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(54) **ULTRASONIC OBSERVATION APPARATUS AND OPERATION METHOD AND OPERATION PROGRAM OF THE SAME**

ULTRASCHALLBEOBACHTUNGSVORRICHTUNG SOWIE BETRIEBSVERFAHREN UND BETRIEBSPROGRAMM ZU DEREN BETRIEB

DISPOSITIF D'OBSERVATION ÉCHOGRAPHIQUE ET PROCÉDÉ DE FONCTIONNEMENT ET PROGRAMME DE FONCTIONNEMENT DUDIT DISPOSITIF

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## Description

### Field

**[0001]** The present invention relates to an ultrasonic observation apparatus, an operation method of the ultrasonic observation apparatus, and an operation program of the ultrasonic observation apparatus for enabling observation of tissues of a specimen using ultrasonic sound waves.

### Background

**[0002]** Typically, in order to perform screening for breast cancer using ultrasonic sound waves, a technology called ultrasonic elastography is known (for example, see Patent Literature 1). The ultrasonic elastography is a technology which makes use of the fact that cancer tissues or tumor tissues inside a body have different hardness depending on the disease progression or depending on the body nature. In this technology, while continually applying external compression to the screening location, the strain amount or the degree of elasticity of the body tissues at the screening location is measured using ultrasonic sound waves, and the measurement result is displayed in the form of cross-sectional images.

### Citation List

### Patent Literature

**[0003]** Patent Literature 1: WO/2005/122906

### Summary

### Technical Problem

**[0004]** However, in the abovementioned ultrasonic elastography, there is a problem in that it is difficult to transmit applied pressure to the lower part of a vascular channel, such as a blood vessel or a lymph channel. Therefore, when a tumor is formed near the vascular channel, a border of the tumor becomes indistinct, which makes it difficult to distinguish tumor invasion in the vascular channel. Thus, in the ultrasonic elastography, it is sometimes difficult to observe a specimen or distinct tissue characterization with accuracy.

**[0005]** Moreover, in the ultrasonic elastography, there is another problem in that the reliability of a measurement result is low due to individual differences in pressure or compression speed applied by an examiner when compression is applied to the screening location.

**[0006]** The present invention has been made in view of the above and it is an object of the present invention to provide an ultrasonic observation apparatus, an operation method of the ultrasonic diagnosis apparatus, and an operation program of the ultrasonic diagnosis apparatus capable of observing a specimen with accuracy and enhancing the observation result in terms of reliability.

### Solution to Problem

**[0007]** In order to solve the abovementioned problem and achieve the object, an ultrasonic observation apparatus according to the invention transmits ultrasonic sound waves to a specimen and receives ultrasonic sound waves reflected from the specimen. The ultrasonic observation apparatus includes: a frequency analyzing unit that analyzes frequencies of the received ultrasonic sound waves and calculates a frequency spectrum; a feature data extracting unit that performs approximation with respect to the frequency spectrum calculated by the frequency analyzing unit and extracts a plurality of sets of feature data of the frequency spectrum; and a display parameter assigning unit that, in a feature data space including a first coordinate system that contains at least some of sets of feature data being respectively extracted for known specimens as its coordinate components, calculates coordinate values of the feature data of the specimen in a second coordinate system and assigns display parameters corresponding to the calculated coordinate values, the second coordinate system having a new coordinate axis as one of its coordinate axes, the new coordinate axis being an axis on which sum of distances between adjacent representative points is largest, the representative points representing respective groups obtained by classifying the known specimens on the basis of information regarding each known specimen, the distances being obtained when the adjacent representative points, which are adjacent along a predetermined coordinate axis in the first coordinate system, are projected on a predetermined axis.

**[0008]** In the ultrasonic observation apparatus according to the invention, the new coordinate axis is a coordinate axis on which the sum of distances between the adjacent representative points, which are adjacent along the predetermined coordinate axis of the first coordinate system, is the largest value.

