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(54) **Optical imaging diagnostic apparatus and the display control method thereof**

Optische Bildgebungsdiagnosevorrichtung und Anzeigesteuerungsverfahren dafür

Appareil de diagnostic d'imagerie optique et son procédé de contrôle d'affichage

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EP 2 371 277 B1

Description

[0001] The present invention relates to an optical imaging diagnostic apparatus and a display control method thereof. Description of the Related Art:

From the past, there has been used an optical coherent tomography (OCT) apparatus (see, for example, Japanese unexamined patent publication No. 2001-79007) and an optical frequency domain imaging (OFDI) apparatus utilizing wavelength sweep, which is an improvement type thereof for a diagnosis of arteriosclerosis, for a diagnosis before operation at the time of treatment inside a blood vessel depending on a high functional catheter such as a balloon catheter, a stent and the like or for a result confirmation after operation (Hereinafter, in the present specification, the optical coherent tomography (OCT) apparatus and the optical frequency domain imaging (OFDI) apparatus utilizing wavelength sweep will be generically referred to as "optical imaging diagnostic apparatus").

[0002] In the optical imaging diagnostic apparatus, an optical probe unit inserted with an imaging core which is attached with an optical lens and an optical mirror (transmitting and receiving unit) at a distal end of an optical fiber is inserted into a blood vessel, and a radial scan in a blood vessel is carried out by emitting a measurement light into the blood vessel from the transmitting and receiving unit at the distal end while rotating the imaging core and concurrently, by receiving a reflected light from a biological tissue. Then, a coherent light is produced by making the light-received reflected light and a reference light interfere with each other, and a cross-sectional image of the blood vessel is drawn out based on the coherent light.

[0003] Generally, in order to carry out a diagnosis by using a measurement result in such an optical imaging diagnostic apparatus, it is preferable for a user, based on the measurement result, to be able to accurately comprehend the morphological feature of the biological tissues inside the blood vessel and the scattering intensity and the absorption level of the measurement light in each biological tissue.

[0004] On the other hand, with respect to the blood vessel cross-sectional image drawn out by a B mode in the optical imaging diagnostic apparatus in the present situation, scattering intensity is expressed as pixel intensity, so that it is possible for a user to comprehend the morphological feature of the biological tissue based on the intensity distribution of the pixel. Also, it is possible to comprehend the scattering intensity of the measurement light in each biological tissue based on the intensity value of the pixel. In addition, in case of an optical imaging diagnostic apparatus, it is possible to draw out a blood vessel cross-sectional image of high resolution, so that it is also possible to distinguish among tunica intima &

tunica media & tunica adventitia, or the like and further, to identify a plaque or the like.

[0005] However, in case of the blood vessel cross-sectional image drawn out by the B mode, with respect to the biological tissue which is a biological tissue in which scattering intensity of a calcific plaque, a lipid or the like is low and for which it is necessary to make identification depending on the difference of the absorption level of the measurement light, these may occur in a situation in which it is difficult to make identification thereof. On the other hand, from the past, there has been proposed a method in which identification is made based on the sharpness of the intensity change of the pixel in the boundary area of the biological tissues, but in case of a biological tissues in which characteristics thereof are mixed up, it sometimes happens even for a well trained expert to make a mistake in the identification only by depending on the method. Consequently, in the optical imaging diagnostic apparatus, there has been desired an improvement of the identification performance with respect to a biological tissue in which it is necessary to make identification depending on the difference of the absorption level.

[0006] The present invention was invented in view of the problem described above and is addressed, in an optical imaging diagnostic apparatus, to make it possible for each biological tissue constituting the drawn out blood vessel cross-sectional image to be identified based on the difference of the absorption level of the measurement light.

[0007] An optical imaging diagnostic apparatus relating to the present invention is defined in claim 1 and includes the following constitutions. More specifically, the present invention relates to an optical imaging diagnostic apparatus in which there is connected a probe including a transmitting and receiving unit for carrying out light transmitting and receiving continuously, in which a reflected light from a biological tissue, which the transmitting and receiving unit received, is obtained from the transmitting and receiving unit owing to a fact that the transmitting and receiving unit is moved axially while being rotated inside a body lumen, in which line data with respect to a coherent light produced by interference between the obtained reflected light and a reference light are stored in a storage unit, concurrently, in which a plurality of cross-sectional images of the biological tissue are generated in the axial direction based on the line data, and the images thereof are displayed, wherein there are included:

a designating unit for designating a predetermined circumferential-direction position at the circumference of the transmitting and receiving unit on the cross-sectional image displayed;

an extraction unit for extracting, within the plurality of line data used for the generation of the cross-sectional image, line data corresponding to circumferential-direction position designated in the designat-

ing unit from the storage unit;
 a calculation unit for calculating an attenuation rate in a predetermined region in a radial direction of the body lumen with respect to the extracted line data; and
 a display unit for displaying the calculated attenuation rate.

[0008] According to the present invention, it becomes possible in an optical imaging diagnostic apparatus to identify respective biological tissues, which constitute drawn-out blood vessel cross-sectional images, based on the differences of absorption levels of the measurement light.

FIG. 1 is a diagram showing an external-appearance constitution of an optical imaging diagnostic apparatus relating to one exemplified embodiment of the present invention;

FIG. 2 is a diagram showing a functional constitution in an optical coherent tomography apparatus;

FIG. 3 is a diagram showing a functional constitution in an optical frequency domain imaging apparatus utilizing wavelength sweep;

FIG. 4 is a diagram for explaining a constitution of an imaging core distal end which is inserted into an optical probe unit of an optical imaging diagnostic apparatus and an operation of an imaging core in a state of being inserted into a blood vessel;

FIGS. 5A and 5B are diagrams for explaining an imaging core operation at the time of measurement in an optical imaging diagnostic apparatus and a generation process of a blood vessel cross-sectional image;

FIG. 6 is a diagram for explaining a functional constitution of a signal processing unit in an optical imaging diagnostic apparatus;

FIG. 7 is a flowchart showing a flow of an absorption level visualization process for visualizing absorption level of a predetermined biological tissue based on a drawn-out blood vessel cross-sectional image;

FIGS. 8A to 8D are diagrams showing a user interface used for a steering when visualizing absorption level of a predetermined biological tissue based on a drawn-out blood vessel cross-sectional image; and

FIG. 9 is one example of a graph in which absorption level of a predetermined tissue is visualized.

[0009] First, we will give explanations with respect to outlines of respective exemplified embodiments of the present invention. The feature of the optical imaging diagnostic apparatus relating to each exemplified embodiment mentioned below lies in that in order to make it possible to identify respective biological tissues which constitute the drawn out blood vessel cross-sectional image based on the difference of the absorption level of the measurement light, the absorption level of the measurement light in each biological tissue is visualized and it is

made possible for a user to comprehend the difference of the absorption level accurately.

[0010] Specifically, it is constituted such that there is calculated and displayed the change of the scattering intensity in the emission direction (that is, radial direction of blood vessel) for each biological tissue in a case in which a measurement light is emitted from a transmitting and receiving unit. Here, the change of the scattering intensity in the radial direction for each biological tissue is equivalent to the attenuation rate of the coherent-light intensity (that is, line data) in the radial direction. Consequently, in the optical imaging diagnostic apparatus relating to each exemplified embodiment mentioned below, it is constituted such that the attenuation rate in a predetermined region in the radial direction of the line data is calculated and displayed.

[0011] Owing to the fact that such a constitution is employed, it becomes possible for a user to comprehend the absorption level of the measurement light in each biological tissue quantitatively as attenuation rate of a predetermined region in the line data, so that it become possible to accurately carry out the identification of each biological tissue based on the difference of the absorption level.

[0012] Hereinafter, it will be explained with respect to details of respective exemplified embodiments of the present invention with reference to attached drawings.

[First Exemplified Embodiment]

1. External-Appearance Constitution of Imaging Diagnostic Apparatus

[0013] FIG. 1 is a diagram showing an external-appearance constitution of an optical imaging diagnostic apparatus (optical coherent tomography apparatus or optical frequency domain imaging apparatus utilizing wavelength sweep) 100 relating to a first exemplified embodiment of the present invention.

[0014] As shown in FIG. 1, the optical imaging diagnostic apparatus 100 is provided with an optical probe unit 101, a scanner & pull-back unit 102 and a steering control apparatus 103, and the scanner & pull-back unit 102 and the steering control apparatus 103 are connected by a signal line 104.

[0015] The optical probe unit 101 is inserted directly inside a body lumen of a blood vessel or the like and transmits the transmitted measurement light continuously to a biological tissue and concurrently, includes an imaging core provided with a transmitting and receiving unit for receiving the reflected light from the biological tissue continuously and a state of the biological tissue is measured by using the imaging core. The scanner & pull-back unit 102 is constituted with the optical probe unit 101 attachably and detachably and defines a radial operation of the imaging core inserted in the optical probe unit 101 depending on a fact that an installed motor is driven.

[0016] The steering control apparatus 103 includes, on

an occasion when carrying out measurements, a function for inputting various kinds of setting values, and a function for processing data obtained by the measurement and for displaying it as a blood vessel cross-sectional image.

[0017] In the steering control apparatus 103, a reference numeral 111 indicates a main body control unit and it happens that the data obtained by the measurement is processed and the processed result is outputted. A reference numeral 111-1 indicates a printer & DVD recorder and it happens that the processed result in the main body control unit 111 is printed and is stored as data signals.

[0018] A reference numeral 112 indicates an operation panel and a user carries out inputs of various kinds of setting values and instruction through the operation panel 112. A reference numeral 113 indicates an LCD monitor as a display apparatus and it displays the processed result in the main body control unit 111.

2. Functional Constitution of Optical Coherent Tomography Apparatus

[0019] Next, it will be explained by using FIG. 2 with respect to a functional constitution of an optical coherent tomography apparatus within the optical imaging diagnostic apparatus 100 relating to this exemplified embodiment.

[0020] A reference numeral 209 indicates a low coherent light source of a super high intensity light-emitting diode or the like. The low coherent light source 209 outputs a low coherent light whose wavelength is around 1310 nm and which shows coherence only in such a short distance range in which a coherent-length is around a few μm to ten and a few μm .

[0021] Consequently, in a case in which this light is divided into two lights and thereafter, they are mixed again, the light is to be detected as a coherent light in a case in which the difference between the two optical path lengths from a point at which the light is divided to a point at which they are mixed is within a short distance range of around a few μm to ten and a few μm or less, and the light is never to be detected as a coherent light in a case in which the difference of the optical path lengths is larger than that.

[0022] The light of the low coherent light source 209 is entered into one end of a first single mode fiber 228 and is transmitted to the distal end surface side. The first single mode fiber 228 is connected optically with a second single mode fiber 229 and a third single mode fiber 232 by a photo coupler unit 208 on the way.

[0023] The photo coupler unit means an optical component in which it is possible to divide one optical signal into two or more outputs and/or to combine inputted two or more optical signals for one output and the light of the low coherent light source 209 is transmitted by being divided into three optical paths at the maximum by the photo coupler unit 208.

[0024] The scanner & pull-back unit 102 is provided on

the distal end side ahead the photo coupler unit 208 of the first single mode fiber 228. In the inside of a rotary drive apparatus 204 of the scanner & pull-back unit 102, there is provided an optical rotary joint 203 for connecting between a non-rotary portion (fixed portion) and a rotary portion (rotary drive portion) and for transmitting the light.

