, the fluorescence signal P derived from

the analysis object DNA is the first fluorescence signal. The fluorescence signal P with the analysis exclusion mark JN is a second fluorescence signal derived from an object except the analysis object. In other words, in the embodiment 1-1, the primer-derived fluorescence signal P is the second fluorescence signal.

[0105]

In this way, the compression range set unit 105 sorts (detecting distinguishingly) all the fluorescence signals P of the electrophoresis image EP into the fluorescence signal P derived from the analysis object DNA, and the analysis-exclusion fluorescence signal P derived from the primer.

[0106]

After execution of processing in steps S106 and S107, the compression range set unit 105 determines whether or not the processing to all the fluorescence signals P has been completed (S108). The following describes the determination to be made with respect to completion of processing to all the fluorescence signals P. The compression range set unit 105 determines whether or not there is no fluorescence signal P detected after completion of processing to the fluorescence signal P until the last frame number of the electrophoresis image EP (see Fig. 16).

[0107]

If processing to all the fluorescence signals P has not been completed (S108 → No), the compression range set unit 105 executes processing in step S103 and subsequent steps repeatedly.

If processing to all the frames has been completed (S108 → Yes), the compression range set unit 105 determines whether or not the analysis-exclusion fluorescence signal has been detected (S109).

In other words, the compression range set unit 105 determines in step S109 whether or not the fluorescence signal P with the analysis-exclusion object mark JN has been detected.

[0108]

If the analysis-exclusion fluorescence signal P is detected (S109 → Yes), the compression range set unit 105 sets the compression range H (S110). In step S110, the compression range set unit 105 selects the last (for example, the largest starting frame number) fluorescence signal P among those with the analysis exclusion marks JN. The compression range set unit 105 acquires the end frame number of the selected fluorescence signal P. For example, if the selected fluorescence signal P exists in the range of the frame numbers between "1500" and "2000", the compression range set unit 105 acquires "2000" as the end frame number of the selected fluorescence signal P. The compression range set unit 105 sets the range including all the frame numbers from the next frame number as the compression range H. For example, it is supposed that the electrophoresis image EP has the frame numbers from "1" to "5000" as illustrated in Fig. 16. The last frame number of the selected fluorescence signal P is "2000". Accordingly, the frame number of the subsequent frame becomes "2001". In step S110, the compression range set unit 105 sets all the frame numbers from "2001", that is, the range between "2001" and "5000" is set as the compression range H. The specific description of processing executed in step S110 will be described later.

[0109]

In step S109, if the fluorescence signal P with the analysis-exclusion mark JN is not contained (S109 → No), the compression range

set unit 105 sets all the frames as the compression range H (S111). For example, as illustrated in Fig. 16, if the electrophoresis image EP includes the frame numbers from "1" to "5000", the compression range set unit 105 sets the range between "1" and "5000" as the compression range H.

[0110]

As described above, the compression range set unit 105 detects the fluorescence signal P derived from the analysis object DNA and the primer-derived fluorescence signal P distinguishingly from the fluorescence signals contained in the fluorescence signal data D25. The compression range set unit 105 sets the compression range H with respect to the frames of the fluorescence signal data D25 based on the detection result.

[0111]

The compression range set unit 105 outputs the compression range H set in steps S110 and S111 to the compression ratio calculation unit 106 and the compression unit 107 (S112).

[0112]

The embodiment 1-1 describes an example of setting fixed numbers for the thresholds, for example, the first threshold is set to "50", the second threshold is set to "100000", and the third threshold is set to "2500". The fixed numbers, however, are not limited to those values. The first threshold, the second threshold, and the third threshold are appropriately set based on the primer, the DNA fragment, and the like, which are used for electrophoresis. As the first, second, and third thresholds are appropriately set based on the primer and the DNA fragment used for electrophoresis, the analysis object and the analysis exclusion object can be

appropriately distinguished irrespective of the electrophoresis condition.

[0113]

In the embodiment 1-1 with reference to Fig. 15, the width of the fluorescence signal P is determined in step S103, the area of the fluorescence signal P is determined in step S104, and the timing of detecting the fluorescence signal P is determined in step S105. Based on the determinations, the compression range set unit 105 determines distinguishingly whether the fluorescence signal P is derived from the analysis object (DNA) or the primer. Alternatively, it is also possible to determine with respect to the fluorescence signal P distinguishingly by executing at least one of processes executed in steps S103 to S105 besides the above-described process for determination.

[0114]

As described above, the compression range set unit 105 detects the primer-derived fluorescence signal P and the fluorescence signal P derived from the analysis object DNA distinguishingly from the fluorescence signals P contained in the fluorescence signal data D25. At this time, the compression range set unit 105 performs the detection based on at least one of the width of the fluorescence signal P, the area of the fluorescence signal P, and the last frame including the fluorescence signal P (end frame number).

[0115]

(Compression Ratio Calculation Processing)

Fig. 17 is a flowchart representing a procedure of a compression ratio calculation processing executed by the compression ratio calculation unit 106 which is a compression ratio calculation

step according to the embodiment 1-1. Fig. 4 is appropriately referred.

The compression ratio calculation unit 106 acquires the fluorescence signal data D25 from the color conversion unit 104 (S201).

The compression ratio calculation unit 106 acquires the compression range H from the compression range set unit 105 (S202).

The compression ratio calculation unit 106 draws (generates) the electrophoresis image EP (see Fig. 16) of the fluorescence signal data D25. The compression ratio calculation unit 106 acquires a signal intensity maximum value D26 as the maximum fluorescence signal intensity from the fluorescence signal data D25 included in the compression range H (S203). Specific processing to be executed in step S203 will be described later. The signal intensity maximum value D26 denotes the maximum fluorescence signal intensity among the fluorescence signal data D25 included in the compression range H. In other words, the signal intensity maximum value D26 denotes the maximum value of the fluorescence signal intensity included in the compression range H.

[0116]

The compression ratio calculation unit 106 calculates the compression ratio D27 from the signal intensity maximum value D26, and an upper limit value of an output value of the compression unit 107 (S204). The compression ratio D27 is obtained by calculating "the upper limit value output by the compression unit 107/signal intensity maximum value D26". The present embodiment will be described on the assumption that the upper limit value output by the compression unit 107 is "32767". The upper limit value output by the

compression unit 107 is the value to be determined by the secondary analysis. Specifically, the upper limit value output by the compression unit 107 is a maximum value (upper limit value) of the signal intensity that can be used for the secondary analysis. The secondary analysis represents the analysis utilizing data of the processing device 10. The upper limit value output by the compression unit 107 is not limited to "32767".

[0117]

The compression ratio calculation unit 106 calculates the compression ratio D27 based on the signal intensity maximum value D26 of the fluorescence signal intensity included in the compression range H, and the maximum value of the signal intensity that can be used for the secondary analysis.

[0118]

The compression ratio calculation unit 106 outputs the calculated compression ratio D27 to the compression unit 107 and the external memory 30 (S205).

[0119]

The specific processing as shown in Fig. 17 will be described later.

[0120]

(Compression Processing)

Fig. 18 is a flowchart representing a procedure of a compression processing executed which is a compression step by a compression unit 107 according to the embodiment 1-1. Fig. 4 is appropriately referred.

Firstly, the compression unit 107 acquires the fluorescence signal data D25 from the color conversion unit 104 (S301).

Then the compression unit 107 acquires the compression range H from the compression range set unit 105. (S302).

The compression unit 107 acquires the compression ratio D27 from the compression ratio calculation unit 106 (S303).

The compression unit 107 selects one frame from those constituting the acquired fluorescence signal data D25. The compression unit 107 determines whether or not the selected frame is included in the compression range H (S304). The frame may be selected in order from the smaller frame number.

[0121]

If the frame is included in the compression range H (S304 → Yes), the compression unit 107 multiplies the fluorescence signal intensity of the fluorescence signal data D25 corresponding to the frame to be processed by the compression ratio D27 (S305).

[0122]

If the selected frame is not included in the compression range H (S304 → No), the compression unit 107 determines whether or not the fluorescence signal intensity of the selected frame is larger than "32767" (S306).

[0123]

If the fluorescence signal intensity exceeds "32767" (S306 → Yes), the compression unit 107 sets the fluorescence signal intensity of the frame to be processed to "32767" (S307). Specifically, if the fluorescence signal intensity is larger than "32767" in a region outside the compression range H, the compression unit 107 rounds down the fluorescence signal intensity to "32767" (compression is not executed).

[0124]

If the fluorescence signal intensity is equal to or smaller than "32767" (S306 → No), the fluorescence signal intensity of the frame to be processed is kept unchanged (S308).

[0125]

After executing processing in steps from S305 to S308, the compression unit 107 determines whether or not processing in steps from S304 to S308 to all the frames has been completed (S309).

If execution of processing in steps from S304 to S308 to all the frames has not been completed (S309 → No), the compression unit 107 returns to step S304. The compression unit 107 executes processing in steps from S304 to S308 to the next frame.

[0126]

If execution of processing in steps from S304 to S308 to all the frames has been completed (S309 → Yes), the compression unit 107 executes processing in step S310. In step S310, the compression unit 107 outputs the fluorescence signal data D25 subjected to processing in steps from S304 to S308 to the external memory 30 as fluorescence signal compressed data D28 (S310). In the present embodiment, the external memory 30 is an output object in step S310. However, the fluorescence signal compressed data D28 may be directly output to the computer for performing the secondary analysis via a network or the like.

[0127]

The compression unit 107 compresses the fluorescence signal data D25 based on the compression ratio D27 to generate the fluorescence signal compressed data D28, and outputs the generated fluorescence signal compressed data D28. As illustrated in Fig. 4, the compression unit 107 outputs the analysis object sample signal

D11 and the compression ratio D27 in addition to the fluorescence signal compressed data D28.

[0128]

[Operation]

Operations in the embodiment 1-1 will be described with reference to Fig. 19 to Fig. 21. Fig. 19 to Fig. 21 illustrate the respective electrophoresis images EP1, EP2 (EP) of the analysis object sample D10. The analysis object sample D10 includes the fluorescence signal P derived from the analysis object DNA and the analysis-exclusion primer-derived fluorescence signal P.

[0129]

Figs. 19 to 21 illustrate the example of the electrophoresis image EP.

The first threshold is used in step S103 of Fig. 15. In an example as illustrated in Fig. 19, the first threshold is set to "50" frames. The second threshold is used in step S104 of Fig. 15. In an example as illustrated in Fig. 19, the second threshold is set to "10000000", as described above. The third threshold is used in step S105 of Fig. 15. In an example as illustrated in Fig. 19, the third threshold is set to "2500" frames, as described above.

[0130]

(Operation of Compression Range Set Unit 105)

Operations of the compression range set unit 105 will be described with reference to Fig. 3, Fig. 15, Fig. 19, and Fig. 20. The step numbers in the following description correspond to those used in Fig. 15.