**[0009]** The ultrasonic observation apparatus according to the invention further includes: an image processing unit that generates feature-data image data which has pixel values determined according to the display parameters assigned by the display parameter assigning unit to the feature data of the specimen; and a display unit that is capable of displaying images corresponding to feature-data image data generated by the image processing unit.

**[0010]** In the ultrasonic observation apparatus according to the invention, the display parameters are variables constituting a color space.

**[0011]** In the ultrasonic observation apparatus according to the invention, the variables constituting the color space are either one of specific components of a primary color system, specific components of a complementary color system, hues, color intensity values, and luminosity values.

**[0012]** In the ultrasonic observation apparatus according to the invention, the image processing unit generates feature-data image data further using second-type display parameters that are associated with the coordinate values of the feature data of the specimen in a second new coordinate axis orthogonal to the new coordinate axis and that determine the display form of images independent of the display parameters.

**[0013]** In the ultrasonic observation apparatus according to the invention, the second display parameters are variables constituting a color space.

**[0014]** In the ultrasonic observation apparatus according to the invention, the variables constituting the color space are either one of specific components of a primary color system, specific components of a complementary color system, hues, color intensity values, and luminosity values.

**[0015]** In the ultrasonic observation apparatus according to the invention, a plurality of specimens, each having feature data belonging to same group, has mutually same tissue characterization.

**[0016]** In the ultrasonic observation apparatus according to the invention, the feature data extracting unit includes: an approximating unit that performs an approximation operation with respect to the frequency spectrum calculated by the frequency analyzing unit and extracts pre-correction feature data as feature data prior to performing attenuation correction by which there is a decrease in the contribution of attenuation, which occurs due to the reception depth and the frequency of ultrasonic sound waves being propagated, with respect to the frequency spectrum; and an attenuation correcting unit that performs the attenuation correction with respect to the pre-correction feature data extracted by the approximating unit, and extracts feature data of the frequency spectrum.

**[0017]** In the ultrasonic observation apparatus according to the invention, the feature data extracting unit includes: an attenuation correcting unit that performs the attenuation correction with respect to the frequency spectrum; and an approximating unit that performs the approximation operation with respect to the frequency spectrum corrected by the attenuation correcting unit and extracts feature data of the frequency spectrum.

**[0018]** In the ultrasonic observation apparatus according to the invention, the feature data extracting unit performs polynomial approximation with respect to the frequency spectrum by means of regression analysis.

**[0019]** In the ultrasonic observation apparatus according to the invention, the approximating unit performs linear approximation with respect to the frequency spectrum and extracts a plurality of sets of feature data that include at least two components from among a gradient of the linear expression, an intercept of the linear expression, and an intensity that is determined using the gradient, the intercept, and a specific frequency included in the frequency band of the frequency spectrum.

**[0020]** In the ultrasonic observation apparatus according to the invention, greater the reception depth of ultrasonic sound waves, greater is the extent of correction performed by the attenuation correcting unit.

**[0021]** An operation method according to the invention is a method of an ultrasonic observation apparatus that transmits ultrasonic sound waves to a specimen and receives ultrasonic sound waves reflected from the specimen. The operation method includes: a frequency analyzing step including analyzing frequencies of the received ultrasonic sound waves and calculating a frequency spectrum by a frequency analyzing unit; a feature data extracting step including performing approximation with respect to the frequency spectrum that has been calculated at the frequency analyzing step and extracting sets of feature data of the frequency spectrum by a feature data extracting unit; and a display parameter assigning step including calculating, in a feature data space including a first coordinate system that contains at least some of sets of feature data being respectively extracted for known specimens as its coordinate components, coordinate values of the feature data of the specimen in a second coordinate system and assigning display parameters corresponding to the calculated coordinate values by a display parameter assigning unit, the second coordinate system having a new coordinate axis as one of its coordinate axes, the new coordinate axis being an axis on which sum of distances between adjacent representative points is largest, the representative points representing respective groups obtained by classifying the known specimens on the basis of information regarding each known specimen, the distances being obtained when the adjacent representative points, which are adjacent along a predetermined coordinate axis in the first coordinate system, are projected on a predetermined axis.