[0025] Further, the distal end side of a fourth single mode fiber 230 in the inside of the optical rotary joint 203 is connected freely detachably with a fifth single mode fiber 231 of the optical probe unit 101 through an adapter 202. Thus, the light from the low coherent light source 209 is transmitted to the fifth single mode fiber 231 which is passed-through in the imaging core 201 provided with the transmitting and receiving unit, which repeats the transmitting and receiving of the light and which is rotary-drivable.

[0026] The light transmitted to the fifth single mode fiber 231 is emitted while radially operating with respect to the biological tissue of the blood vessel from the transmitting and receiving unit arranged at the distal end of the imaging core 201. Then, a portion of the reflected light scattered on the surface or on the inside of the biological tissue is taken-in by the imaging core 201 and returns to the first single mode fiber 228 side through a reverse optical path, and a portion thereof moves to the second single mode fiber 229 side by the photo coupler unit 208. Then, it is light-received by a photo detector (for example, photo diode 210) owing to a fact that it is emitted from one end of the second single mode fiber 229.

[0027] It should be noted that the rotary drive portion side of the optical rotary joint 203 is rotatingly driven by a radial scanning motor 205 of the rotary drive apparatus 204. Also, a rotary angle of the radial scanning motor 205 is detected by an encoder unit 206. Further, the scanner & pull-back unit 102 is provided with a linear drive apparatus 207 and movement (axial-direction operation) in an axial direction (distal direction of the body lumen and opposite direction thereof) of the imaging core 201 is defined based on an instruction from a signal processing unit 214. The axial-direction operation is realized owing to a fact that the linear drive apparatus 207 makes the scanner including the optical rotary joint 203 move based on a control signal from the signal processing unit 214.

[0028] At that time, only the imaging core 201 inserted into a catheter sheath moves axially while the catheter sheath of the optical probe unit 101 is maintained to be fixed in the blood vessel, so that it is possible to carry out the axial-direction operation without injuring a blood vessel wall.

[0029] On the other hand, a variable mechanism 216 of the optical path length for changing the optical path length of the reference light is provided on the distal end side ahead the photo coupler unit 208 of the third single mode fiber 232 (on the reference light path).

[0030] The variable mechanism 216 of this optical path length is provided with a first optical path length changing unit for changing the optical path length which corresponds to an inspection region in the depth direction (di-

rection of emission of the measurement light) of the biological tissue speedily and a second optical path length changing unit for changing the optical path length which corresponds to fluctuation of the length thereof such that there can be absorbed the fluctuation of the length of the individual optical probe unit 101 in case of using the optical probe unit 101 by being exchanged.

[0031] Further, in the variable mechanism 216, facing the distal end of the third single mode fiber 232, there is arranged, through a collimating lens 221 which is freely movable in the direction shown in an arrow 223, with a mirror 219 which is mounted on an one-axis stage 220 together with this distal end. Also, there is mounted, through a mirror 218 corresponding to this mirror 219 (diffraction lattice), with a galvanometer 217 which is rotatable by a small angle as the first optical path length changing unit. This galvanometer 217 is rotated speedily in an arrow 222 direction by a galvanometer controller 224.

[0032] The galvanometer 217 is a device which reflects light by a mirror of the galvanometer and it is constituted such that the mirror mounted on a movable portion thereof is to be rotated speedily by applying an AC drive signal to the galvanometer which functions as a reference mirror.

[0033] That is to say, owing to a fact that the drive signal is applied with respect to the galvanometer 217 from the galvanometer controller 224 and it is rotated speedily by the drive signal in the arrow 222 direction, it happens that the optical path length of the reference light is to change speedily only by the optical path length which corresponds to the inspection region in the depth direction of the biological tissue. One cycle of the change of this optical path difference becomes a cycle of obtaining coherent light for one line.

[0034] On the other hand, the one-axis stage 220 functions as the second optical path length changing unit having such an amount of variable range of optical path length, which can absorb the fluctuation of the optical path length of the optical probe unit 101 in case of exchanging the optical probe unit 101. Further, the one-axis stage 220 is also provided with a function as an adjuster for adjusting an offset. For example, even in a case in which the distal end of the optical probe unit 101 is not closely-attached to the surface of the biological tissue, it is possible, by changing the optical path length by the one-axis stage 220, to set it in a state of interfering with the reflected light from the surface position of the biological tissue.

[0035] The light whose optical path length is changed by the variable mechanism 216 of the optical path length is mixed with the reflected light obtained from the first single mode fiber 228 side by the photo coupler unit 208 which is provided on the way of the third single mode fiber 232 and is light-received as coherent light by the photo diode 210.

[0036] The coherent light which is light-received by the photo diode 210 in this manner is photoelectrically con-

verted and amplified by an amplifier 211 and thereafter, is inputted to a demodulator 212.

[0037] In the demodulator 212, a demodulation process for extracting only the signal component of the coherent light is carried out and the output thereof is inputted to an A/D converter 213.

[0038] In the A/D converter 213, there is produced digital data "coherent light data" of one line by sampling the coherent light signal, for example, for 200 points. In this case, the sampling frequency becomes a value dividing one scanning time period of the optical path length by 200.

[0039] The coherent light data per line unit which is produced by the A/D converter 213 is inputted to a signal processing unit 214. In the signal processing unit 214, by carrying out a predetermined process with respect to the coherent light data, there is produced line data which are the coherent light intensity data in the depth direction of the biological tissue and thereafter, by converting the line data to the video signal, there is produced a cross-sectional image at each position in the axial direction inside the blood vessel, and it is outputted to a user interface apparatus 215 by a predetermined frame rate (corresponding to LCD monitor 113 and operation panel 112 in FIG. 1).

[0040] The signal processing unit 214 is connected further to an optical path length adjuster control apparatus 226. The signal processing unit 214 carries out the control of the position of the one-axis stage 220 through the optical path length adjuster control apparatus 226. Also, the signal processing unit 214 is connected to a motor control circuit 225 and controls the rotary drive of the radial scanning motor 205.

[0041] Further, the signal processing unit 214 is connected to the galvanometer controller 224 for controlling the scan of the optical path length of the reference mirror (galvanometer mirror) and the galvanometer controller 224 outputs the drive signal to the signal processing unit 214. In the motor control circuit 225, synchronization with the galvanometer controller 224 is taken by using this drive signal.

3. Functional Constitution of Optical Frequency Domain Imaging Apparatus Utilizing Wavelength Sweep

[0042] Next, it will be explained by using FIG. 3 with respect to a functional constitution of an optical frequency domain imaging apparatus utilizing wavelength sweep within the optical imaging diagnostic apparatus 100 relating to this exemplified embodiment.

[0043] FIG. 3 is a diagram showing a functional constitution of the optical frequency domain imaging apparatus 100 utilizing wavelength sweep.

[0044] A reference numeral 308 indicates a wavelength swept light source and a Swept-Laser is used. The wavelength swept light source 308 using the Swept-Laser is one kind of an Extended-Cavity-Laser which is composed of an optical fiber 316 connected with SOA315

(semiconductor optical amplifier) in a ring shape and a polygon scanning filter (308b).

[0045] The light outputted from the SOA315 proceeds inside the optical fiber 316 and enters in the polygon scanning filter 308b and the wavelength selected here is amplified by the SOA315 and finally, it is outputted from a coupler 314.

[0046] In the polygon scanning filter 308b, the wavelength is selected depending on the combination of a diffraction lattice 312 for light-splitting the light and a polygon mirror 309. Specifically, the light which is light-split by the diffraction lattice 312 is focused on the surface of the polygon mirror 309 depending on two pieces of lenses (310, 311). Thus, it happens that only the light of the wavelength perpendicular to the polygon mirror 309 returns to the same optical path and is outputted from the polygon scanning filter 308b, so that it is possible to carry out the time sweep of the wavelength by rotating the polygon mirror 309.

[0047] For the polygon mirror 309, for example, an icosadodecahedron mirror is used and the rotation speed thereof is around 50000 rpm. Owing to the wavelength sweep system in which the polygon mirror 309 and the diffraction lattice 312 are combined, it becomes possible to employ the wavelength sweep of high speed and high power.

[0048] The light of the wavelength swept light source 308, which is outputted from a coupler 314, is entered into one end of a first single mode fiber 330 and is transmitted to the distal end side. The first single mode fiber 330 is optically connected with a second single mode fiber 337 and a third single mode fiber 331 in a photo coupler unit 334 on the way. Therefore, the light which is entered into the first single mode fiber 330 is transmitted by being split into three optical paths at the maximum by this photo coupler unit 334.

[0049] On the distal end side ahead the photo coupler unit 334 of the first single mode fiber 330, there is provided, in a rotary drive apparatus 304, with an optical rotary joint 303 which connects between a non-rotary portion (fixed portion) and a rotary portion (rotary drive portion) and which transmits the light.

[0050] Further, the distal end side of a fourth single mode fiber 335 inside the optical rotary joint 303 is connected freely detachably through a fifth single mode fiber 336 and an adapter 302 of the optical probe unit 101. Thus, the light from the wavelength swept light source 308 is transmitted to the fifth single mode fiber 336 which is passed-through in an imaging core 301 and which is rotary-drivable.

[0051] The transmitted light is emitted from the transmitting and receiving unit arranged at a distal end of the imaging core 301 with respect to the biological tissue while being radially operated. Then, a portion of the reflected light which is scattered on the surface of or on the inside of the biological tissue is taken-in by the imaging core 301 and returns to the first single mode fiber 330 side through the reverse optical path. Further, the light

is light-received by a photo detector (for example, photo diode 319) owing to a fact that a portion thereof moves to the second single mode fiber 337 side by the photo coupler unit 334 and is emitted from one end of the second single mode fiber 337.

[0052] It should be noted that the rotary drive portion side of the optical rotary joint 303 is rotatingly driven by a radial scanning motor 305 of the rotary drive apparatus 304. Also, the rotary angle of the radial scanning motor 305 is detected by an encoder unit 306. Further, the scanner & pull-back unit 102 is provided with a linear drive apparatus 307 and defines the axial-direction operation of the imaging core 301 based on an instruction from a signal processing unit 323.

[0053] On the other hand, there is provided a variable mechanism 325 of the optical path length for fine-adjusting the optical path length of the reference light at a distal end on the opposite side with respect to the photo coupler unit 334 of the third single mode fiber 331.

[0054] The variable mechanism 325 of this optical path length is provided with the optical path length changing unit for changing the optical path length which corresponds to the fluctuation of the length thereof such that the fluctuation of the length of the individual optical probe unit 101 can be absorbed in case of using the optical probe unit 101 by being exchanged.

[0055] The third single mode fiber 331 and a collimating lens 326 are provided on a one-axis stage 332 which is freely movable in the optical axial direction thereof as shown by an arrow 333, and they form the optical path length changing unit.

[0056] Specifically, the one-axis stage 332 functions as the optical path length changing unit having such an amount of variable range of optical path length, which can absorb the fluctuation of the optical path length of the optical probe unit 101 in case of exchanging the optical probe unit 101. Further, the one-axis stage 332 is also provided with a function as an adjuster for adjusting an offset. For example, even in a case in which the distal end of the optical probe unit 101 is not closely-attached to the surface of the biological tissue, it becomes possible, by changing the optical path length by the one-axis stage, to set it in a state of interfering with the reflected light from the surface position of the biological tissue.