As described above, the compression range set unit 105 acquires the fluorescence signal data D25 from the color conversion unit 104

(S101). The compression range set unit 105 draws the electrophoresis image EP1 (EP) in step S102 as illustrated in Fig. 19. Referring to Fig. 19, numerical values at the lower part indicate the frame numbers. For example, the fluorescence signal P1 (P) exists in a range of frame numbers between "300" and "800". This applies to other fluorescence signals P2 to P7 (P). The frame number "5000" is the last frame number of the electrophoresis image EP1 (that is, the fluorescence signal data D25).

[0131]

Referring to Fig. 19, the area of a fluorescence signal P1 is "100000000", the area of the fluorescence signal P2 is "90000000", and the area of the fluorescence signal P3 is "70000000". The area of the fluorescence signal P4 is "2500000", the area of the fluorescence signal P5 is "1000000". The area of the fluorescence signal P6 is "3000000", the area of the fluorescence signal P7 is "500000".

[0132]

The compression range set unit 105 searches the fluorescence signals P from the frame number "1", and executes processing to the firstly detected fluorescence signal P1.

[0133]

Referring to Fig. 19, the fluorescence signal P1 has its starting frame number "300", and its end frame number "800". The frame width of the fluorescence signal P1 corresponds to "500" frames. Accordingly, the frame width of the fluorescence signal P1 is equal to or larger than the first threshold (in the present embodiment, "50" frames). Then in step S103, "YES" is determined, and the compression range set unit 105 proceeds to step S104.

[0134]

Then in step S104, processing is executed based on the area of the fluorescence signal P1. The area of the fluorescence signal P1 is "100000000" as described above. The area of the fluorescence signal P1 is equal to or larger than the second threshold (in the present embodiment, "100000000"). Then in step S104, "YES" is determined, and the compression range set unit 105 proceeds to step S105.

[0135]

Then in step S105, processing is executed based on the end frame number of the fluorescence signal P1. The end frame number of the fluorescence signal P1 is "800", and smaller than the third threshold (in the present embodiment, "2500" frames). As described above, the primer is manually migrated. This identifies the time (that is, the frame number) representing the extent to which the primer-derived signal exists. Additionally, it is known that the primer reaches the fluorescence detection position 24 earlier than DNA. Based on the information, the third threshold is preliminarily set.

[0136]

Then in step S105, "YES" is determined, and the compression range set unit 105 proceeds to step S106. In step S106, the compression range set unit 105 applies the analysis-exclusion mark JN to the fluorescence signal P1 as illustrated in Fig. 19. (distinguishingly detected as the second fluorescence signal).

[0137]

Then in step S108, subsequent to the processing to the fluorescence signal P1, the compression range set unit 105 determines

whether or not processing to all the fluorescence signals P has been completed. The electrophoresis image EP1 as illustrated in Fig. 19 contains other fluorescence signals P besides the fluorescence signal P1. Accordingly, "No" is determined in step S108. The compression range set unit 105 executes processing to the fluorescence signal P2 in step S103 and subsequent steps repeatedly.

[0138]

Referring to Fig. 19, similar to the fluorescence signal P1, the fluorescence signals P2 and P3 are applied with analysis-exclusion marks JN, respectively in step S106 as illustrated in Fig. 19. (distinguishingly detected as the second fluorescence signal).

[0139]

After applying the analysis exclusion mark JN to the fluorescence signal P3, the compression range set unit 105 determines whether or not processing to all the fluorescence signals P has been completed in step S108. As illustrated in Fig. 19, the electrophoresis image EP1 contains fluorescence signals P besides the fluorescence signals P1 to P3. Accordingly, "No" is determined in step S108. The compression range set unit 105 executes processing to the fluorescence signal P4 in step S103 and subsequent steps repeatedly.

[0140]

Referring to Fig. 19, the fluorescence signal P4 has its starting frame number "2700", and its end frame number "2720". Therefore, the fluorescence signal P4 has its frame width of "20" that is smaller than the first threshold (in the present embodiment, "50" frames). Accordingly, "No" is determined in step S103. The compression range set unit 105 proceeds to step S107 where the

analysis object mark JY is applied to the fluorescence signal P4 as illustrated in Fig. 19 (distinguishingly detected as the first fluorescence signal).

[0141]

Then in step S108, subsequent to processing to the fluorescence signals P1 to P4, the compression range set unit 105 determines whether or not processing to all the fluorescence signals P included in the electrophoresis image EP1 has been completed. The electrophoresis image EP1 as illustrated in Fig. 19 contains fluorescence signals P besides the fluorescence signals P1 to P4. Accordingly, "No" is determined in step S108. The compression range set unit 105 executes processing to the fluorescence signal P5 in step S103 and subsequent steps repeatedly.

[0142]

Referring to Fig. 19, similar to the fluorescence signal P4, the analysis object marks JY are applied to the fluorescence signals P5 to P7, respectively in step S106 (distinguishingly detected as the first fluorescence signal).

[0143]

Then in step S108, subsequent to processing to the fluorescence signals P1 to P7, the compression range set unit 105 determines whether or not processing to all the fluorescence signals P has been completed. The electrophoresis image EP1 as illustrated in Fig. 19 contains the fluorescence signals P from P1 to P7 in all. Then in step S108, "YES" is determined, and the compression range set unit 105 proceeds to step S109.

[0144]

In step S109, the compression range set unit 105 determines

whether or not the fluorescence signal P with the analysis-exclusion mark JN exists. As described before, the electrophoresis image EP1 as illustrated in Fig. 19 contains the analysis-exclusion fluorescence signals P1 to P3. Then in step S109, "YES" is determined, and the compression range set unit 105 proceeds to step S110.

[0145]

In step S110, the compression range H is determined. As described with reference to Fig. 19, among the fluorescence signals P, each of the fluorescence signals P1 to P3 is applied with the analysis-exclusion mark JN in step S106. Accordingly, the fluorescence signal P3 is the last fluorescence signal P applied with the analysis exclusion mark JN. As illustrated in Fig. 19, the end frame number of the fluorescence signal P3 is "2000" (the frame in which the second fluorescence signal is detected). The compression range set unit 105 sets the compression range H as the range of the frame numbers between "2001" (the frame subsequent to the one in which the second fluorescence signal is detected) subsequent to the frame number "2000" and the last frame number "5000" of the electrophoresis image EP1 as illustrated in Fig. 19. The compression range H as illustrated in Fig. 20 is determined by the above-described processing.

[0146]

The compression range set unit 105 sets the compression range H from the frame subsequent to the one in which the primer-derived fluorescence signal P is detected.

[0147]

The compression range set unit 105 may be configured to set the

compression range H based on the fluorescence signal P with the analysis object mark JY in step S110. In this case, the fluorescence signal P4 is the first fluorescence signal P to which the analysis object mark JY has been applied. As illustrated in Fig. 19, the fluorescence signal P4 has its starting frame number "2700".

Accordingly, the compression range set unit 105 sets the compression range H as the range of the frame number between "2700" and the last frame number "5000" of the electrophoresis image EP1 as illustrated in Fig. 19.

[0148]

The compression range H is set with respect to the frames of the fluorescence signal data D25 based on detection results of the fluorescence signals P4 to P7 derived from the analysis object DNA (first fluorescence signal), and the primer-derived fluorescence signals P1 to P3 (second fluorescence signal).

[0149]

The compression range set unit 105 outputs the set compression range H to the compression ratio calculation unit 106 and the compression unit 107 in step S112.

[0150]

The compression range set unit 105 executes processing utilizing the characteristic of the primer-derived fluorescence signal P (in the example as illustrated in Fig. 19, the fluorescence signals P1 to P3). The primer-derived fluorescence signal P is characterized to have the wider frame width, larger area, and the frame number that allows earlier detection compared with the fluorescence signal P derived from the analysis object DNA. This makes it possible to distinguish between the primer-derived

fluorescence signal P and the fluorescence signal P derived from the analysis object DNA, and to set the compression range H.

[0151]

(Operation of Compression Ratio Calculation Unit 106)

Operations of the compression ratio calculation unit 106 will be described with reference to Fig. 4, Fig. 17, and Fig. 20. The step numbers in the following description correspond to those used in Fig. 17.

The compression ratio calculation unit 106 acquires the fluorescence signal data D25 from the color conversion unit 104 (S201). The compression ratio calculation unit 106 acquires the compression range H from the compression range set unit 105 (S202). As illustrated in Fig. 20, in an example of the present embodiment, the compression range H is the range of frame numbers between "2001" and "5000". In steps S201 and S202, the compression ratio calculation unit 106 acquires the fluorescence signal data D25 and the compression range H as illustrated in Fig. 20. The compression ratio calculation unit 106 acquires the maximum value (signal intensity maximum value D26) of the fluorescence signal intensity of the fluorescence signal data D25 included in the compression range H in step S203. Referring to Fig. 20, the signal intensity maximum value D26 of the fluorescence signal intensity is "360000" in the range of frame numbers between "2001" and "5000".

[0152]

The compression ratio calculation unit 106 calculates the compression ratio D27 in step S204. As described above, the signal intensity maximum value D26 is "360000", and the upper limit value of the output value of the compression unit 107 is "32767". The

compression ratio calculation unit 106 calculates "32767/360000" to obtain "0.091" as the compression ratio D27.

[0153]

(Operation of Compression Unit 107)

Operations of the compression unit 107 will be described with reference to Fig. 4, Fig. 18, and Fig. 21. The step numbers in the following description correspond to those used in Fig. 18. Numerical values "2000", "2001" together with lead lines below the abscissa of the drawing represent the frame numbers.

The compression unit 107 acquires the fluorescence signal data D25 from the color conversion unit 104 (S301). The compression unit 107 acquires the compression range H from the compression range set unit 105 (S302). The fluorescence signal data D25 and the compression range H as illustrated in Fig. 20 are acquired by executing processing in steps S301 and S302. As illustrated in Fig. 20, in the example of the present embodiment, the compression range H is the range of frame numbers between "2001" and "5000". The compression unit 107 acquires the compression ratio D27 from the compression ratio calculation unit 106 (S303). As described above, in the example of the present embodiment, the compression ratio D27 is "0.091". In step S304, the compression unit 107 determines whether or not the frame as the processing object is included in the compression range H.

[0154]

For example, referring to Fig. 20, frames corresponding to the frame numbers from "3800" to "3820" constituting the fluorescence signal P6 are included in the compression range H. Then in step S304, "Yes" is determined, and the compression unit 107 proceeds to

step S305. In step S305, the compression unit 107 multiplies the fluorescence signal intensity of the frame to be processed by the compression ratio D27. For example, the fluorescence signal intensity of the frame corresponding to the signal intensity maximum value D26 is "360000" in the range of frame numbers between "3800 and "3820". When the compression unit 107 multiplies the fluorescence signal intensity of the frame by the compression ratio D27 of "0.091", the fluorescence signal intensity of the frame to be processed is compressed to $360000 \times 0.091 = 32767$ ". The compression unit 107 multiplies the fluorescence signal intensity for each frame included in the compression range H by "0.091".