[0057] The light whose optical path length is fine-adjusted by the variable mechanism 325 of the optical path length is mixed with the reflected light obtained from the first single mode fiber 330 side by the photo coupler unit 334 which is provided on the way of the third single mode fiber 331 and is light-received by the photo diode 319.

[0058] The coherent light which is light-received by the photo diode 319 in this manner is photoelectrically converted and amplified by an amplifier 320 and thereafter, is inputted to a demodulator 321. In the demodulator 321, a demodulation process for extracting only the signal component of the coherent light is carried out and the output thereof is inputted to an A/D converter 322 as the coherent light signal.

[0059] In the A/D converter 322, there is produced digital data "coherent light data" of one line by sampling the coherent light signal, for example, for 2048 points by 180 MHz. It should be noted that the reason why the sampling frequency is set to be 180 MHz is because it is on the assumption that about 90% of the cycle (12.5 μ sec) of the wavelength sweep is to be extracted as the digital data of 2048 points in case of setting the repeat frequency of the wavelength sweep to be 80 kHz and it is not especially limited by this aspect.

[0060] The coherent light data per line unit produced in the A/D converter 322 is inputted to the signal processing unit 323. In the signal processing unit 323, the coherent light data are frequency-decomposed depending on an FFT (Fast Fourier Transform) and then, there are generated line data which are the coherent light intensity data in the depth direction, and by coordinate-converting those data, there is formed a cross-sectional image at each position in the axial direction of the inside of the blood vessel and it is outputted to an user interface apparatus 317 (which corresponds to LCD monitor 113 and operation panel 112 in FIG. 1) by a predetermined frame rate.

[0061] The signal processing unit 323 is connected further to an optical path length adjuster control apparatus 318. The signal processing unit 323 carries out the control of the position of the one-axis stage 332 through the optical path length adjuster control apparatus 318. Also, the signal processing unit 323 is connected to a motor control circuit 324 and receives a video synchronization signal of the motor control circuit 324. In the signal processing unit 323, the generation of the cross-sectional image is carried out in synchronization with the received video synchronization signal.

[0062] In addition, the video synchronization signal of this motor control circuit 324 is transmitted also to the rotary drive apparatus 304 and in the rotary drive apparatus 304, the drive signal in synchronization with the video synchronization signal is outputted.

4. Constitution of Distal End of Imaging Core Inserted in Optical Probe Unit and Operation of the Imaging Core

[0063] Next, it will be explained with respect to a constitution of a distal end of the imaging core 201, 301 inserted in the optical probe unit 101 and an operation of the imaging core 201, 301. First, it will be explained by using FIG. 4 with respect to a constitution of a distal end of the imaging core 201, 301 inserted in the optical probe unit 101. FIG. 4 is a diagram showing a state in which the optical probe unit 101 is inserted into a blood vessel.

[0064] As shown in FIG. 4, the imaging core 201, 301 provided with the transmitting and receiving unit and the optical fiber 231, 336 is inserted in the optical probe unit 101, and it is constituted so as to operate linearly in an arrow 402 direction, while rotating in an arrow 401 direction inside the optical probe unit 101 which is inserted into the blood vessel (it is constituted so as to carry out

radial operation).

[0065] The transmitting and receiving unit is provided with an optical mirror and an optical lens and emits the measurement light which is transmitted through the optical fiber 231, 336 in the direction approximately perpendicular to the axial direction (radial direction of the blood vessel). Also, the reflected light from the biological tissue with respect to the emitted measurement light is light-received and is transmitted to the steering control apparatus 103 side through the optical fiber 231, 336. Owing to the fact that the transmitting and receiving of such a light caused by the optical mirror and the optical lens is carried out during the radial operation of the imaging core 201, 301, it is possible to generate the line data necessary for drawing but a plurality of cross-sectional images inside the blood vessel in the axial direction.

[0066] FIG. 5A is a diagram showing a state in which the measurement light is emitted toward the radial direction of the blood vessel while radially operating the imaging core 201, 301. As shown in FIG. 5A, owing to a fact that the measurement light is emitted while rotating the imaging core 201, 301 in the arrow 401 direction, it is possible to light-receive the reflected light from the biological tissue at each position in the circumferential direction (that is, line data at each position can be generated). "Line 1", "Line 2", ... shown in FIG. 5A express the distribution of the data which are generated based on the reflected light from the biological tissue of the measurement light which is emitted with respect to the biological tissue at each position in the circumferential direction. In this manner, owing to the fact that the line data of a plurality of lines are generated at each position in the axial direction, it is possible to draw out the blood vessel cross-sectional image at each position in the axial direction.

[0067] FIG. 5B is a diagram showing one example of the number of times of the measurement-light emissions toward the radial direction of the blood vessel at a predetermined position in the axial direction. In the example of FIG. 5B, 512-times emissions are carried out while the imaging core 201, 301 is rotated once in the circumferential direction and the line data for 512 lines are generated.

5. Functional Constitution of Signal Processing Unit

[0068] Next, by using FIG. 6, it will be explained, in the signal processing unit 214, 323 of the optical imaging diagnostic apparatus 100, with respect to a functional constitution of a drawing-out process for drawing out the blood vessel cross-sectional image and a visualization process for visualizing the absorption level of a predetermined biological tissue in the blood vessel cross-sectional image. It should be noted that it is allowed for the drawing-out process and the visualization process explained hereinafter to be realized by using a hardware for exclusive use or it is also allowed for the function of each portion to be realized by a software (by executing a computer program).

[0069] FIG. 6 is a diagram showing a functional constitution of a drawing-out process and a visualization process in the signal processing unit 214, 323 of the imaging diagnostic apparatus 100 and showing functional blocks related thereto. It should be noted in the following description that in order to simplify the explanation, it is determined that it will be explained with respect to the signal processing unit 214 of the optical coherent tomography apparatus 100 (in FIG. 2) (a case of using an optical frequency domain imaging apparatus utilizing the wavelength sweep is also similar, so that the explanation thereof will be omitted here).

[0070] The coherent light data produced by the A/D converter 213 is processed in the line memory unit 601 such that the number of lines per one rotation of the radial scanning motor becomes 512 lines by using the signal of the encoder unit 206 of the radial scanning motor 205, which is outputted from the motor control circuit 225 and thereafter, it is outputted to the line data generation unit 602 in the succeeding stage.

[0071] In the line data generation unit 602, a line addition-averaging process, a filtering process, a logarithmic conversion process and the like are applied with respect to the coherent light data and the line data which is the coherent light intensity data in the depth direction of the biological tissue is generated and thereafter, the generated line data are outputted to the signal post-processing unit 603 in the succeeding stage. In the signal post-processing unit 603, a contrast adjustment, a intensity adjustment, a gamma correction, a frame correlation, a sharpness process and the like are carried out with respect to the line data and it is outputted to the image construction unit (DSC) 604.

[0072] In the image construction unit 604, a blood vessel cross-sectional image is generated owing to a fact that the line data series of the polar coordinate are R θ -converted and thereafter, it is converted to a video signal and the blood vessel cross-sectional image is displayed on the cross-sectional image data display unit 611 of the user interface apparatus 215. It should be noted, in this exemplified embodiment, that it is assumed to generate the blood vessel cross-sectional image from 512 lines as one example, but it is not to be limited by this number of lines.

[0073] It should be noted in the explanation described above that it is explained by assuming that the signal post-processing unit 603 directly processes the line data outputted from the line data generation unit 602, but the present invention is not limited by this aspect and it is also allowed to be constituted such that the line data outputted from the line data generation unit 602 is parallelly stored in a storage unit which is not shown as a file form in association with predetermined patient attribute information and measurement condition information. In this case, it becomes in a state in which the signal post-processing unit 603 carries out the process described above by reading-out the line data from the storage unit based on an instruction of a user. It should be noted that

it is allowed for the storage unit to be provided inside the control unit 605 or to be provided outside the signal processing unit 214 (for example, it is also allowed for the DVD recorder 111-1 to function as the storage unit). Alternatively, it is also allowed for the line data generation unit 602 itself to have a function as the storage unit.

[0074] On the other hand, there is provided in the user interface apparatus 215 with an absorption level visualization position designating unit 613 and it is constituted such that a position (predetermined circumferential-direction position in the circumference of the transmitting and receiving unit) at which there exists a biological tissue whose absorption level is assumed to be comprehended within the biological tissues constituting the blood vessel cross-sectional image displayed on the cross-sectional image data display unit 611 is to be designated on the blood vessel cross-sectional image.

[0075] Information relating to the position designated by the absorption level visualization position designating unit 613 is inputted to the control unit 605 and is transmitted to the line data extraction unit 606. In the line data extraction unit 606, the line data corresponding to the position designated by the absorption level visualization position designating unit 613, which are within the line data, are extracted from the storage unit which is not shown.

[0076] In the line data extraction unit 606, the line data extracted from the storage unit which is not shown is displayed on the line data graph display unit 612 of the user interface apparatus 215 and concurrently, the attenuation rate of a predetermined range of the coherent light intensity in the emission direction (radial direction of the blood vessel) of the measurement light is calculated and is displayed in association with the line data. It should be noted that it will be mentioned later with respect to the details of the visualization process from the position designation by the absorption level visualization position designating unit 613 until reaching the display of the corresponding line data and the calculation of the attenuation rate.

6. Flow of Visualization Process for Visualizing Absorption Level

[0077] Next, it will be explained by using FIG. 7 to FIG. 9 with respect to the visualization process for visualizing the absorption level of each biological tissue constituting the blood vessel cross-sectional image. FIG. 7 is a flow-chart showing a flow of the visualization process in a case in which the absorption level of a predetermined biological tissue is visualized with respect to the displayed blood vessel cross-sectional image. Also, FIG. 8 is a diagram showing the user interface used for the operation for visualizing the absorption level of a predetermined biological tissue with respect to the displayed blood vessel cross-sectional image. Further, FIG. 9 is one example of a graph showing the absorption level of a predetermined biological tissue.

[0078] As shown in FIG. 8A, in the user interface used when visualizing the absorption level, there is arranged a file-designation button 801 for designating a desired file from a plurality of files in which line data for generating the blood vessel cross-sectional image are stored. Also, there are arranged a cross-sectional image data display unit 611 for displaying the blood vessel cross-sectional image continuously in real time at the time of measurement (or for displaying the blood vessel cross-sectional image continuously based on the line data stored in the designated file) and a display area 802 for displaying various kinds of information (patient attribute information showing the attribute of a patient of a patient name and the like, and measurement condition information of a measurement day and time, the settings at the time of measurement and the like) with respect to the blood vessel cross-sectional image which is displayed on the cross-sectional image data display unit 611.

[0079] Further, in the cross-sectional image data display unit 611, there is provided an operation switch 803 for displaying a plurality of blood vessel cross-sectional images continuously, for temporarily stopping the blood vessel cross-sectional image which is displayed continuously, for fast forwarding or rewinding the display and the like.

[0080] Under such a constitution, a user operates, for example, the file-designation button 801 and reads-out a desired file and concurrently, makes the blood vessel cross-sectional image of the desired position in the axial direction be displayed on the cross-sectional image data display unit 611 by operating an operation switch 803. The absorption level visualization process shown in FIG. 7 is carried out by the control unit 605. When the operation is completed by a user, the absorption level visualization process shown in FIG. 7 is started.

[0081] When the absorption level visualization process is started, in step S701, the absorption level visualization position designating unit 613 accepts the designation of the absorption level visualization position. Specifically, owing to a fact that a user presses an absorption level calculation position-designation switch 804 in FIG. 8A, as shown in FIG. 8B, a designation line 811 is displayed on the cross-sectional image data display unit 611. It should be noted that the designation line 811 is a line extending in the radial direction of the blood vessel by setting the center position of the transmitting and receiving unit of the imaging core 201, 301 as an endpoint node and it is constituted so as to be rotated in the circumferential direction depending on the steering of a user. Consequently, owing to a fact that a user moves another one of the endpoint nodes of the designation line 811 in the circumferential direction and matches it with the position of the biological tissue whose absorption level is desired to be comprehended, the designation of the absorption level visualization position can be carried out. In the signal processing unit 214, 323, the circumferential-direction position which is designated by the designation line 811 is accepted as the absorption level visualization po-

sition.

[0082] When the designation of the absorption level visualization position is accepted, in step S702, the line data extraction unit 606 extracts the line data corresponding to the position accepted in the step S701 from the storage unit which is not-shown and concurrently, displays the extracted line data on the line data graph display unit 612 (see FIG. 8C).

[0083] In step S703, so as to find out the attenuation curve in a predetermined region corresponding to a predetermined biological tissue within the line data extracted in step S702, a start point of the lumen is extracted from the extracted line data. Specifically, a differentiation process is carried out in the radial direction from a position corresponding to the outer surface of the catheter sheath of the optical probe unit 101 and the point at which the differentiation value is a predetermined threshold value or more and also at which the scattering intensity (coherent light intensity) is a predetermined threshold value or more is made to be a start point of the lumen.

[0084] In step S704, a termination point for finding out the attenuation curve is extracted. Specifically, a position which proceeds as much as a predetermined distance (for example, 50 pixels), in the radial direction from the start point of the lumen extracted in step S703 is made to be the termination point.

[0085] In step S705, there is carried out a smoothing process for smoothing the line data between the start point of the lumen extracted in step S703 and the termination point extracted in step S704. Specifically, the line data are smoothed by applying a movement averaging process and a median filtering process with respect to the line data between the start point and the termination point.

[0086] In step S706, with respect to the line data which is applied with the smoothing process, the attenuation rate of the coherent light intensity is found out between the start point and the termination point by using, for example, a least squares method or the like. The control unit 605 (FIG. 6) which carries out the operational sequence shown in FIG. 7 is thus an example of a calculation means which calculates the attenuation rate in a predetermined region in the radial direction of the body lumen with respect to the extracted line data. In step S707, the calculated attenuation rate is displayed on the user interface apparatus 317 (see 805 of FIG. 8D) and concurrently, the calculated attenuation curve is displayed by being superimposed on the line data which are displayed on the line data graph display unit 612 (see 612 of FIG. 8D). Thus, it happens that the attenuation rate and the attenuation curve which are calculated are displayed in association with the blood vessel cross-sectional image and the designation line 811.

[0087] FIG. 9 is an enlarged view showing the line data which is displayed on the line data graph display unit 612 and the attenuation curve which is displayed by being superimposed on the line data. As shown in FIG. 9, on the line data graph display unit 612, there are displayed

the distance in the radial direction (distance in the radial direction of the blood vessel by setting the optical lens to be the start point) in the horizontal axis and the intensity value in the vertical axis.

[0088] In an example of FIG. 9, there is shown a state in which an attenuation curve 903 found out depending on the least squares method is superimposed on the line data by setting a reference numeral 901 to be the start point and a reference numeral 902 to be the termination point. It is possible for a user to comprehend high and low levels in the absorption level based on the inclination of the attenuation curve 903 (in a case in which the inclination of the attenuation curve 903 is large, it is possible to recognize that the absorption level of the biological tissue at the position is high and in a case in which the inclination of the attenuation curve 903 is small, it is possible to recognize that the absorption level of the biological tissue at the position is low).

[0089] In this manner, by visualizing the absorption level in the biological tissue and by making it possible to recognize it quantitatively, it becomes possible for a user to identify the biological tissue based on the difference of the absorption level.

[0090] As is clear from the explanation above, in the optical imaging diagnostic apparatus relating to this exemplified embodiment, a constitution is employed in which it is possible, on the displayed blood vessel cross-sectional image, for a user to optionally designate the biological tissue whose absorption level is to be comprehended.

[0091] Also, in a case in which there is designation from a user, there is employed a constitution in which the line data corresponding to the position is extracted and displayed on the user interface apparatus and concurrently, the attenuation rate of a predetermined region is calculated based on the line data and is displayed. Thus, it became possible for a user to recognize high and low levels in the absorption level of the biological tissue at a desired position on the blood vessel cross-sectional image as large and small rates in the attenuation rate.

[0092] Further, there is employed a constitution in which the start point and the termination point which are used for the calculation of the attenuation rate and the attenuation curve calculated depending on the least squares method are displayed by being superimposed on the line data. Thus, it becomes possible for a user to easily recognize which region in the radial direction of the line data is targeted by the calculated attenuation rate and concurrently, it became possible to recognize the absorption level in such a fashion as the inclination of the attenuation curve.

[Second Exemplified Embodiment]

[0093] In the first exemplified embodiment described above, on an occasion when calculating the attenuation curve, the point at which the differential value is a predetermined threshold value or more and also the scattering

intensity (coherent light intensity) is a predetermined threshold value or more is set to be the start point, but the present invention is not limited by this aspect and, for example, it is also allowed for a point which is deviated as many as a few pixels from the point at which the differential value is a predetermined threshold value or more and also the scattering intensity (coherent light intensity) is a predetermined threshold value or more to be extracted as the start point. Thus, it becomes possible to repress the fluctuation of the numerical value caused by the reflection from the surface of the biological tissue and it becomes possible to calculate the attenuation rate accurately.

[0094] Also, in the first exemplified embodiment described above, on an occasion when calculating the attenuation curve, a constitution is employed in which the smoothing process is carried out preliminarily between the start point and the termination point, but the present invention is not limited by this aspect and it is also allowed to employ a constitution in which the smoothing process is omitted.

[0095] In addition, in the first exemplified embodiment described above, it is assumed that the attenuation curve is calculated directly by using the extracted line data, but the present invention is not limited by this aspect and it is allowed to be constituted such that the attenuation curve is calculated on an occasion after there is carried out the process for correcting the sensitivity difference which is resulted from the position (position in the axial direction, position in the circumferential direction or position in the radial direction) in the blood vessel cross-sectional image of the extracted line data. Specifically, it is allowed to employ a constitution in which the sensitivity curve corresponding to the position of the line data is prepared preliminarily and the extracted line data are subtracted from the corresponding sensitivity curve.

[Third Exemplified Embodiment]

[0096] In the first exemplified embodiment described above, it was constituted such that the attenuation rate is calculated with respect to the line data designated by the designation line, but the present invention is not limited by this aspect and it is also allowed to employ a constitution in which the attenuation rate is calculated by targeting all of the circumferential directions (all line data used for the generation of the blood vessel cross-sectional image).

[0097] Also, it is also allowed to be constituted such that there is displayed, by being emphasized, the position on the blood vessel cross-sectional image corresponding to the line data having the attenuation rate identical to that of the designated line data within the attenuation rates of all the calculated line data. For the emphasizing display in such a case, it is assumed that processes of colorization, thick-line making, gray-out making and the like are to be included.

[0098] Having described preferred embodiments of the

invention with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments and that various changes and modifications could be effected therein by one skilled in the art without departing from the scope of the invention as defined in the appended claims.

Claims

1. An optical imaging diagnostic apparatus (100) connected to a probe (101), said optical imaging diagnostic apparatus (100) further including a transmitting and receiving unit (201, 301) for carrying out light transmitting and receiving continuously, adapted to obtain a reflected light from a biological tissue, the transmitting and receiving unit being axially movable while being rotated inside a body lumen, a storage unit (601) adapted to store concurrently line data representing coherent light intensity data in the emission direction of the transmitting and receiving unit, derived from a coherent light produced by interference between the obtained reflected light and a reference light, the apparatus being configured to generate a plurality of cross-sectional images of the biological tissue in the axial direction based on the line data, and to display the images thereof; a designating unit (613) for designating a predetermined circumferential-direction position at the circumference of the transmitting and receiving unit on the cross-sectional image displayed; an extraction unit (606) for extracting, within the plurality of line data used for the generation of the cross-sectional image, line data corresponding to a circumferential-direction position designated in the designating unit from the storage unit (601); a calculation unit (605) for calculating attenuation rate in a predetermined region in a radial direction of the body lumen with respect to the extracted line data; and a display unit (215, 317) for displaying the calculated attenuation rate, **characterized in that** the designating unit (613) is configured to designates the predetermined circumferential-direction position depending on a line which extends in a radial direction of the body lumen by setting the position of the transmitting and receiving unit (201, 301) on the displayed cross-sectional image to be an endpoint node and which is rotatable on the circumference of the transmitting and receiving unit (201, 301).
2. The optical imaging diagnostic apparatus according to claim 1, wherein the calculation unit (605) is configured to calculate the attenuation rate by setting a region, in which a point at which the line data value is a predetermined threshold value or more and also

at which the differential value in the radial direction of the line data becomes a predetermined threshold value or more is made to be a start point and a point of a predetermined distance in the radial direction from the start point is made to be a termination point, to be the predetermined region.

3. The optical imaging diagnostic apparatus according to claim 1, wherein the calculation unit (605) is configured to calculate the attenuation rate by setting a region, in which a point at which the line data value is a predetermined threshold value or more and also which is apart by a predetermined distance in the radial direction from a point at which the differential value in the radial direction of the line data becomes a predetermined threshold value or more is made to be a start point and a point of further a predetermined distance in the radial direction from the start point is made to be a termination point, to be the predetermined region.
4. The optical imaging diagnostic apparatus according to any one of claims 1 to 3, wherein the display unit (215, 317) is configured to display the calculated attenuation rate by being associated with the designated circumferential-direction position.
5. The optical imaging diagnostic apparatus according to any one of claims 1 to 4, wherein the display unit (201, 301) is configured to display an attenuation curve found out in a calculation of the attenuation rate by superimposing the attenuation curve on the extracted line data and by associating the attenuation curve with the position of the designated circumferential direction.
6. The optical imaging diagnostic apparatus according to any one of claims 1 to 5, configured to display an area corresponding to the predetermined region of the line data having an attenuation rate equal to the attenuation rate calculated by the calculation unit (605) within the line data constituting the displayed cross-sectional image, and to emphasize said area on the displayed cross-sectional image,
7. A display control method of an optical imaging diagnostic apparatus (100) including the steps of: connecting a probe (101) including a transmitting and receiving unit (201, 301) for carrying out transmitting and receiving of light continuously, obtaining a reflected light from a biological tissue, by moving the transmitting and receiving unit axially while being rotated inside a body lumen, storing line data representing coherent light intensity in the emission direction of the transmitting and receiving unit derived from a coherent light produced by interference between the obtained reflected light and a reference light in a storage unit (601), concurrently, generating

a plurality of cross-sectional images of the biological tissue in the axial direction based on the line data, and displaying the images thereof, wherein there are comprised:

a designating process consisting on designating a predetermined circumferential-direction position at the circumference of the transmitting and receiving unit (201, 301) on the cross-sectional image displayed;
 an extraction process consisting on extracting, within the plurality of line data used for the generation of the cross-sectional image, line data corresponding to circumferential-direction position designated in the designating process from the storage unit (601);
 a calculating process consisting on calculating attenuation rate in a predetermined region in a radial direction of the body lumen with respect to the extracted line data; and
 a display process consisting on displaying the calculated attenuation rate,

characterized in that

the designating unit (613) designates the predetermined circumferential-direction position depending on a line which extends in a radial direction of the body lumen by setting the position of a transmitting and receiving unit (201, 301) on the displayed cross-sectional image to be an endpoint node and wherein said line is rotatable around the endpoint node on the circumference of the transmitting and receiving unit (201, 301).