[0155]

Meanwhile, the frame in the range of frame numbers between "300" and "800" constituting the fluorescence signal P1 is not included in the compression range H. Then in step S304, "No" is determined, and the compression unit 107 proceeds to step S306. In step S306, the compression unit 107 determines whether or not the fluorescence signal intensity of the frame to be processed is larger than "32767". As for the frame with the fluorescence signal intensity larger than "32767", the compression unit 107 rounds down the fluorescence signal intensity to "32767" (S307). As described above, the frame is not compressed in step S307. As for the frame with the fluorescence signal intensity equal to or smaller than "32767", the compression unit 107 keeps the fluorescence signal intensity unchanged (S308). The compression unit 107 executes processing in steps from S306 to S308 to each frame of the electrophoresis image EP (fluorescence data D25) in the region outside the compression range H.

[0156]

Processing in steps from S304 to S308 is executed to each frame that constitutes the fluorescence signal data D25. As a result, the electrophoresis image EP2 corresponding to the fluorescence signal compressed data D28 is generated as illustrated in Fig. 21.

Referring to Fig. 21, a broken line V1 represents the value (fluorescence signal intensity of the compressed fluorescence signal P6) corresponding to the signal intensity maximum value D26 as shown in Fig. 20. As illustrated in Fig. 21, in the compression range H, the fluorescence signal data D25 are compressed so that the value corresponding to the signal intensity maximum value D26 as illustrated in Fig. 20 becomes a maximum value of the signal intensity which can be used for the secondary analysis. In the present embodiment, the maximum value of the signal intensity that can be used for the secondary analysis is "32676". In other words, the broken line V1 corresponds to the maximum value of the signal intensity that can be used for the secondary analysis. In the region outside the compression range H, the compression unit 107 executes processing in steps from S306 to S308. As a result, each of the fluorescence signals P1 to P3 has its part above the value "32676" missing.

[0157]

[Effect]

Patent Literature 1 discloses the method for selection between hardware binning and software binning. Patent Literature 1, however, does not disclose the means that allows the use of the output value of the electrophoresis system 1 for the secondary analysis.

[0158]

In the embodiment 1-1, if the value of the fluorescence signal data D25 exceeds the fluorescence signal intensity "32767", which can be used for the secondary analysis, processing is executed to allow the fluorescence signal intensity to be "32767". It is possible to make each fluorescence signal intensity of all the frames of the fluorescence signal compressed data D28 equal to or smaller than "32767". This makes it possible to execute the secondary analysis.

[0159]

According to the embodiment 1-1, the fluorescence signal data D25 are compressed in accordance with the fluorescence signals P derived from the analysis object DNA. This makes it possible to minimize the compression ratio D27. The minute fluorescence signal P can be kept by minimizing the compression ratio D27. Minimization of the compression ratio D27 represents calculation of the minimum compression ratio D27.

[0160]

Non-patent Literature 1 discloses that the data are compressed by the fixed compression ratio D27 for bringing the value that can be output by the electrophoresis system 1 into the range of values that can be input to the secondary analysis software. However, the data to be output by the electrophoresis system 1 contain the fluorescence signals P of the reagent called primer used for DNA amplification. As described above, the primer is excessively added compared with the analysis object DNA, resulting in high fluorescence signal intensity. As the primer is shorter than the analysis object DNA, the primer can be detected at a timing earlier than the analysis object DNA.

[0161]

When executing the software binning, under the influence of the

primer-derived fluorescence signal P, the fluorescence signal intensity acquired by the electrophoresis system 1 becomes significantly high to deviate from the range of values that can be input to the secondary analysis software. If the data compression is performed by the fixed compression ratio D27 as disclosed in Non-patent Literature 1, the compression ratio D27 in the direction of the fluorescence signal intensity becomes large. Accordingly, this may reduce the volume of information of the analysis object DNA with minute fluorescence signal intensity.

[0162]

The digital conversion unit 232 as described in the embodiment 1-1 converts an analog signal value upon saturation of the summing gate 213 into a digital signal value "65535" (ADU). The signal integration unit 101 executes the software binning with reference to Fig. 14. In this case, the maximum value of the fluorescence signal intensity output after the software binning becomes " $65535 \times 12 = 786420$ ". The numerical value "12" represents the number of bins B (see Fig. 3) when executing the software binning with reference to Fig. 14. If the upper limit value that can be input to the secondary analysis software is "32767", the compression ratio D27 is obtained by calculating " $32767/786420 = 0.042$ ". The excessively large compression ratio D27 may fail to keep the minute fluorescence signal P derived from DNA. In other words, the DNA-derived fluorescence signal P becomes too small to perform the secondary analysis.

[0163]

Patent Literature 2 discloses selection and processing of the data point with respect to the experimental data. Selection of the data point can be perceived as selection of the abscissa of a graph

of the experimental data. Patent Literature 2 discloses selection of the data point for deleting the data point, and normalizing the ordinate (processing of the ordinate) when graphing the experimental data.

[0164]

Patent Literature 2 discloses the method for reducing the data point by clutter rejection. Patent Literature 2, however, does not disclose the method for removing the primer-derived fluorescence, which causes high signal intensity in the data output by the electrophoresis system 1.

[0165]

Meanwhile, the embodiment 1-1 relates to selection of the analysis object range based on the primer specific to the electrophoresis (selection of the abscissa), and compression of data in the analysis object range (processing of the ordinate).

In the embodiment 1-1, distinguishment between the primer-derived fluorescence signal P and the fluorescence signal P derived from the analysis object DNA allows the compression ratio D27 to be minimized.

[0166]

The following describes comparison between the technology disclosed in Patent Literature 2 and the embodiment 1-1. Concerning selection of the abscissa as disclosed in Patent Literature 2, the abscissa of the graph relating to the experimental data is selected by deleting the data point. In Patent Literature 2, the spectrum (the graph having the abscissa as the wavelength and the ordinate as the signal intensity) at each data point is compared with the specific shape. In the case of non-match with the specific shape,

the data at the data point are deleted. Meanwhile, in the embodiment 1-1, the abscissa is selected by setting the range used for analysis (compression range H). Specifically, in the embodiment 1-1, the range to be used for the secondary analysis (compression range H) is determined based on the characteristic of the fluorescence signal generated specific to the pre-processing using the primer for the electrophoresis.

[0167]

Patent Literature 2 intends to improve visibility of the ordinate-related processing on GUI. In Patent Literature 2, the ordinate-related processing is executed by normalizing the ordinate of the graph (it does not necessarily mean that the compression is performed). In Patent Literature 2, the normalization may cause the loss of the information of the signal intensity ratio between signal peaks. Meanwhile, the embodiment 1-1 intends to execute the ordinate-related processing (compression) for bringing values into the range of the value that can be used for the secondary analysis without losing the information of the minute signal such as the DNA-derived fluorescence signal P. In the embodiment 1-1, compression is performed so that, in the range for the analysis object (compression range H), the signal intensity maximum value D26 becomes the value that can be used for the secondary analysis. As the entire fluorescence signal data D25 are uniformly compressed, it is possible to keep the information of the fluorescence signal intensity ratio between peaks of the fluorescence signals P. This is attributable to the importance of the fluorescence signal intensity ratio for the secondary analysis.

[0168]

The content of the embodiment 1-1 is totally different from the technology disclosed in Patent Literature 2.

[0169]

Besides Patent Literatures 1, 2 and Non-patent Literature 1, there are many literatures relating to the data compression technology for making data values equal to or smaller than a predetermined value. In contrast to the embodiment 1-1, there has been no literature that discloses selection of the range (compression range H) for calculating the compression ratio D27 with respect to the abscissa of the electrophoresis image EP.

[0170]

In other words, the compression range set unit 105 allows distinguishment between the primer-derived fluorescence signal P and the fluorescence signal P derived from the analysis object DNA. The compression range set unit 105 sets the compression range H, and the compression ratio calculation unit 106 sets the compression ratio D27 in accordance with the compression range H. This allows the compression ratio calculation unit 106 to minimize the compression ratio D27. Referring to the electrophoresis image EP1 as illustrated in Fig. 20, each fluorescence signal intensity of the primer-derived fluorescence signals P1 to P3 is "786420" that is far higher than each fluorescence signal intensity of the DNA-derived fluorescence signals P4 to P7. Even in this case, the compression ratio calculation unit 106 acquires the signal intensity maximum value D26 based on the fluorescence signal P6 derived from the analysis object DNA, and calculates the compression ratio D27 based on the signal intensity maximum value D26. This makes it possible to calculate the appropriate compression ratio D27. In the example of the present

embodiment, the compression ratio D27 is "0.091" that can be made smaller compared with the compression ratio D27 of "0.042" according to Non-patent Literature 1. This prevents the DNA-derived fluorescence signals P4 to P7 of the fluorescence signal compressed data D28 for the secondary analysis from being made excessively small, resulting in easy execution of the secondary analysis.

[0171]

According to the embodiment 1-1, even if the primer of the analysis object sample D10 is mixed, the compression ratio D27 can be minimized based on the characteristic of the fluorescence signal P derived from the analysis object DNA. It is possible to compress the fluorescence signal data D25 to be in the range of values that can be input for the secondary analysis software while keeping the minute signal like the DNA-derived fluorescence signal.

[0172]

The method as described in the embodiment 1-1 can be implemented by changing the program of the processing device 10. In other words, the method described in the embodiment 1-1 can be implemented without changing hardware configurations of the electrophoresis apparatus 20 and the processing device 10. As it is possible to implement the method as described in the embodiment 1-1 without changing the configuration of the electrophoresis apparatus 20, the cost reduction can be attained. The embodiment 1-1 allows appropriate compression of the fluorescence signal data D25 without losing characteristics of the dynamic range derived from the hardware binning and the software binning.

[0173]

The following describes the output operation to the external

memory 30 according to the embodiment 1-1 with reference to Fig. 12, Fig. 20, Fig. 14.

The electrophoresis image EP of the analysis object sample D10 generated in step S102 of the present embodiment as illustrated in Fig. 15 is defined as the electrophoresis image EP1 as illustrated in Fig. 19. The software binning as illustrated in Fig. 12 is executed to the analysis object sample signal D11 of the bin B of the frame in which the signal intensity maximum value D26 of the fluorescence signal P6 is acquired as illustrated in Fig. 20. In the example of Fig. 20, the number of the frame in which the signal intensity maximum value D26 is acquired is "3810". The software binning is executed in accordance with Fig. 14.

[0174]

Each value of the analysis object sample signals D11 of the respective bins B is uniformly set to "30000" as illustrated in Fig. 12. Upon execution of the software binning, the maximum signal intensity of the analysis object sample integration signal D12 of the soft bin C becomes "360000" (30000×12).