Patentansprüche

1. Optische Bildgebungsdiagnosevorrichtung (100), die mit einer Sonde (101) verbunden ist, wobei die optische Bildgebungsdiagnosevorrichtung (100) ferner Folgendes einschließt:

eine Sende- und Empfangseinheit (201, 301) zum kontinuierlichen Durchführen des Sendens und Empfangens von Licht, die dafür eingerichtet ist, reflektiertes Licht von einem biologischen Gewebe zu erfassen, wobei die Sende- und Empfangseinheit in Axialrichtung beweglich ist, während sie innerhalb eines Körperlumens gedreht wird,
 eine Speichereinheit (601), die dafür eingerichtet ist, gleichzeitig Liniendaten, die kohärente Lichtintensitätsdaten in der Emissionsrichtung der Sende- und Empfangseinheit darstellen, zu speichern, die von einem kohärenten Licht abgeleitet sind, das durch Interferenz zwischen

dem erfassten reflektierten Licht und Referenzlicht erzeugt wird,

wobei die Vorrichtung dafür konfiguriert ist, auf der Grundlage der Liniendaten mehrere Querschnittsbilder des biologischen Gewebes in der Axialrichtung zu erzeugen und die Bilder desselben anzuzeigen,

eine Bezeichnungseinheit (613) zum Bezeichnen einer vorbestimmten Umfangsrichtungsposition am Umfang der Sende- und Empfangseinheit auf dem angezeigten Querschnittsbild, eine Extraktionseinheit (606) zum Extrahieren, innerhalb der mehreren Liniendaten, die zur Erzeugung des Querschnittsbildes verwendet werden, von Liniendaten, die einer in der Bezeichnungseinheit bezeichneten Umfangsrichtungsposition entsprechen, aus der Speichereinheit (601),

eine Berechnungseinheit (605) zum Berechnen einer Dämpfungsrate in einer vorbestimmten Region in einer Radialrichtung des Körperlumens in Bezug auf die extrahierten Liniendaten, und

eine Anzeigeeinheit (215, 317) zum Anzeigen der berechneten Dämpfungsrate,

dadurch gekennzeichnet, dass

die Bezeichnungseinheit (613) dafür konfiguriert ist, die vorbestimmte Umfangsrichtungsposition in Abhängigkeit von einer Linie, die sich in einer Radialrichtung des Körperlumens erstreckt, zu bezeichnen durch das Festlegen, dass die Position der Sende- und Empfangseinheit (201, 301) auf dem angezeigten Querschnittsbild ein Endpunktknoten ist, und die auf dem Umfang der Sende- und Empfangseinheit (201, 301) drehbar ist.

2. Optische Bildgebungsdiagnosevorrichtung nach Anspruch 1, wobei die Berechnungseinheit (605) die Dämpfungsrate berechnet durch das Festlegen, dass eine Region, in der ein Punkt, an dem der Liniendatenwert ein vorbestimmter Schwellenwert oder mehr ist und an dem außerdem der Differentialwert in der Radialrichtung der Liniendaten ein vorbestimmter Schwellenwert oder mehr wird, zu einem Startpunkt gemacht wird und ein Punkt mit einem vorbestimmten Abstand in der Radialrichtung von dem Startpunkt zu einem Endpunkt gemacht wird, die vorbestimmte Region ist.
3. Optische Bildgebungsdiagnosevorrichtung nach Anspruch 1, wobei die Berechnungseinheit (605) die Dämpfungsrate berechnet durch das Festlegen, dass eine Region, in der ein Punkt, an dem der Liniendatenwert ein vorbestimmter Schwellenwert oder mehr ist und der außerdem durch einen vorbestimmten Abstand in der Radialrichtung von einem Punkt getrennt ist, an dem der Differentialwert in der

Radialrichtung der Liniendaten ein vorbestimmter Schwellenwert oder mehr wird, zu einem Startpunkt gemacht wird und ein Punkt mit einem weiteren vorbestimmten Abstand in der Radialrichtung von dem Startpunkt zu einem Endpunkt gemacht wird, die vorbestimmte Region ist.

4. Optische Bildgebungsdiagnosevorrichtung nach einem der Ansprüche 1 bis 3, wobei die Anzeigeeinheit (215, 317) dafür konfiguriert ist, die berechnete Dämpfungsrate dadurch anzuzeigen, dass sie mit der bezeichneten Umfangsrichtungsposition verknüpft wird.
5. Optische Bildgebungsdiagnosevorrichtung nach einem der Ansprüche 1 bis 4, wobei die Anzeigeeinheit (201, 301) dafür konfiguriert ist, eine in einer Berechnung der Dämpfungsrate herausgefundene Dämpfungskurve anzuzeigen durch das Überlagern der Dämpfungskurve auf die extrahierten Liniendaten und das Verknüpfen der Dämpfungskurve mit der Position der bezeichneten Umfangsrichtung.
6. Optische Bildgebungsdiagnosevorrichtung nach einem der Ansprüche 1 bis 5, die dafür konfiguriert ist, einen Bereich, welcher der vorbestimmten Region der Liniendaten entspricht, die eine Dämpfungsrate gleich der durch die Berechnungseinheit (605) berechneten Dämpfungsrate, hat, innerhalb der Liniendaten, die das angezeigte Querschnittsbild ausmachen, anzuzeigen und den Bereich auf dem angezeigten Querschnittsbild hervorzuheben.
7. Anzeigesteuerungsverfahren einer optischen Bildgebungsdiagnosevorrichtung (100), das die folgenden Schritte einschließt: das Anschließen einer Sonde (101), die eine Sende- und Empfangseinheit (201, 301) zum kontinuierlichen Durchführen des Sendens und Empfangens von Licht einschließt, das Erfassen eines reflektierten Lichts von einem biologischen Gewebe durch das Bewegen der Sende- und Empfangseinheit in Axialrichtung, während sie innerhalb eines Körperlumens gedreht wird, wobei die Vorrichtung dafür konfiguriert ist, das Speichern von Liniendaten, die kohärente Lichtintensitätsdaten in der Emissionsrichtung der Sende- und Empfangseinheit darstellen, die von einem kohärenten Licht abgeleitet sind, das durch Interferenz zwischen dem erfassten reflektierten Licht und Referenzlicht erzeugt wird, in der Speichereinheit (601), gleichzeitig das Erzeugen mehrerer Querschnittsbilder des biologischen Gewebes in der Axialrichtung auf der Grundlage der Liniendaten und das Anzeigen der Bilder desselben, worin Folgendes umfasst ist:

ein Bezeichnungsvorgang, der im Bezeichnen einer vorbestimmten Umfangsrichtungsposition am Umfang der Sende- und Empfangseinheit

(201, 301) auf dem angezeigten Querschnittsbild besteht,
 ein Extraktionsvorgang, der im Extrahieren, innerhalb der mehreren Liniendaten, die zur Erzeugung des Querschnittsbildes verwendet werden, von Liniendaten, die einer in dem Bezeichnungsvorgang bezeichneten Umfangsrichtungsposition entsprechen, aus der Speichereinheit (601) besteht,
 ein Berechnungsvorgang, der im Berechnen einer Dämpfungsrate in einer vorbestimmten Region in einer Radialrichtung des Körperlumens in Bezug auf die extrahierten Liniendaten besteht, und
 ein Anzeigevorgang, der im Anzeigen der berechneten Dämpfungsrate,
dadurch gekennzeichnet, dass
 die Bezeichnungseinheit (613) die vorbestimmte Umfangsrichtungsposition in Abhängigkeit von einer Linie, die sich in einer Radialrichtung des Körperlumens erstreckt, bezeichnet durch das Festlegen, dass die Position einer Sende- und Empfangseinheit (201, 301) auf dem angezeigten Querschnittsbild ein Endpunktknoten ist, und wobei die Linie um den Endpunktknoten auf dem Umfang der Sende- und Empfangseinheit (201, 301) drehbar ist.

Revendications

1. Appareil de diagnostic par imagerie optique (100) connecté à une sonde (101), ledit appareil de diagnostic par imagerie optique (100) comprenant en outre :

une unité d'émission et de réception (201, 301) pour réaliser l'émission et la réception de lumière de façon continue, adaptée pour obtenir une lumière réfléchie par un tissu biologique, l'unité d'émission et de réception étant mobile axialement tout en la faisant tourner à l'intérieur d'une lumière corporelle,
 une unité de stockage (601) adaptée pour stocker simultanément des données de ligne représentant des données d'intensité de lumière cohérente dans la direction d'émission de l'unité d'émission et de réception, obtenues à partir d'une lumière cohérente produite par interférence entre la lumière réfléchie obtenue et une lumière de référence,
 l'appareil étant configuré pour générer une pluralité d'images en coupe transversale du tissu biologique dans la direction axiale basées sur les données de ligne, et pour afficher les images de celui-ci ;
 une unité de désignation (613) pour désigner une position de direction circumférentielle pré-