[0175]

Meanwhile, the value of the fluorescence signal compressed data D28 after the compression processing executed by the compression unit 107 as illustrated in Fig. 18 becomes "32767".

The analysis object sample signal D11, the fluorescence signal compressed data D28 according to the present embodiment, and the compression ratio D27 (in the present embodiment, "0.091") are output to the external memory 30.

[0176]

A user is allowed to compare the value of the analysis object

sample signal D11 in the specific frame, the value of the fluorescence signal compressed data D28 relating to the subject frame, and the compression ratio D27. For example, the value of the analysis object sample signal D11 in the specific frame may be "360000" as illustrated in Fig. 12. For example, the value of the fluorescence signal compressed data D28 relating to the specific frame may be "32767" as illustrated in Fig. 12. Comparison of those values allows the user to recognize whether or not the compression processing according to the embodiment 1-1 has been executed.

[0177]

The embodiment 1-1 allows the fluorescence signal intensity of the fluorescence signal data D25 to be within the range of values that can be input to the secondary analysis software. At this time, the compression ratio D27 is determined based on the signal intensity maximum value D26 of the fluorescence signal P in the compression range H and the upper limit value to be used for the secondary analysis software. This allows the secondary analysis software to appropriately analyze the primary analysis file output by the electrophoresis system 1. The primary analysis file represents data output by the processing device 10.

[0178]

In the embodiment 1-1, the fluorescence signals P are distinguished between the analysis object and the analysis-exclusion object so that only the fluorescence signal P in the analysis object range is compressed. This makes it possible to keep the information of the minute fluorescence signal P by preventing the compression ratio D27 from being excessively large.

[0179]

The compression range set unit 105 detects the fluorescence signal P distinguishingly based on at least one of the width/area of the fluorescence signal P, and the last frame (end frame number) including the fluorescence signal P. The fluorescence signals P are distinguished into the fluorescence signal P derived from the analysis object DNA and the primer-derived fluorescence signal P. This allows distinguishment between the fluorescence signal P derived from the analysis object DNA and the primer-derived fluorescence signal P.

[0180]

<Embodiment 1-2>

An embodiment 1-2 according to the present invention will be described with reference to Fig. 22 and Fig. 23.

Figs. 22 and 23 illustrate the example of the electrophoresis image EP.

The embodiment 1-1 describes the electrophoresis data processing method for the electrophoresis image EP that contains the primer-derived fluorescence signal P.

The embodiment 1-2 describes the electrophoresis data processing method for the electrophoresis image EP (fluorescence signal data D25) that does not contain the primer-derived fluorescence signal P. The embodiment 1-2 shows applicability of the processing as described in the embodiment 1-1 to the fluorescence signal data D25 that do not contain the primer.

The system configuration and operations in the embodiment 1-2 are the same as those of the embodiment 1-1. Accordingly, illustration of the system configuration and operations (flowchart) of the embodiment 1-2 are omitted.

[0181]

[Operation]

The following describes the case where the electrophoresis image EP drawn in step S102 of Fig. 15 corresponds to an electrophoresis image EP3 as illustrated in Fig. 22. Fig. 22 illustrate the respective electrophoresis image EP3 (EP) of the analysis object sample D10. The analysis object sample D10 does not contain the analysis-exclusion primer-derived fluorescence signal P, but only contains the fluorescence signal P derived from the analysis object DNA. The first threshold, the second threshold, and the third threshold are the same as those described in the embodiment 1-1.

[0182]

(Operation of Compression Range Set Unit 105)

Operations of the compression range set unit 105 will be described with reference to Fig. 3, Fig. 15 and Fig. 22. The step numbers in the following description correspond to those used in Fig. 15.

The compression range set unit 105 acquires the fluorescence signal data D25 from the color conversion unit 104 (S101). Fig. 22 illustrates the electrophoresis image EP3 (EP) drawn by the compression range set unit 105 in step S102. The electrophoresis image EP3 contains seven fluorescence signals P (P8 to P14) as illustrated in Fig. 22.

[0183]

Referring to Fig. 22, numerical values together with lead lines below the abscissa of the drawing represent the frame numbers. The electrophoresis image EP3 as illustrated in Fig. 22 has a range of frame numbers between "0" and "5000". The fluorescence signal P8

exists in the range of frame numbers between "300" and "320", and has its area of "30000000". The fluorescence signal P9 exists in the range of frame numbers between "1100" and "1130", and has its area of "20000000". The fluorescence signal P10 exists in the range of frame numbers between "2000" and "2020", and has its area of "8000000". The fluorescence signal P11 exists in the range of frame numbers between "2700" and "2720", and has its area of "25000000". The fluorescence signal P12 exists in the range of frame numbers between "3175" and "3200", and has its area of "10000000". The fluorescence signal P13 exists in the range of frame numbers between "3800" and "3820", and has its area of "30000000". The fluorescence signal P14 exists in the range of frame numbers between "4300" and "4320", and has its area of "5000000".

[0184]

The compression range set unit 105 searches the fluorescence signals P from the frame number "1", and executes processing to the firstly detected fluorescence signal P8.

[0185]

Referring to Fig. 22, the fluorescence signal P8 has its starting frame number "300", and its end frame number "320". The frame width is represented by "20" frames. The frame width of the fluorescence signal P8 is smaller than the first threshold (in the present embodiment, "50" frames). Then in step S103, "No" is determined, and the compression range set unit 105 proceeds to step S107. In step S107, the compression range set unit 105 applies the analysis object mark JY to the fluorescence signal P8 as illustrated in Fig. 22 (distinguishingly detected as the first fluorescence signal).

[0186]

Then in step S108, subsequent to processing to the fluorescence signal P8, the compression range set unit 105 determines whether or not processing to all the fluorescence signals P has been completed.

[0187]

The fluorescence signal P expressed by the electrophoresis image EP3 contains other fluorescence signals besides the fluorescence signal P8. Therefore, "No" is determined in step S108, and the compression range set unit 105 executes processing to the next fluorescence signal P9 in step S103 and subsequent steps.

[0188]

Referring to Fig. 22, the compression range set unit 105 applies analysis object marks JY to the fluorescence signals P9 to P14 in step S106 (distinguishingly detected as the first fluorescence signal) like the fluorescence signal P8.

[0189]

Then in step S108, subsequent to processing to the fluorescence signal P14, the compression range set unit 105 determines whether or not processing to all the fluorescence signals P has been completed. The electrophoresis image EP3 as shown in Fig. 22 contains the fluorescence signals P8 to P14 in all. Then in step S108, "YES" is determined, and the compression range set unit 105 proceeds to step S109.

[0190]

In step S109, it is determined whether or not the analysis-exclusion fluorescence signal P exists. As illustrated in Fig. 22, the electrophoresis image EP3 does not contain the analysis-exclusion fluorescence signal P but contains all the fluorescence signals P to

be analyzed. Then in step S109, "NO" is determined, and the compression range set unit 105 proceeds to step S111.

[0191]

In step S111, the compression range H is determined. As described above, in an example of the embodiment 1-2, as the analysis-exclusion fluorescence signal P is not contained, all the frames are set to be within the compression range H. The compression range set unit 105 sets the range of frame numbers of the electrophoresis image EP3 between "1" and "5000" as the compression range H.

[0192]

Then, in step S112, the compression range set unit 105 outputs the set compression range H to the compression ratio calculation unit 106 and the compression unit 107.

[0193]

The compression range set unit 105 is allowed to set the compression range H for the fluorescence signal data D25 that do not contain the analysis-exclusion primer-derived fluorescence signal P.

[0194]

(Operation of Compression Ratio Calculation Unit 106)

Operations of the compression ratio calculation unit 106 will be described with reference to Fig. 4, Fig. 17, and Fig. 22. The step numbers in the following description correspond to those used in Fig. 17.

The compression ratio calculation unit 106 acquires the fluorescence signal data D25 from the color conversion unit 104 (S201). The compression ratio calculation unit 106 acquires the compression range H from the compression range set unit 105 (S202).

In the embodiment 1-2, the compression range H is the range of frame numbers between "1" and "5000". The compression ratio calculation unit 106 acquires the signal intensity maximum value D26 of the fluorescence signal data D25 included in the compression range H in step S203. As illustrated in Fig. 22, the signal intensity maximum value D26 of the fluorescence signal data D25 included in the range of frame numbers between "1" and "5000" is "360000".

[0195]

Then in step S204, the compression ratio calculation unit 106 calculates the compression ratio D27. As described above, similar to the embodiment 1-1, the signal intensity maximum value D26 is "360000", and the upper limit value of the output value of the compression unit 107 is "32767". The compression ratio calculation unit 106 obtains the compression ratio D27 by calculating $32767/360000 = 0.091$.

[0196]

(Operation of Compression Unit 107)

Operations of the compression unit 107 will be described with reference to Fig. 3, Fig. 18, Fig. 22 and Fig. 23. The step numbers in the following description correspond to those used in Fig. 18.

The compression unit 107 acquires the fluorescence signal data D25 from the color conversion unit 104 (S301). The compression unit 107 acquires the compression range H from the compression range set unit 105 (S302). In the embodiment 1-2, as described above, the compression range H is the range of frame numbers between "1" and "5000". The compression unit 107 acquires the compression ratio D27 from the compression ratio calculation unit 106 (S303). In the embodiment 1-2, the compression ratio D27 is "0.091" as described

above.

[0197]

The compression unit 107 selects the frame in order from the smaller frame number. In step S304, it is determined whether or not the frame to be processed is included in the compression range H.

Referring to Fig. 22, all the frames respectively constituting the fluorescence signals P8 to P14 are included in the compression range H. The compression unit 107 determines "Yes" in step S304 with respect to any of the fluorescence signals P8 to P14. The compression unit 107 proceeds to step S305 to multiply the fluorescence signal intensity of the frame to be processed by the compression ratio D27 (S305). The fluorescence signal intensity of the frame corresponding to the signal intensity maximum value D26 is compressed to "32767" by calculating " 360000×0.091 ".

[0198]

Execution of processing in step S305 generates an electrophoresis image EP4 (EP) as illustrated in Fig. 23. In step S310, the compression unit 107 outputs the electrophoresis image EP4 illustrated in Fig. 23 as the fluorescence signal compressed data D28. Referring to Fig. 21, a broken line V2 represents the value (fluorescence signal intensity of the fluorescence signal P13) corresponding to the signal intensity maximum value D26 as shown in Fig. 22. As illustrated in Fig. 23, the fluorescence signal data 25 are compressed so that the value corresponding to the signal intensity maximum value D26 illustrated in Fig. 22 becomes a maximum value (in the present embodiment, "32676") of the signal intensity that can be used for the secondary analysis. In other words, the broken line V2 corresponds to the maximum value of the signal

intensity that can be used for the secondary analysis.