- déterminée sur la circonférence de l'unité d'émission et de réception sur l'image en coupe transversale affichée ;
 une unité d'extraction (606) pour extraire, dans la pluralité de données de ligne utilisées pour la génération de l'image en coupe transversale, des données de ligne correspondant à une position de direction circonférentielle désignée dans l'unité de désignation à partir de l'unité de stockage (601) ;
 une unité de calcul (605) pour calculer une vitesse d'atténuation dans une région prédéterminée dans une direction radiale de la lumière corporelle relativement aux données de ligne extraites ; et
 une unité d'affichage (215, 317) pour afficher la vitesse d'atténuation calculée, **caractérisé en ce que** l'unité de désignation (613) est configurée pour désigner la position de direction circonférentielle prédéterminée en fonction d'une ligne qui s'étend dans une direction radiale de la lumière corporelle en réglant la position de l'unité d'émission et de réception (201, 301) sur l'image en coupe transversale affichée de telle manière qu'elle soit un noeud de point limite et qui est rotative sur la circonférence de l'unité d'émission et de réception (201, 301).
2. Appareil de diagnostic par imagerie optique selon la revendication 1, dans lequel l'unité de calcul (605) est configurée pour calculer la vitesse d'atténuation en définissant une région, dans laquelle un point auquel la valeur de donnée de ligne est une valeur de seuil prédéterminée ou plus et aussi auquel la valeur différentielle dans la direction radiale des données de ligne devient supérieure ou égale à une valeur de seuil prédéterminée devient un point de départ et un point d'une distance prédéterminée dans la direction radiale à partir du point de départ devient un point de fin, comme étant la région prédéterminée.
 3. Appareil de diagnostic par imagerie optique selon la revendication 1, dans lequel l'unité de calcul (605) est configurée pour calculer la vitesse d'atténuation en définissant une région, dans laquelle un point auquel la valeur de donnée de ligne est une valeur de seuil prédéterminée ou plus et aussi qui est à l'écart d'une distance prédéterminée dans la direction radiale par rapport à un point auquel la valeur différentielle dans la direction radiale des données de ligne devient supérieure ou égale à une valeur de seuil prédéterminée devient un point de départ et un point d'une autre distance prédéterminée dans la direction radiale à partir du point de départ devient un point de fin, comme étant la région prédéterminée.
 4. Appareil de diagnostic par imagerie optique selon l'une quelconque des revendications 1 à 3, dans lequel l'unité d'affichage (215, 317) est configurée pour afficher la vitesse d'atténuation calculée en étant associée à la position de direction circonférentielle désignée.
 5. Appareil de diagnostic par imagerie optique selon l'une quelconque des revendications 1 à 4, dans lequel l'unité d'affichage (201, 301) est configurée pour afficher une courbe d'atténuation trouvée dans un calcul de la vitesse d'atténuation en superposant la courbe d'atténuation sur les données de ligne extraites et en associant la courbe d'atténuation à la position de la direction circonférentielle désignée.
 6. Appareil de diagnostic par imagerie optique selon l'une quelconque des revendications 1 à 5, configuré pour afficher une zone correspondant à la région prédéterminée des données de ligne ayant une vitesse d'atténuation égale à la vitesse d'atténuation calculée par l'unité de calcul (605) à l'intérieur des données de ligne qui constituent l'image en coupe transversale affichée, et pour mettre en valeur ladite zone sur l'image en coupe transversale affichée.
 7. Procédé de commande d'affichage d'un appareil de diagnostic par imagerie optique (100) comprenant les étapes suivantes : connecter une sonde (101) comportant une unité d'émission et de réception (201, 301) pour réaliser l'émission et la réception de lumière de façon continue, obtenir une lumière réfléchie par un tissu biologique, en déplaçant axialement l'unité d'émission et de réception à l'intérieur d'une lumière corporelle tout en la faisant tourner, stocker des données de ligne représentant une intensité de lumière cohérente dans la direction d'émission de l'unité d'émission et de réception, obtenues à partir d'une lumière cohérente produite par interférence entre la lumière réfléchie obtenue et une lumière de référence dans une unité de stockage (601), générer simultanément une pluralité d'images en coupe transversale du tissu biologique dans la direction axiale basées sur les données de ligne, et afficher les images de celui-ci, dans lequel il est prévu :
 - un processus de désignation consistant à désigner une position de direction circonférentielle prédéterminée sur la circonférence de l'unité d'émission et de réception (201, 301) sur l'image en coupe transversale affichée ;
 - un processus d'extraction consistant à extraire, dans la pluralité de données de ligne utilisées pour la génération de l'image en coupe transversale, des données de ligne correspondant à une position de direction circonférentielle désignée dans le processus de désignation à partir

de l'unité de stockage (601) ;
un processus de calcul consistant à calculer une
vitesse d'atténuation dans une région prédéter-
minée dans une direction radiale de la lumière
corporelle relativement aux données de ligne 5
extraites ; et
un processus d'affichage consistant à afficher
la vitesse d'atténuation calculée,

caractérisé en ce que

l'unité de désignation (613) désigne la position 10
de direction circonférentielle prédéterminée en
fonction d'une ligne qui s'étend dans une direc-
tion radiale de la lumière corporelle en réglant
la position d'une unité d'émission et de réception
(201, 301) sur l'image en coupe transversale af- 15
fichée de telle manière qu'elle soit un noeud de
point limite et dans lequel ladite ligne est rotative
autour du noeud de point limite sur la circonfé-
rence de l'unité d'émission et de réception (201, 20
301).