[0199]

The processing device 10 is allowed to compress the electrophoresis image EP (fluorescence signal data D25) which does not contain the primer-derived fluorescence signal P by the processing as described in the embodiment 1-1.

[0200]

[Effect]

Besides the advantageous effect derived from the embodiment 1-1, the embodiment 1-2 provides the similar effect to that of the embodiment 1-1 even if the primer-derived fluorescence signal is not contained in the fluorescence signal data D25. In other words, even if the fluorescence signal data D25 do not contain the primer-derived fluorescence signal P, the data can be compressed to be in the range of values that can be input to the secondary analysis software while keeping the minute signal by minimizing the compression ratio D27.

[0201]

<<Embodiment 2>>

Then, an embodiment 2 of the present invention will be described with reference to Fig. 25 and Fig. 30.

In the embodiment 1, the compression range H is determined by distinguishing the fluorescence signals P based on the characteristic of the analysis-exclusion primer-derived fluorescence signal P. In the embodiment 2, the compression range H is determined based on the characteristics of the fluorescence signal P and the size standard.

[0202]

<Embodiment 2-1>

[System Configuration]

Fig. 24 illustrates a configuration of the processing device 10 according to an embodiment 2-1.

Referring to Fig. 24, the configuration of this embodiment is different from the configuration as illustrated in Fig. 4 in that an analysis object sample D10a is a mixture liquid that contains DNA as an analysis object, the primer, and a size standard. The processing device 10 as illustrated in Fig. 24 is different from that of the embodiment 1 in the method for setting the compression range H by the compression range set unit 105. Other configurations are the same as those illustrated in Fig. 4.

[0203]

The size standard is a sample (DNA) that has a known base length, and contains a plurality of fluorescence signals P. The use of the size standard makes the base length of the analysis object DNA known. The number of the size-standard-derived fluorescence signals is known. The size standard is mixed with the analysis object sample D10a for use. In other words, the analysis object sample D10a according to the embodiment 2 contains the size standard. The range of the base length of DNA which contains the size standard is set to be wider than the range of the base length of the analysis object DNA. In other words, the size-standard-derived fluorescence signal P is detected in the range wider than that of the fluorescence signal P derived from the analysis object DNA.

[0204]

The frame number at which the size-standard-derived fluorescence signal P is detected is larger than the frame number at which the primer-derived fluorescence signal P is detected (detected in the later timing). Furthermore, the pigment in color different

from that of the analysis object DNA is used for the size standard.

[0205]

[Operation]

Referring to Fig. 25, the following describes procedures of the electrophoresis data processing method according to the embodiment 2-1.

(Processing for Determining Compression Range H)

Fig. 25 is a flowchart of compression range determination processing as a compression range setting step executed by the compression range set unit 105 according to the embodiment 2-1. Fig. 4 is appropriately referred.

Firstly, the compression range set unit 105 acquires the fluorescence signal data D25 from the color conversion unit 104 (S401). In step S401, the compression range set unit 105 acquires the fluorescence signal data D25 relating to all the frames.

[0206]

The compression range set unit 105 draws (generates) the electrophoresis image EP (see Fig. 16) of the fluorescence signal data D25 (S402). Similar to the embodiment 1-1, the electrophoresis image EP is generated for each electrophoresis.

[0207]

The compression range set unit 105 selects one fluorescence signal P from those contained in the generated electrophoresis image EP. The method for selecting the fluorescence signal P is similar to the method as described in the embodiment 1-1. The compression range set unit 105 determines whether or not the color of the selected fluorescence signal P matches the color used for the size standard (size standard color)(S403). The size standard color represents the

color of the pigment used for the size standard. As described above, the color of the pigment used for the size standard is different from the color of the pigment used for the analysis object DNA. This allows the compression range set unit 105 to distinguish by color between the size-standard-derived fluorescence signal P and the fluorescence signal P derived from the analysis object DNA.

[0208]

The determination whether or not the color matches the size standard color is made based on the color information of the fluorescence signal P.

[0209]

If the color of the fluorescence signal P does not match the size standard color (S403 → No), the compression range set unit 105 selects the next fluorescence signal P (S404), and executes processing in step S403 and subsequent steps.

[0210]

If the color of the fluorescence signal P matches the size standard color (S403 → Yes), the compression range set unit 105 applies a size standard mark JS (Fig. 26) to the fluorescence signal P. That is, the compression range set unit 105 applies the mark JS to the fluorescence signal P determined as the size-standard-derived fluorescence signal P.

[0211]

The fluorescence signal P with no size standard mark JS indicates that it is detected as the fluorescence signal P derived from the analysis object DNA. The fluorescence signal P with no size standard mark JS is a first fluorescence signal derived from the analysis object. In other words, in the embodiment 2-1, the

fluorescence signal P derived from the analysis object DNA is the first fluorescence signal. The fluorescence signal P with the size standard mark JS indicates that it is detected as the size-standard-derived fluorescence signal P. The fluorescence signal P with the size standard mark JS is a second fluorescence signal derived from an object except the analysis object. In other words, in the embodiment 2-1, the size-standard-derived fluorescence signal P is a second fluorescence signal. As described above, the compression range set unit 105 detects the size-standard-derived fluorescence signal P as the second fluorescence signal.

[0212]

As described above, in the embodiment 2-1, the compression range set unit 105 detects the fluorescence signal P derived from the analysis object DNA and the size-standard-derived fluorescence signal P distinguishingly based on the color information of the fluorescence signal P.

[0213]

The compression range set unit 105 then determines whether or not processing to all the fluorescence signals P of the electrophoresis image EP has been completed (S406).

[0214]

If execution of processing to all the fluorescence signals P has not been completed (S406 → No), the compression range set unit 105 selects the next fluorescence signal P (S407), and executes processing in step S403 and subsequent steps.

[0215]

If execution of processing to all the fluorescence signals P has been completed (S406 → Yes), the compression range set unit 105

applies a number to the fluorescence signal P with the size standard mark JS (S408). At this time, the compression range set unit 105 applies the number starting from "1" to the fluorescence signal P with the size standard mark JS in order from the larger frame number.

[0216]

The compression range set unit 105 then determines whether or not the maximum value of the number applied in step S408 is the same as the specified number of size standards (maximum value of the number = specified number : S409). In other words, the compression range set unit 105 determines whether or not the maximum value of the number applied in step S408 exceeds the specified number of size standards.

[0217]

If the maximum value of the applied number is the same as the specified number of size standards (S409 → Yes), the compression range set unit 105 proceeds to step S410.

If the maximum value of the applied number is not the same as the specified number of size standards (S409 → No), the compression range set unit 105 deletes the mark JS (S411). At this time, the compression range set unit 105 deletes the size standard mark JS from the fluorescence signal P with the number larger than the specified number. The compression range set unit 105 proceeds to step S410. It is unlikely that the number of fluorescence signals P each with the size standard mark JS becomes smaller than the specified number of size standards.

[0218]

In step S410, the compression range set unit 105 sets the compression range H. In step S410, the compression range set unit

105 acquires a starting frame number of the fluorescence signal P having the smallest frame number among those with the size standard marks JS. The starting frame number is called the minimum frame number. The compression range set unit 105 acquires an end frame number of the fluorescence signal P having the largest frame number among those with the size standard marks JS. The end frame number is called the maximum frame number. The compression range set unit 105 sets the range of frame numbers between the minimum frame number and the maximum frame number as the compression range H.

[0219]

As described above, in the embodiment 2-1, the frame range in which the fluorescence signal P (second fluorescence signal) with the size standard mark JS is detected is set as the compression range H.

[0220]

The compression range set unit 105 outputs the compression range H set in step S410 to the compression ratio calculation unit 106 and the compression unit 107 (S412).

[0221]

The specific example of the processing as represented by Fig. 25 will be described later.

[0222]

(Compression Ratio Calculation Processing and Compression Processing)

In the embodiment 2-1, as the compression ratio calculation processing to be executed by the compression ratio calculation unit 106 is similar to the processing as shown in Fig. 17, illustration and description of the processing in the embodiment 2-1 will be omitted. In the embodiment 2-1, as the compression processing to be executed by the compression unit 107 is similar to the processing as

shown in Fig. 18, the description of the processing in the embodiment 2-1 will be omitted.

[0223]

In the compression processing according to the embodiment 2-1, unlike the primer-derived fluorescence signal P, the size-standard-derived fluorescence signal P does not have to be compressed. This is attributable to the size-standard-derived fluorescence signal P that is smaller than the DNA-derived fluorescence signal P. In other words, so long as care is taken about an amount of the size standard to be added to the analysis object sample D10a, the size-standard-derived fluorescence signals P may be brought into the range of values to be output by the compression unit 107 without compression.

[0224]

Compression of the size-standard-derived fluorescence signal P may lower its fluorescence signal intensity. In this case, there may be the risk that the user fails to recognize the size-standard-derived fluorescence signal P. This may cause the user to erroneously recognize that the size standard is not contained.

[0225]

If the size-standard-derived fluorescence signal P is not compressed, the fluorescence signal intensity of the size-standard-derived fluorescence signal P is not lowered. It is unlikely that the user erroneously recognizes that the size standard is not contained.

[0226]

[Operation]

Operations in the embodiment 2-1 will be described with reference to Fig. 18, Fig. 25 to Fig. 28.

Figs. 26 to 28 illustrate the example of the electrophoresis image EP.

Fig. 26 to Fig. 28 illustrate the respective electrophoresis images EP5, EP6 (EP) of the analysis object sample D10a. In the embodiment 2 (2-1, 2-2), the size-standard-derived fluorescence signal P is composed of four fluorescence signals P. The size-standard-derived fluorescence signals P is not limited to the one composed of four fluorescence signals. Referring to the electrophoresis image EP as illustrated in Fig. 26 to Fig. 28, the fluorescence signal P with the size standard color is expressed by a dash-dotted line.

[0227]

In the embodiment 2-1, an electrophoresis image EP5 as illustrated in Fig. 26 contains the fluorescence signals P (P18, P20, P22) derived from the analysis object DNA. The electrophoresis image EP5 contains the analysis-exclusion primer-derived fluorescence signals P (P15, P16), and the size-standard-derived fluorescence signals P (P17, P19, P21, P23). The following describes the case that the electrophoresis image EP generated in step S402 as illustrated in Fig. 25 is the electrophoresis image EP5 as shown in Fig. 26.

[0228]

(Operation of Compression Range Set Unit 105)

Operations of the compression range set unit 105 will be described with reference to Figs. 25 to 27. The step numbers in the following description correspond to those used in Fig. 25.

The compression range set unit 105 acquires the fluorescence signal data D25 from the color conversion unit 104 (S401). Fig. 26

illustrates the electrophoresis image EP5 drawn by the compression range set unit 105 in step S402. The compression range set unit 105 selects one of the fluorescence signals P contained in the generated electrophoresis image EP. That is, the compression range set unit 105 searches those fluorescence signals P from the frame number "1", and executes processing to the firstly detected fluorescence signal P15. Thereafter, the compression range set unit 105 determines whether or not the color of the selected fluorescence signal P matches the color used for the size standard (size standard color) (S403).