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FIG.1

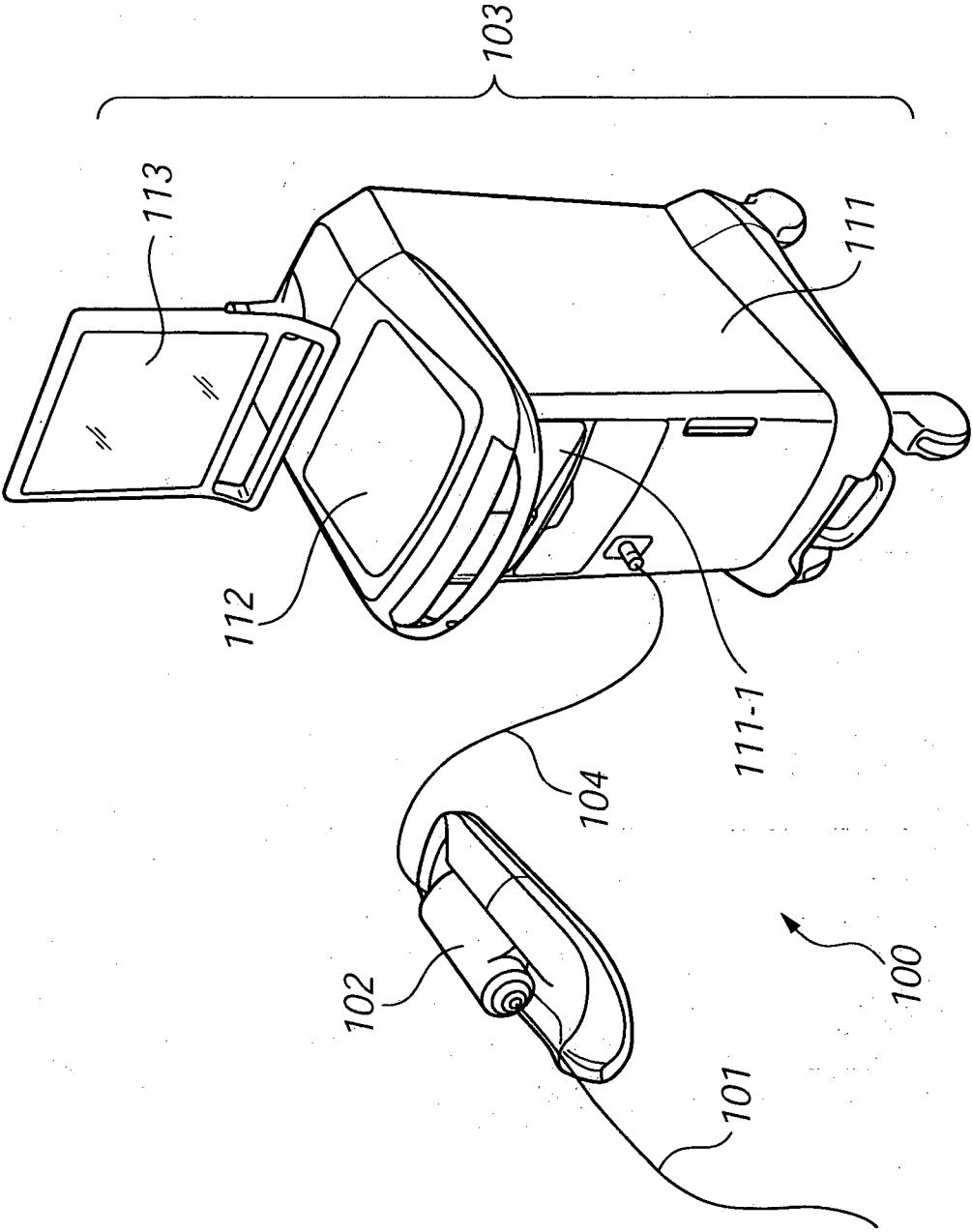


FIG.3

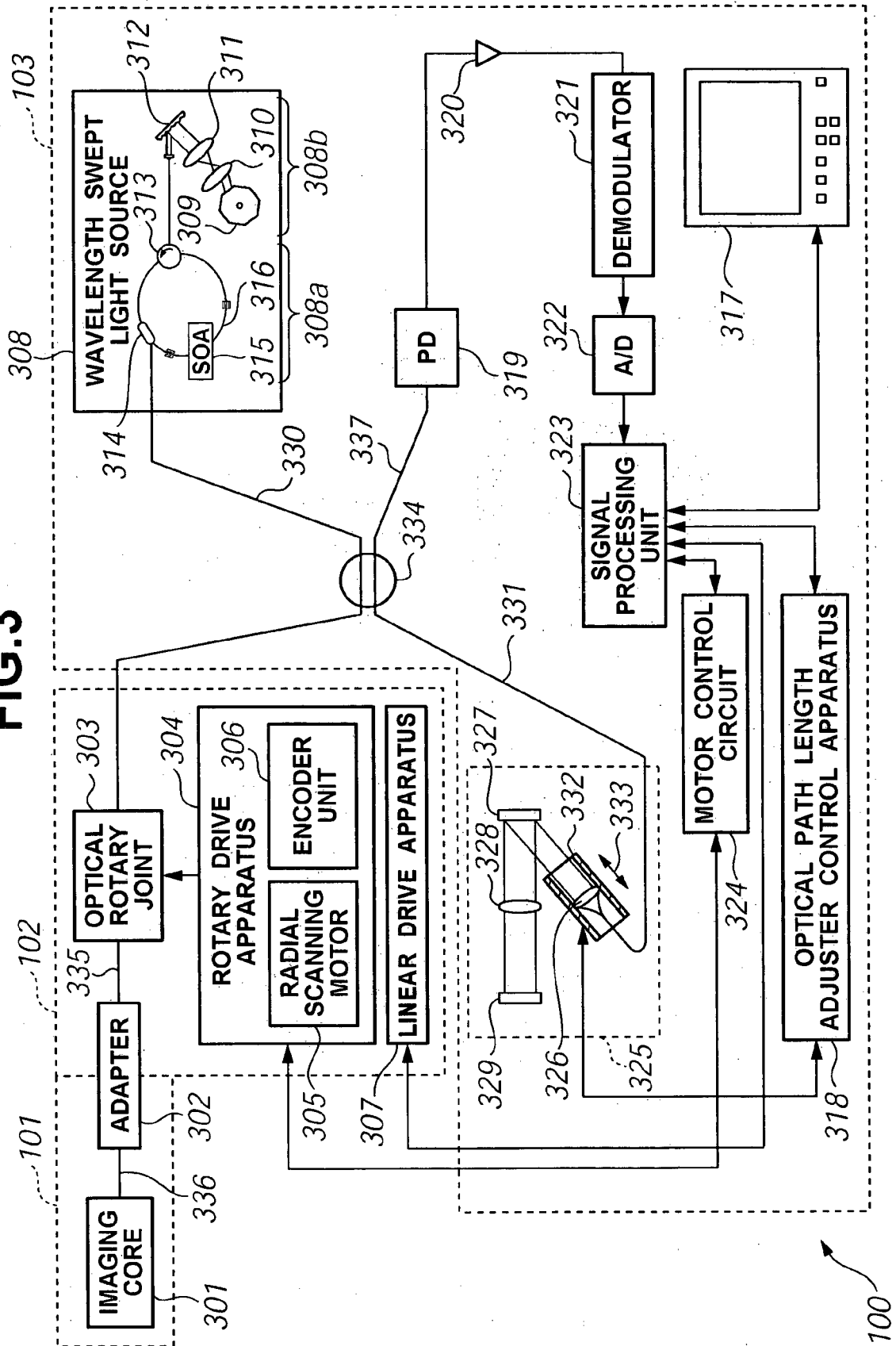


FIG.4

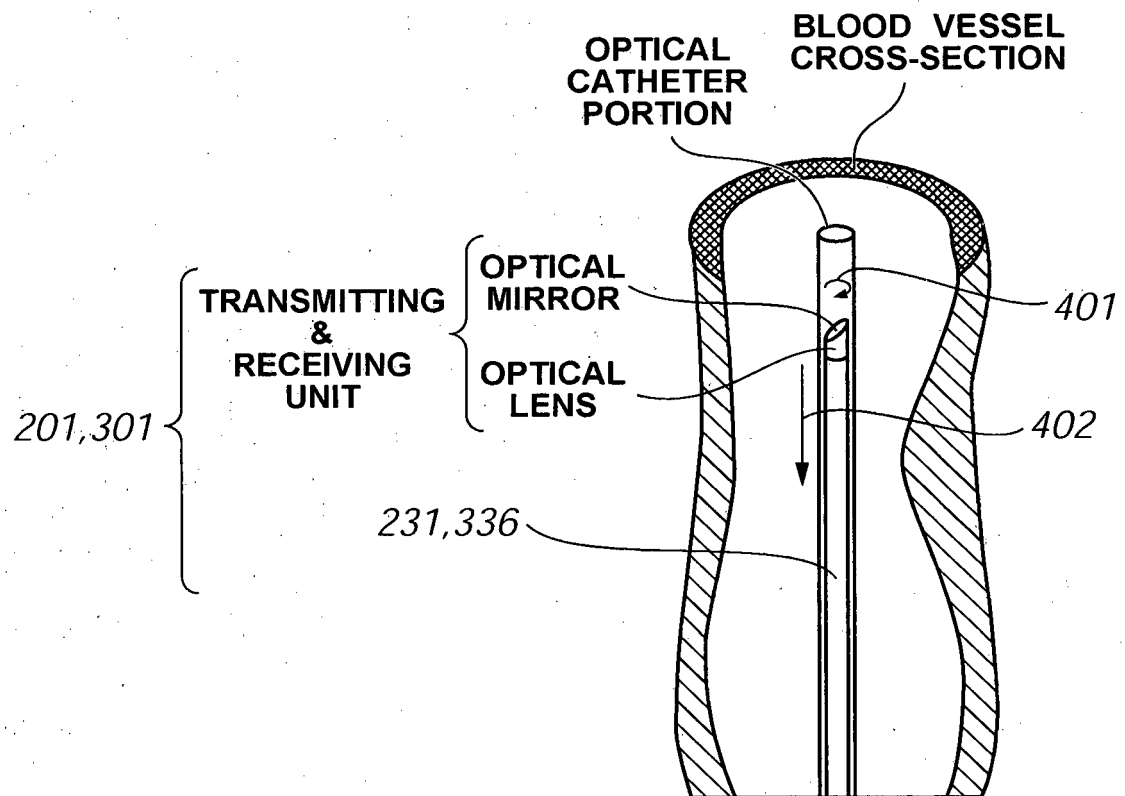


FIG.5A

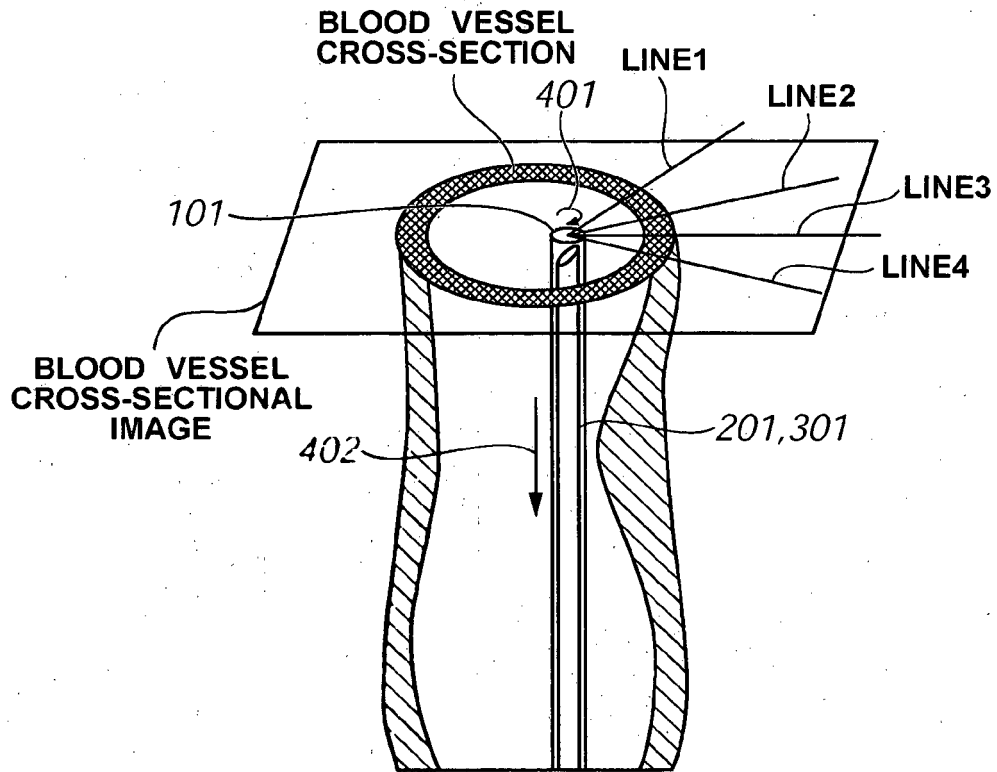


FIG.5B

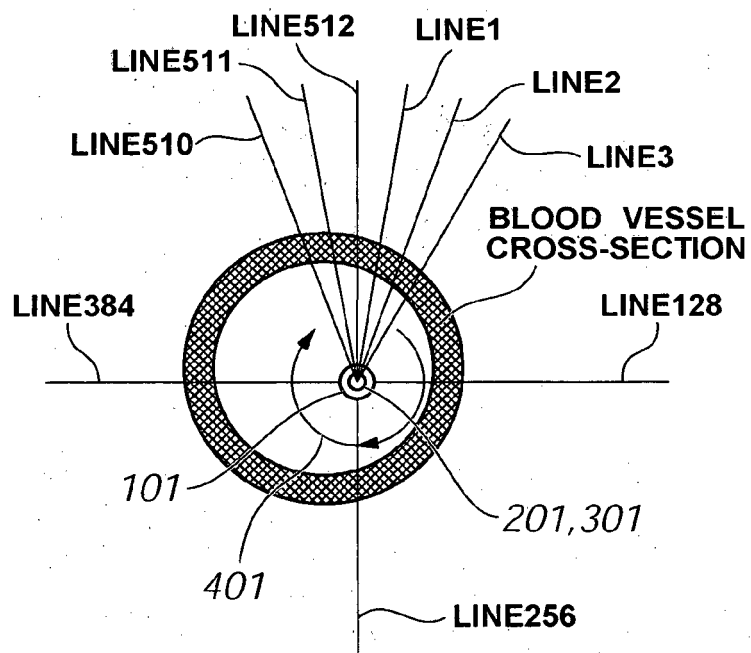


FIG.6

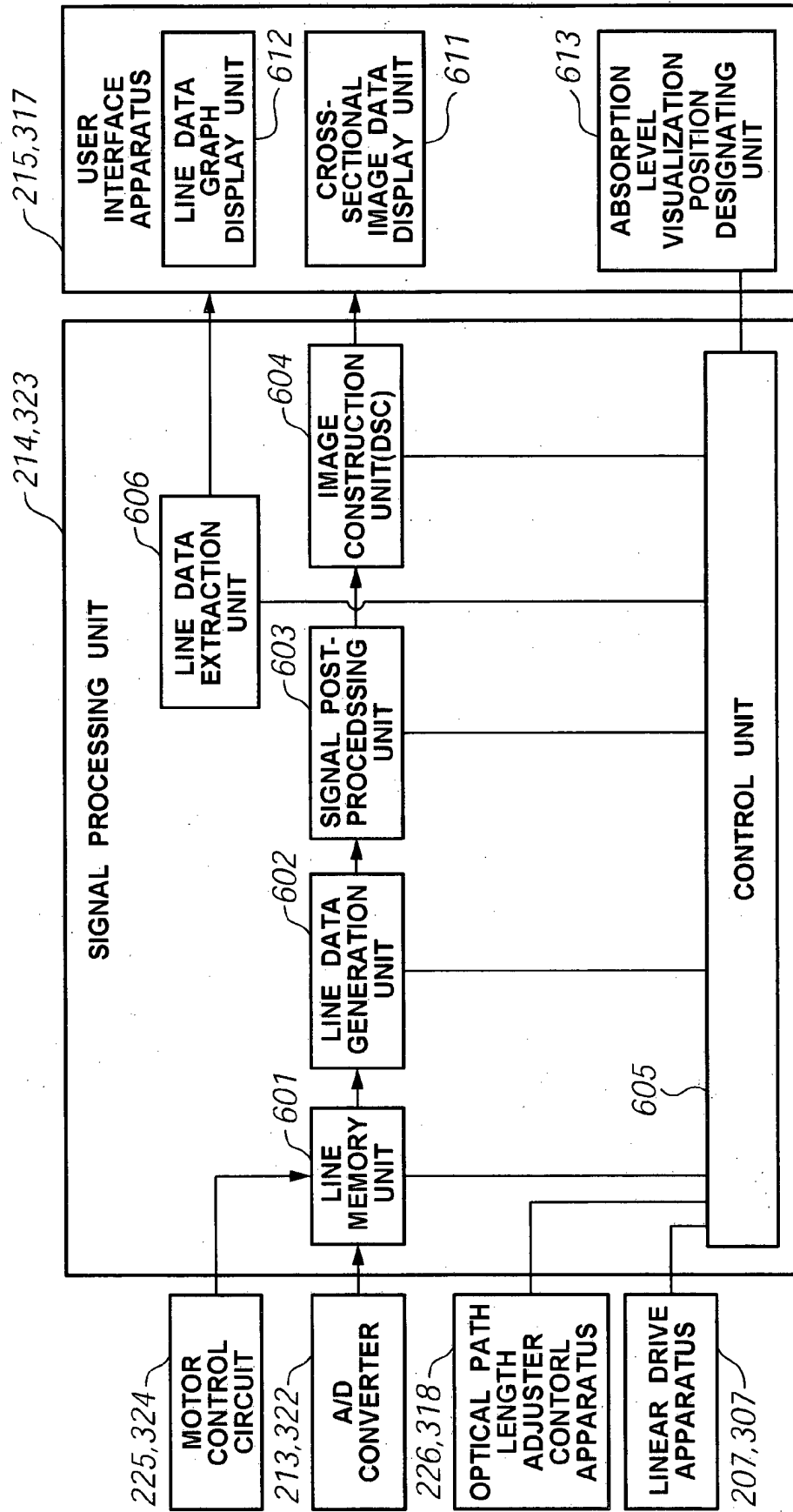


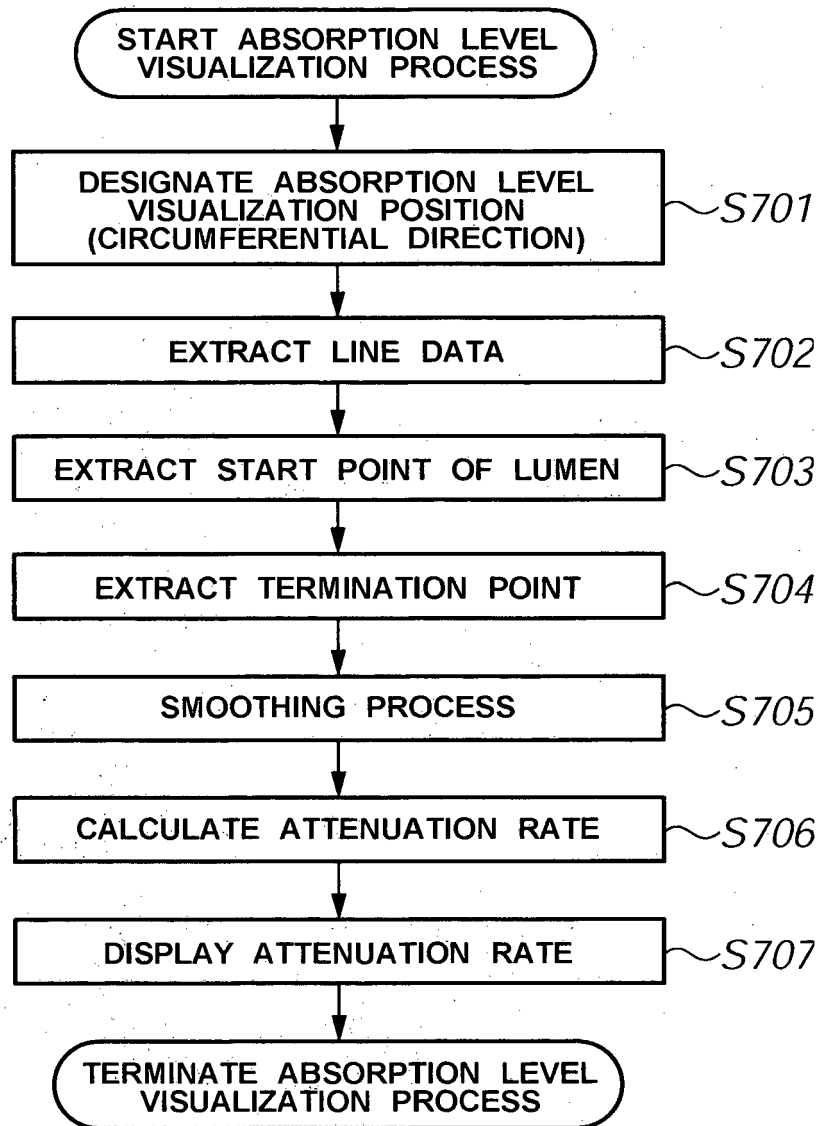
FIG.7

FIG.8A

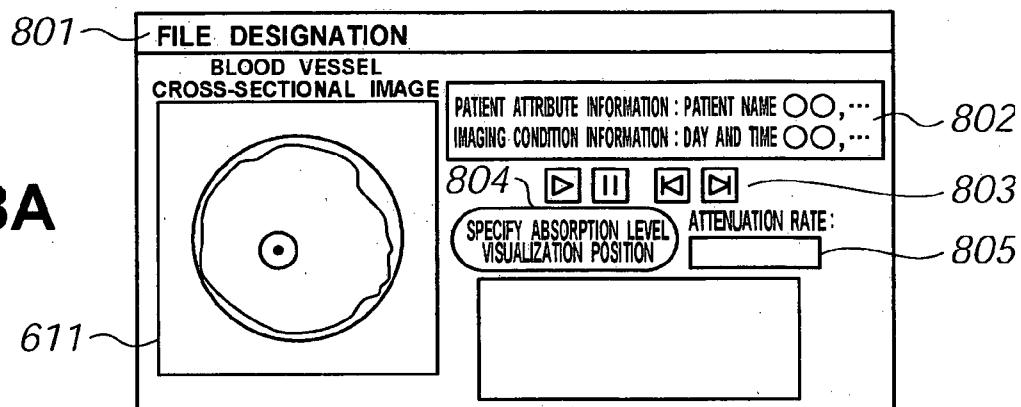


FIG.8B