[0229]

Referring to Fig. 26, the color of the firstly selected fluorescence signal P15 does not match the size standard color. Accordingly, "No" is determined in step S403. In step S404, the compression range set unit 105 selects the next fluorescence signal P16 (step S404), and executes processing in step S403 and subsequent steps.

[0230]

Referring to Fig. 26, the color of the fluorescence signal P16 subsequent to the fluorescence signal P15 matches the size standard color. Accordingly, "Yes" is determined in step S403. The compression range set unit 105 applies the size standard mark JS to the fluorescence signal P16 as illustrated in Fig. 26 (S405). As described above, the fluorescence signal P16 is the primer-derived fluorescence signal P. As the color of the fluorescence signal P16 matches the size standard color, it is erroneously recognized as the size-standard-derived fluorescence signal P. Correction of the erroneous recognition will be described later.

[0231]

In step S406, subsequent to processing to the fluorescence signal P16, it is determined whether or not processing to all the fluorescence signals P has been completed. The electrophoresis image EP5 as illustrated in Fig. 26 contains other fluorescence signals besides the fluorescence signals P15, P16. Accordingly, "No" is determined in step S406. The compression range set unit 105 selects the next fluorescence signal P17 (S407), and executes processing in step S403 and subsequent steps.

[0232]

The similar processing is repeatedly executed to the fluorescence signals P17 to P23 as shown in Fig. 26, respectively. The size standard mark JS is not applied to each of the fluorescence signals P15, P18, P20, P22 (detected as the first fluorescence signal). Meanwhile, the size standard mark JS is applied to each of the fluorescence signals P16, P17, P19, P21, P23 (detected as the second fluorescence signal).

[0233]

As the processing to all the fluorescence signals P has been completed, the compression range set unit 105 determines "Yes" in step S406.

[0234]

The compression range set unit 105 applies numbers to the fluorescence signals P each with the size standard mark JS in order from the larger frame number (S408). As illustrated in Fig. 26, the size standard number "1" (code JS1 as illustrated in Fig. 26) is applied to the fluorescence signal P23. The size standard number "2" (code JS2 as illustrated in Fig. 26) is applied to the fluorescence

signal P21. The number "3" (code JS3 as illustrated in Fig. 26) and the number "3" (code JS4 as illustrated in Fig. 26) are applied to the fluorescence signals P19 and P17, respectively. Similarly, the number "5" (code JS5 as illustrated in Fig. 26) as the size standard number is applied to the fluorescence signal P16.

[0235]

The compression range set unit 105 determines whether or not the maximum value of the number applied in step S408 is the same as the specified number of size standards (S409). The maximum value of the number applied in step S408 is "5" (code JS5). Meanwhile, the specified number of size standards is four. The maximum value of the applied number is not equal to the specified number of size standards. Accordingly, the compression range set unit 105 determines "No" in step S409.

[0236]

The compression range set unit 105 then deletes the size standard mark JS from the fluorescence signal P with the number larger than the specified number of size standards (S411).

The fluorescence signal P16 as illustrated in Fig. 27 is applied with "5" (code JN5) that is larger than the specified number of size standards. Accordingly, the compression range set unit 105 deletes the size standard mark JS applied to the fluorescence signal P16. The compression range set unit 105 proceeds to step S410. The fluorescence signal P16 erroneously recognized as the size-standard-derived fluorescence signal P is excluded from the size-standard-derived fluorescence signals P.

[0237]

In the embodiment 2-1, in step S408, the compression range set

unit 105 applies the frame number to the fluorescence signal P with the size standard mark JS in order from the larger number. The compression range set unit 105 may be configured to apply the frame number to the fluorescence signal P with the size standard mark JS in order from the smaller number (corresponding frame number). In this case, in step S411, the compression range set unit 105 calculates the value of difference between the number of detected fluorescence signals P each with the size standard color and the specified number of size standards. The compression range set unit 105 deletes the size standard marks J by the difference value in order from the smaller number.

[0238]

In step S411, if the number of the fluorescence signals each marked with JS exceeds the number of the size standards in use, the compression range set unit 105 deletes the mark JS applied to the fluorescence signal P. At this time, the compression range set unit 105 deletes the marks JS applied to the fluorescence signals P from those with marks JS of the fluorescence signal data D25 in order from the smaller frame number of the corresponding signal by the excessive amount.

[0239]

Referring to the electrophoresis image EP5 as illustrated in Fig. 27, among the fluorescence signals P each with size standard mark JS, the fluorescence signal P with the smallest frame number is the fluorescence signal P17 applied with the number "4" (code JS4). Among the fluorescence signals P with the size standard mark S, the fluorescence signal P with the largest frame number is the fluorescence signal P23 that is applied with the number "1" and

marked with JS (code JS1). Accordingly, the compression range set unit 105 acquires the frame number "2000" which is the starting frame number of the fluorescence signal P17 as the minimum frame number. The compression range set unit 105 acquires the end frame number of the fluorescence signal P23 with the largest frame number among those each with size standard mark JS as the maximum frame number. As illustrated in Fig. 27, the end frame number of the fluorescence signal P23 with the largest frame number is the frame number "4500". The compression range set unit 105 sets the range between the minimum frame number and the maximum frame number as the compression range H (S410). In an example as illustrated in Fig. 27, the range of frame numbers between "2000" and "4500" is set as the compression range H. [0240]

As illustrated in Fig. 27, the size standard mark JS is deleted from the fluorescence signal P16. Accordingly, illustration of the mark JS and the code JS5 is omitted. [0241]

Numerical values "300", "800", "2000", "4000", "4020", "5000" together with lead lines below the abscissa of the drawing represent the frame numbers. [0242]

The compression range set unit 105 sets the frame range in which the fluorescence signal P with the size standard mark JS is detected as the compression range H. [0243]

The compression range set unit 105 then outputs the compression range H (in the example of Fig. 27, the range of frame numbers between "2000" and "4500") to the compression ratio calculation unit

106 and the compression unit 107 (step S412).

[0244]

The compression range set unit 105 sets the compression range H utilizing the characteristic that the primer-derived fluorescence signal P is detected at the timing earlier than detection of the fluorescence signal derived from the analysis object DNA or from the size standard. Furthermore, the compression range set unit 105 sets the compression range H utilizing the characteristic of the size-standard-derived fluorescence signal P. The following describes characteristics of the size-standard-derived fluorescence signal P.

(1) The number of size-standard-derived fluorescence signals P is known.

(2) The size-standard-derived fluorescence signal P is detected in the range wider than the range for detecting the fluorescence signal P derived from the analysis object DNA.

(3) The size-standard-derived fluorescence signal P is detected at the timing later than the primer-derived fluorescence signal P.

[0245]

In the embodiment 2-1, the use of the characteristics (1) to (3) allows distinguishment between the primer-derived fluorescence signal P and the fluorescence signal P derived from the analysis object DNA, and setting of the compression range H. Based on the above-described characteristic (3), the range in which the size-standard-derived fluorescence signal P is detected is set as the compression range H. This excludes the primer-derived fluorescence signal P from the compression range H.

[0246]

(Operation of Compression Ratio Calculation Unit 106)

In the embodiment 2-1, operations of the compression ratio calculation unit 106 are similar to those described in the embodiment 1-1. Accordingly, in the embodiment 2-1, illustration and description of the operations performed by the compression ratio calculation unit 106 will be omitted. In the embodiment 2-1, "0.091" is calculated as the compression ratio D27.

[0247]

Operation of Compression Unit 107)

Operations of the compression unit 107 will be described with reference to Fig. 18, Fig. 27 and Fig. 28. The step numbers in the following description correspond to those used in Fig. 18.

Firstly, the compression unit 107 acquires the fluorescence signal data D25 from the color conversion unit 104 (S301). Then the compression unit 107 acquires the compression range H from the compression range set unit 105 (S302). Execution of processing in steps S301 and S303 acquires the fluorescence signal data D25 and the compression range H as illustrated in Fig. 27. In the embodiment 2-1, the range of frame numbers between "2000" and "4500" is set as the compression range H as illustrated in Fig. 27.

[0248]

The compression unit 107 acquires the compression ratio D27 from the compression ratio calculation unit 106 (S303). As described above, in the embodiment 2-1, the compression ratio D27 is "0.091". The compression unit 107 determines in step S304 whether or not the frame to be processed is included in the compression range H.

[0249]

Referring to Fig. 27, for example, the compression range H includes frame numbers between "4000" and "4020" constituting the

fluorescence signal P22. If the frame to be processed is included in the range of frame numbers between "4000" and "4020", the compression unit 107 determines "Yes" in step S304 as illustrated in Fig. 16.

The compression unit 107 proceeds to step S305 in Fig. 16. In step S305, the compression unit 107 multiplies the fluorescence signal intensity of the frame to be processed by the compression ratio D27. For example, in the range of frame numbers between "4000" and "4020", the fluorescence signal intensity of the frame corresponding to the signal intensity maximum value D26 is "360000". Accordingly, when the compression unit 107 multiplies the fluorescence signal intensity of the frame by "0.091" as the compression ratio D27, the fluorescence signal intensity of the frame to be processed is compressed to $360000 \times 0.091 = 32767$.

[0250]

Meanwhile, the compression range H does not include the frame numbers between "300" to "800" constituting the fluorescence signal P15. Then in step S304 in Fig. 16, "NO" is determined, and the compression unit 107 proceeds to step S306 in Fig. 16. In step S306, the compression unit 107 determines whether or not the fluorescence signal intensity of the frame to be processed is larger than "32767". As for the frame with the fluorescence signal intensity larger than "32767", the compression unit 107 rounds down the fluorescence signal intensity to "32767" (S307). As described above, the frame is not compressed in step S307. As for the frame with the fluorescence signal intensity equal to or smaller than "32767", the compression unit 107 keeps the fluorescence signal intensity unchanged (S308). The compression unit 107 executes processing in steps from S306 to S308 to each frame of the electrophoresis image EP (fluorescence data

D25) in the region outside the compression range H.

[0251]

Processing is executed in steps S305, S307, S308. In step S310, an electrophoresis image EP6 (EP) as illustrated in Fig. 28 is output as the fluorescence signal compressed data D28. Referring to Fig. 28, a broken line V3 represents the value (fluorescence signal intensity of the fluorescence signal P22) corresponding to the signal intensity maximum value D26 as shown in Fig. 27. The fluorescence signal data D25 are compressed so that the value corresponding to the signal intensity maximum value D26 as illustrated in Fig. 28 becomes the maximum value (in the present embodiment, "32676") of the signal intensity that can be used for the secondary analysis. In other words, the broken line V3 corresponds to the maximum value of the signal intensity that can be used for the secondary analysis. As illustrated in Fig. 28, numerical values "2000", "4500" together with lead lines below the abscissa of the drawing represent the frame numbers.

[0252]

Processing in steps from S304 to S308 is executed to each frame that constitutes the fluorescence signal data D25. As a result, the electrophoresis image EP2 corresponding to the fluorescence signal compressed data D28 is generated as illustrated in Fig. 28. Referring to Fig. 28, the broken line V3 represents the value (fluorescence signal intensity of the fluorescence signal P6) corresponding to the signal intensity maximum value D26 as shown in Fig. 27. As illustrated in Fig. 21, in the compression range H, the fluorescence signal data D25 are compressed so that the value corresponding to the signal intensity maximum value D26 as

illustrated in Fig. 20 becomes a maximum value of the signal intensity which can be used for the secondary analysis. In the present embodiment, the maximum value of the signal intensity that can be used for the secondary analysis is "32676". In the region outside the compression range H, the compression unit 107 executes processing in steps from S306 to S308. As a result, each of the fluorescence signals P such as the fluorescence signals P15, P16 has the part above the value of "32676" missing.

[0253]

[Effect]

The embodiment 2-1 utilizes the characteristic of the size standard as well as the advantageous effect of the embodiment 1-1. Even in the case of using the size standard, minimization of the compression ratio D27 allows the fluorescence signal data D25 to be compressed to be within the range of values that can be input to the secondary analysis software while keeping the minute signal.

[0254]

In the embodiment 2-1, the fluorescence signal P derived from the analysis object DNA and the size-standard-derived fluorescence signal P are detected distinguishingly based on the color information of the fluorescence signal P. This makes it possible to easily distinguish between the fluorescence signal P derived from the analysis object DNA and the size-standard-derived fluorescence signal P.

[0255]

In the embodiment 2-1, the compression range set unit 105 determines whether or not the number of the fluorescence signals P each with size standard mark JS exceeds the number of the size

standards in use. The compression range set unit 105 deletes the marks JS applied to the fluorescence signals P from those with marks JS of the fluorescence signal data D25 in order from the smaller frame number of the corresponding signal by the excessive amount. There may be the case where the primer-derived fluorescence signal P is erroneously detected as the size-standard-derived fluorescence signal P because of the color that matches the size standard color. Even in this case, the erroneous detection can be corrected by executing the above-described processing.

[0256]

<Embodiment 2-2>

The following describes an embodiment 2-2 according to the present invention with reference to Fig. 25, Fig. 29, and Fig. 30.

Figs. 29 and 30 illustrate the example of the electrophoresis image EP.

The embodiment 2-1 utilizes the characteristic of the size-standard-derived fluorescence signal P. The following describes, based on the utilized characteristic, the data processing method for the electrophoresis image EP (fluorescence signal data D25) that contains the primer-derived fluorescence signal P.

[0257]

Like the embodiment 2-1, the embodiment 2-2 also utilizes the characteristic of the fluorescence signal P constituting the size standard. The embodiment 2-2 describes the electrophoresis data processing method for the electrophoresis image EP (fluorescence signal data D25) that does not contain the primer-derived fluorescence signal P.

[0258]

The system configuration and operations in the embodiment 2-2 are the same as those of the embodiment 2-1. Accordingly, in the embodiment 2-2, the system configuration, the illustration and the description of the operations of will be omitted.

[0259]

[Operation]

The embodiment 2-2 describes the case that the electrophoresis image EP drawn in step S402 as illustrated in Fig. 25 is an electrophoresis image EP7 (EP) as illustrated in Fig. 29. Fig. 29 illustrates the electrophoresis image EP7 of the analysis object sample D10. The fluorescence signal data D25 contain the fluorescence signal P derived from the analysis object DNA, and the size-standard-derived fluorescence signal P. Meanwhile, the fluorescence signal data D25 do not contain the analysis-exclusion primer-derived fluorescence signal P. In the embodiment 2-2, the size standard is composed of four fluorescence signals P.

The color of the size-standard-derived fluorescence signal P of the electrophoresis image EP7 is expressed by the dash-dotted line.

[0260]

Referring to Fig. 29, numerical values "2000", "4000", "4030", "4500" together with lead lines below the abscissa of the drawing represent the frame numbers.

[0261]

(Operation of Compression Range Set Unit 105)

Operations of the compression range set unit 105 in the embodiment 2-2 will be described with reference to Fig. 25 and Fig. 29. In the following description, the step numbers correspond to those shown in Fig. 25.

Firstly, the compression range set unit 105 acquires the fluorescence signal data D25 from the color conversion unit 104 (S401). Fig. 29 illustrates the electrophoresis image EP7 drawn by the compression range set unit 105 in step S402. As illustrated in Fig. 29, the electrophoresis image EP7 contains seven fluorescence signals P. The compression range set unit 105 searches those fluorescence signals P from the frame number "1", and processes the firstly detected fluorescence signal P24. The fluorescence signal P24 matches the size standard color. Then in step S403, "YES" is determined, the compression range set unit 105 applies the size standard mark JS to the fluorescence signal P24 (S405).

[0262]

Then in step S406, subsequent to processing to the fluorescence signal P24, it is determined whether or not processing to all the fluorescence signals P has been completed. The electrophoresis image EP7 as illustrated in Fig. 29 contains other fluorescence signals besides the fluorescence signal P24. Accordingly, the compression range set unit 105 determines "No" in step S406. The compression range set unit 105 selects the fluorescence signal P25 to be detected subsequently (S407), and executes processing in step S403 and subsequent steps.

[0263]

Referring to Fig. 29, the color of the fluorescence signal P25 does not match the size standard color. Accordingly, the compression range set unit 105 determines "No" in step S403. The compression range set unit 105 selects the fluorescence signal P26 to be detected subsequently in step S404 (S404), and executes processing in step S403 and subsequent steps.

[0264]

The fluorescence signals P26 to P30 are repeatedly processed similarly to the above-described processing executed to the fluorescence signals P24, P25. As a result, the size standard marks JS are not applied to the fluorescence signals P25, P27, P29, respectively (detected as the first fluorescence signal). On the other hand, the size standard mark JS is applied to each of the fluorescence signals P24, P26, P28, P30 (detected as the second fluorescence signal).

[0265]

Upon completion of processing relating to the fluorescence signal P30, it is recognized that processing to all the fluorescence signals P in step S405 has been completed. The compression range set unit 105 determines "Yes" in step S406.

[0266]

The compression range set unit 105 applies frame numbers to the fluorescence signals P each with the size standard mark JS in order from the larger frame number (S408). As illustrated in Fig. 29, the number "1" (code JS1) is applied to the fluorescence signal P23. Similarly, the number "2" (code JS2) is applied to the fluorescence signal P28, the number "3" (code JS3) is applied to the fluorescence signal P26, the number "4" (code JS4) is applied to the fluorescence signal P24.

[0267]

The compression range set unit 105 determines whether or not the maximum value of the number applied in step S408 is the same as the specified number of size standards (S409). The maximum value of the number applied in step S408 of the present embodiment is "4".

Meanwhile, the specified number of the size standards is four. Accordingly, the compression range set unit 105 determines "Yes" in step S409, and proceeds to step S410.

[0268]

Referring to Fig. 29, among the fluorescence signals P each with the size standard mark JS, the fluorescence signal P with the smallest frame number is the fluorescence signal P24 applied with the number "4" (code JS4). Among the fluorescence signals P each with the size standard mark S, the fluorescence signal P with the largest frame number is the fluorescence signal P30 applied with the number "1" (code JS1). Accordingly, the compression range set unit 105 defines the starting frame number "2000" of the fluorescence signal P24 as a minimum frame number. The frame number "4500" as the end frame number of the fluorescence signal P30 is defined as the maximum frame number. The compression range set unit 105 sets the range between the minimum frame number and the maximum frame number as the compression range H (S410).

[0269]

The compression range set unit 105 sets the frame range in which the fluorescence signal P with the size standard mark JS is detected as the compression range H.

[0270]

The compression range set unit 105 then outputs the compression range H set in step S410. In the embodiment 2-2, the compression range set unit 105 outputs the range of frame numbers between "2000" and "4500" as the compression range H to the compression ratio calculation unit 106 and the compression unit 107.

[0271]

(Operation of Compression Ratio Calculation Unit 106)

Operations of the compression ratio calculation unit 106 will be described with reference to Fig. 17 and Fig. 29. The step numbers in the following description correspond to those used in Fig. 17.

Firstly, the compression ratio calculation unit 106 acquires the fluorescence signal data D25 from the color conversion unit 104 (S201). The compression ratio calculation unit 106 acquires the compression range H from the compression range set unit 105 (S202). As described above, in the embodiment 2-2, the range of frame numbers between "2000" and "5000" is the compression range H. The compression ratio calculation unit 106 acquires the signal intensity maximum value D26 of the fluorescence signal data D25 included in the compression range H in step S203. As illustrated in Fig. 29, the signal intensity maximum value D26 of the fluorescence signal data D25 included in the range of frame numbers between "1" and "5000" is "360000".

[0272]

The compression ratio calculation unit 106 calculates the compression ratio D27 in step S204. As described above, the signal intensity maximum value D26 is "360000", and the upper limit value of the output value of the compression unit 107 is "32767". Accordingly, the compression ratio D27 is obtained by calculating $32767/360000 = 0.091$.

[0273]

(Operation of Compression Unit 107)

Operations of the compression unit 107 will be described with reference to Fig. 18, Fig. 29 and Fig. 30. In the following description, the step numbers correspond to those shown in Fig. 18.

Firstly, the compression unit 107 acquires the fluorescence signal data D25 from the color conversion unit 104 (S301). The compression unit 107 acquires the compression range H from the compression range set unit 105 (S302). As described above, in the embodiment 2-2, the range of frame numbers between "2000" and "5000" is the compression range H. The compression unit 107 acquires the compression ratio D27 from the compression ratio calculation unit 106 (S303). As described above, in the embodiment 2-2, the value "0.091" is set as the compression ratio D27.

[0274]

The compression unit 107 determines in step S304 in Fig. 18, whether or not the frame to be processed is included in the compression range H.

Referring to Fig. 29, all the frames constituting the fluorescence signals P24 to P30 are included in the compression range H. The compression unit 107 determines "Yes" in step S304 with respect to any of the frames constituting the fluorescence signals P24 to P30. The compression unit 107 proceeds to step S305 to multiply the fluorescence signal intensity of the frame to be processed by the compression ratio D27 (S305). The fluorescence signal intensity of the frame corresponding to the signal intensity maximum value D26 is compressed to "32767" by calculating 360000×0.091 .