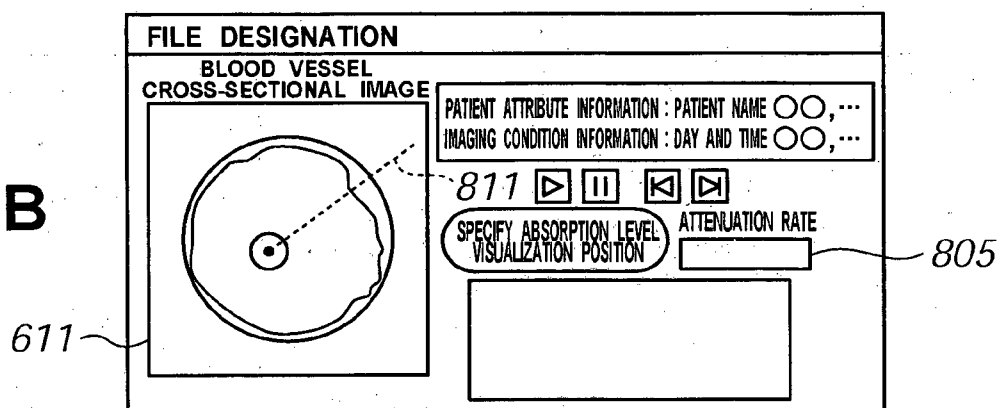


FIG.8C

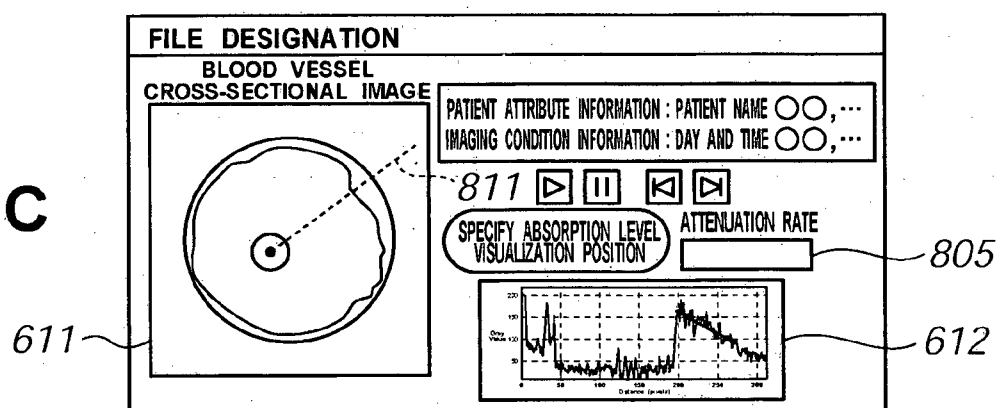


FIG.8D

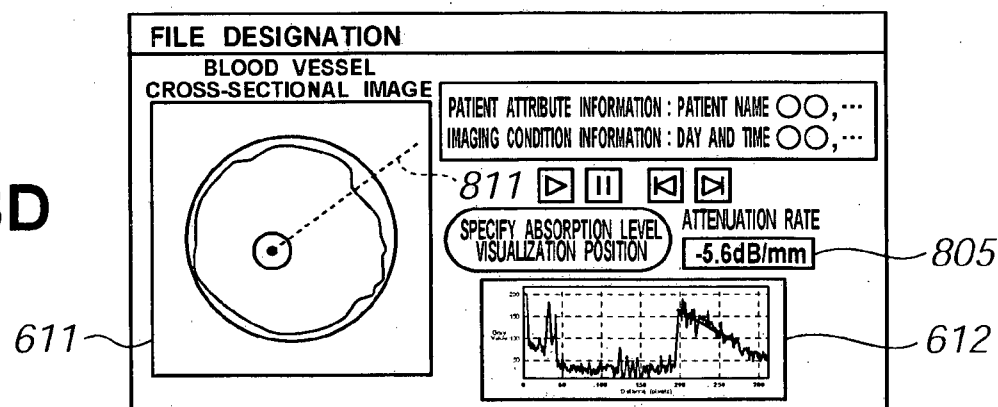
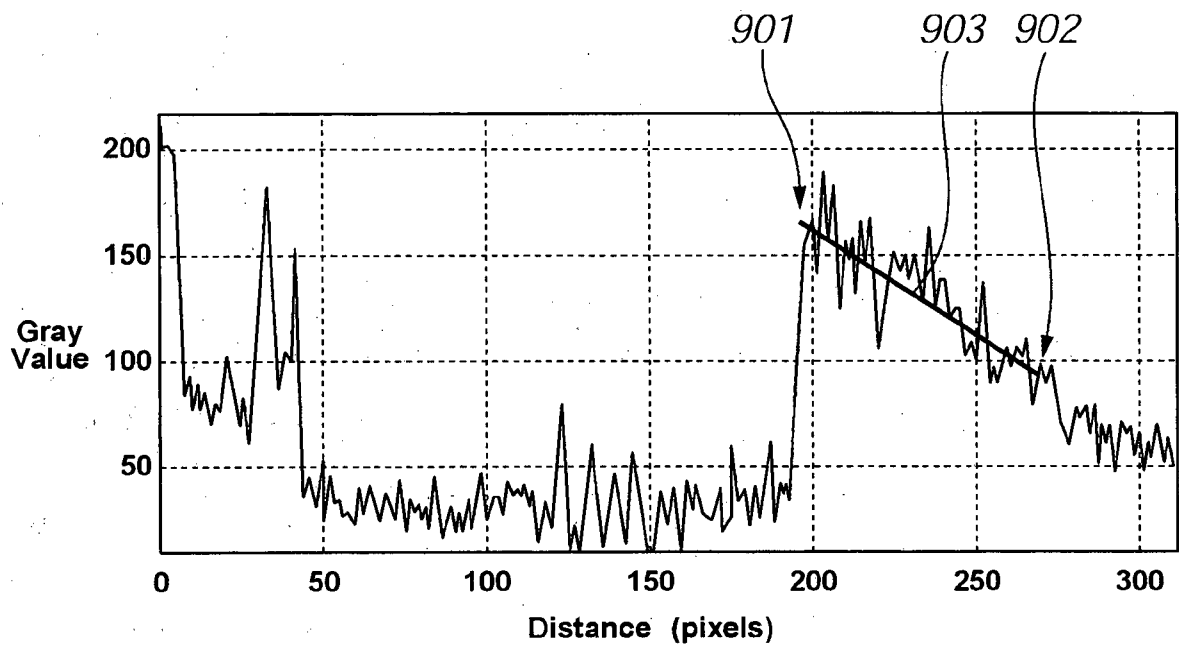


FIG.9



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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摘要(译)

一种光学成像诊断装置，包括：指定单元，用于在所显示的截面图像上指定在发送和接收单元的圆周上的预定圆周方向位置；提取单元，用于在用于产生截面图像的多个线数据中，从存储单元中提取与指定单元中指定的周向位置相对应的线数据；计算单元，用于计算相对于提取的线数据在体腔的径向方向上的预定区域中的衰减率；显示单元，用于显示计算出的衰减率。

FIG.1