[0275]

By executing processing in step S305, the compression unit 107 generates an electrophoresis image EP8 as the fluorescence signal compressed data D28 as illustrated in Fig. 30. In step S310, the compression unit 107 outputs the generated fluorescence signal

compressed data D28. Referring to Fig. 30, a broken line V4 represents the value (fluorescence signal intensity of the fluorescence signal P29) corresponding to the signal intensity maximum value D26 as shown in Fig. 29. As illustrated in Fig. 30, the fluorescence signal data D25 are compressed so that the value corresponding to the signal intensity maximum value D26 as illustrated in Fig. 29 becomes the maximum value (in the present embodiment, "32676) of the signal intensity that can be used for the secondary analysis. In other words, the broken line V4 corresponds to the maximum value of the signal intensity that can be used for the secondary analysis.

[0276]

Numerical values "2000", "4500" together with lead lines below the abscissa of the drawing represent the frame numbers.

[0277]

In the embodiment 2-2, it is possible to execute processing to compress the electrophoresis image EP that does not contain the primer-derived fluorescence signal P by executing the similar processing described in the embodiment 2-1.

[0278]

[Effect]

Besides the advantageous effect derived from the embodiment 2-1, the embodiment 2-2 provides the effect of minimizing the compression ratio D27 even if the primer-derived fluorescence signal is not contained in the electrophoresis. This makes it possible to compress the fluorescence signal data D25 to be within the range of values that can be input to the secondary analysis software while keeping the minute signal like the DNA-derived fluorescence signal P.

[0279]

<<Example of Secondary Analysis Screen 300>>

Fig. 31 illustrates an example of a secondary analysis screen 300 displayed in the present embodiment.

The secondary analysis screen 300 as illustrated in Fig. 31 is displayed on an output device of a computer on which the secondary analysis software is executed by the secondary analysis software for the secondary analysis. The output device for outputting the secondary analysis screen 300 as illustrated in Fig. 31 may be or may not be the output device 155 as illustrated in Fig. 5.

As illustrated in Fig. 31, an image of the fluorescence signal compressed data D28 is displayed on the secondary analysis screen 300. Fig. 31 shows the displayed image of the fluorescence signal compressed data D28 as illustrated in Fig. 21. It is possible to display images of the fluorescence signal compressed data D28 as illustrated in Fig. 23, Fig. 28, Fig. 30. The user executes the secondary analysis with reference to the DNA-derived fluorescence signals P25, P27, P29 as displayed on the secondary analysis screen 300.

[0280]

The secondary analysis screen 300 displays the DNA-derived fluorescence signals P25, P27, P29 with minute fluorescence signal intensity in proper size in contrast to the primer-derived fluorescence signals P1 to P3. This allows the user to execute the appropriate secondary analysis.

[0281]

The present invention is not limited to the above-described embodiments, and further includes various modifications. For

example, the above-described embodiments have been described in detail in order to facilitate the understanding of the present invention, and the present invention is not necessarily limited to those including all of the described configurations. In addition, part of the configuration of one embodiment can be replaced with the configurations of other embodiments, and in addition, the configuration of the one embodiment can also be added with the configurations of other embodiments. In addition, part of the configuration of each of the embodiments can be subjected to addition, deletion, and replacement with respect to other configurations.

[0282]

In the present embodiment, the region of the fluorescence signal data D25 corresponding to the compression range H is compressed, and the other region outside the compression range H is not compressed. Alternatively, the fluorescence signal data D25 may be uniformly compressed by the compression ratio D27.

[0283]

The above-described configurations, functions, elements including elements from the signal integration unit 101 to compression unit 107, the storage device 153, and the like may be partially or entirely implemented as hardware by, for example, designing with an integrated circuit. As illustrated in Fig. 5, the respective configurations, functions, and the like may be implemented as software by the processor such as the CPU for interpreting and executing programs that implement the respective functions. Information of the program, table, file, and the like for implementing the respective functions may be stored in the storage

device such as the memory 151 and SSD, or the recording media such as the IC (Integrated Circuit) card, the SD (Secure Digital) card, and the DVD (Digital Versatile Disc) besides storage in the HD. The foregoing embodiments show control lines and information lines which are considered as necessary for the explanation. However, they do not necessarily indicate all the control lines and the information lines of the product. Actually, it may be considered that the configurations are mostly interconnected with one another.

List of Reference Signs

[0284]

- 1: electrophoresis system
- 10: processing device (electrophoresis data processing device)
- 20: electrophoresis apparatus
- 30: external memory
- 101: signal integration unit (software binning processing unit)
- 102: fluorescence calibration unit (fluorescence signal data generation unit)
- 103: pseudo inverse matrix generation unit (fluorescence signal data generation unit)
- 104: color conversion unit (fluorescence signal data generation unit)
- 105: compression range set unit
- 106: compression ratio calculation unit
- 107: compression unit
- 155: output device
- 211: light receiving unit
- 211A: light receiving element
- 212: horizontal register unit
- 212A: horizontal register

213: summing gate

300: secondary analysis screen

B, B1 to BN: bin

C, C1 to CL: soft bin

D10: analysis object sample (primer is mixed)

D10: analysis object sample (primer and size standard are mixed)

D11: analysis object sample signal

D12: analysis object sample integration signal

D25: fluorescence signal data

D26: signal intensity maximum value (maximum value of fluorescence signal intensity included in the compression range)

D27: compression ratio

D28: fluorescence signal compressed data

EP, EP1 to EP8: electrophoresis image

H: compression range

JN: mark

JS, JS1 to JS5: mark (mark applied to fluorescence signal determined as the second fluorescence signal)

JY, JN: mark

P: fluorescence signal

P1 to P3: fluorescence signal (second fluorescence signal)

P4 to P14: fluorescence signal (first fluorescence signal)

P15, P16: fluorescence signal

P17, P19, P21, P23, P24, P26, P28, P30: fluorescence signal (second fluorescence signal)

P18, P20, P22, P25, P27, P29: fluorescence signal (first fluorescence signal)

V1 to V4: broken line (corresponds to maximum value of the signal)

intensity that can be used for secondary analysis)

S101 to S112: compression range set processing (compression range setting step)

S201 to S205: compression ratio calculation processing (compression ratio calculation step)

S301 to S310: Compression Processing (Compression Step)

S401 to S412: compression range set processing (compression range setting step)

Claims

[Claim 1]

An electrophoresis system comprising:

- an electrophoresis apparatus;

- a software binning processing unit which acquires an analysis object sample signal as a signal relating to a hardware binned analysis object sample, and a matrix standard signal as a signal relating to a hardware binned matrix standard from the electrophoresis apparatus, and executes a software binning to the analysis object sample signal and the matrix standard signal;

- a fluorescence signal data generation unit which generates fluorescence signal data as data relating to fluorescence signal intensity for each frame based on the software binned analysis object sample signal, and the software binned matrix standard signal;

- a compression range set unit which detects a first fluorescence signal derived from an analysis object and a second fluorescence signal derived from an analysis exclusion object distinguishingly from fluorescence signals contained in the fluorescence signal data, and sets a compression range for frames of the fluorescence signal data based on a result of the detection;

- a compression ratio calculation unit which calculates a compression ratio based on a maximum value of the fluorescence signal intensity included in the compression range and a maximum value of the signal intensity usable for a secondary analysis; and

- a compression unit which generates fluorescence signal compressed data by compressing the fluorescence signal data based on the compression ratio, and outputs the generated fluorescence signal compressed data.

[Claim 2]

The electrophoresis system according to claim 1, wherein:
the second fluorescence signal is a fluorescence signal derived from a primer; and
the compression range set unit sets the compression range from a frame subsequent to a frame in which the second fluorescence signal is detected.

[Claim 3]

The electrophoresis system according to claim 2, wherein
the compression range set unit detects the second fluorescence signal derived from the primer and the first fluorescence signal distinguishingly from the fluorescence signals contained in the fluorescence signal data based on at least one of a width of a fluorescence signal, an area of the fluorescence signal, and a last frame containing the fluorescence signal.

[Claim 4]

The electrophoresis system according to claim 1, wherein
the compression range:
sets unit detects a fluorescence signal derived from a size standard as the second fluorescence signal; and
sets a frame range in which the second fluorescence signal is detected as the compression range.

[Claim 5]

The electrophoresis system according to claim 4, wherein
the compression range set unit detects the first fluorescence signal and the second fluorescence signal distinguishingly based on color information of the fluorescence signal.

[Claim 6]

The electrophoresis system according to claim 5, wherein the compression range set unit is configured:

to apply a mark to the fluorescence signal determined as the second fluorescence signal;

in the case where the number of the marked fluorescence signals exceeds the number of the size standards in use, to delete the mark applied to the fluorescence signal by an exceeding number from the marked fluorescence signals in order from a smaller number of the corresponding frame; and

to set a frame range in which the marked fluorescence signal is detected as the compression range.

[Claim 7]

The electrophoresis system according to claim 1, wherein

the compression unit outputs the analysis object sample signal and the compression ratio in addition to the fluorescence signal compressed data.

[Claim 8]

An electrophoresis data processing device, comprising:

a software binning processing unit which acquires an analysis object sample signal as a signal relating to a hardware binned analysis object sample, and a matrix standard signal as a signal relating to a hardware binned matrix standard from an electrophoresis apparatus, and executes a software binning to the analysis object sample signal and the matrix standard signal;

a fluorescence signal data generation unit which generates fluorescence signal data as data relating to fluorescence signal intensity for each frame based on the software binned analysis object sample signal, and the software binned matrix standard signal;

a compression range set unit which detects a first fluorescence signal derived from an analysis object and a second fluorescence signal derived from an analysis exclusion object distinguishingly from fluorescence signals contained in the fluorescence signal data, and sets a compression range for frames of the fluorescence signal data based on a result of the detection;

a compression ratio calculation unit which calculates a compression ratio based on a maximum value of the fluorescence signal intensity included in the compression range and a maximum value of the signal intensity usable for a secondary analysis; and

a compression unit which generates fluorescence signal compressed data by compressing the fluorescence signal data based on the compression ratio, and outputs the generated fluorescence signal compressed data.

[Claim 9]

An electrophoresis data processing method which causes an electrophoresis system for acquiring an analysis object sample signal as a signal relating to a hardware binned analysis object sample, and a matrix standard signal as a signal relating to a hardware binned matrix standard from an electrophoresis apparatus, and generating fluorescence signal data as data relating to fluorescence signal intensity for each frame based on a software binned analysis object sample signal and a software binned matrix standard signal to execute the steps comprising:

a compression range setting step for detecting a first fluorescence signal derived from an analysis object and a second fluorescence signal derived from an analysis exclusion object distinguishingly from fluorescence signals contained in the

fluorescence signal data, and setting a compression range for frames of the fluorescence signal data based on a result of the detection;

a compression ratio calculation step for calculating a compression ratio based on a maximum value of the fluorescence signal intensity included in the compression range and a maximum value of the signal intensity usable for a secondary analysis; and

a compression step for generating fluorescence signal compressed data by compressing the fluorescence signal data based on the compression ratio, and outputting the generated fluorescence signal compressed data.