**[0022]** An operation program according to the invention is a program of an ultrasonic observation apparatus that transmits ultrasonic sound waves to a specimen and receives ultrasonic sound waves reflected from the specimen non-transitory computer readable recording medium with an executable program stored thereon. The operation program instructs the ultrasonic observation apparatus to perform: a frequency analyzing step including analyzing frequencies of the received ultrasonic sound waves and calculating a frequency spectrum by a frequency analyzing unit; a feature data extracting step including performing approximation with respect to the frequency spectrum that has been calculated at the frequency analyzing step and extracting sets of feature data of the frequency spectrum by a feature data extracting unit; and a display parameter assigning step including calculating, in a feature data space including a first coordinate system that contains at least some of sets of feature data being respectively extracted for known specimens as its coordinate components, coordinate values of the feature data of the specimen in a second coordinate system and assigning display parameters corresponding to the calculated coordinate values by a display parameter assigning unit, the second coordinate system having a new coordinate axis as one of its coordinate axes, the new coordinate axis being an axis on which sum of distances between adjacent representative points is largest, the representative points representing respective groups obtained by classifying the known specimens on the basis of information regarding each known specimen, the distances being obtained when the adjacent representative points, which are adjacent along a predetermined coordinate axis in the first coordinate system, are projected on a predetermined axis. Advantageous Effects of Invention

**[0023]** According to the present invention, in a feature data space including a first coordinate system that contains at least some of sets of feature data being respectively extracted for known specimens as its coordinate components, coordinate values of the feature data of the specimen in a second coordinate system are calculated and display parameters corresponding to the calculated coordinate values are assigned, where the second coordinate system has a new coordinate_axis as one of its coordinate axes, the new coordinate axis is an axis on which sum of distances between adjacent representative points is large, the representative points represent respective groups obtained by classifying the known specimens on the basis of information regarding each known specimen, and the distances are obtained when the adjacent representative points, which are adjacent along a predetermined coordinate axis in the first coordinate system, are projected on a predetermined axis. Therefore, the specimen can be observed with more accuracy and the observation result can be enhanced in terms of reliability.

**[0024]** Document US 2007/239007 A1 discloses an apparatus, method and operation program according to the preambles of claims 1, 14 and 16 respectively.

Brief Description of Drawings

**[0025]**

FIG. 1 is block diagram illustrating a configuration of an ultrasonic observation apparatus according to a first embodiment of the present invention.

FIG. 2 is a diagram illustrating an overview of feature data space information stored in a feature-data-space information storing unit of the ultrasonic observation apparatus according to the first embodiment of the present invention.

FIG. 3 is a flowchart illustrating an overview of the operations performed by the ultrasonic observation apparatus according to the first embodiment of the present invention.

FIG. 4 is a diagram illustrating an example of a B-mode image displayed by a display unit of the ultrasonic observation apparatus according to the first embodiment of the present invention.

FIG. 5 is a flowchart illustrating an overview of the operations performed by a frequency analyzing unit of the ultrasonic observation apparatus according to the first embodiment of the present invention.

FIG. 6 is a diagram that schematically illustrates data arrangement of a single acoustic ray.

FIG. 7 is a diagram illustrating an example (first example) of the frequency spectrum calculated by the frequency analyzing unit of the ultrasonic observation apparatus according to the first embodiment of the present invention.

FIG. 8 is a diagram illustrating an example (second example) of the frequency spectrum calculated by the frequency analyzing unit of the ultrasonic observation apparatus according to the first embodiment of the present invention.

FIG. 9 is a diagram illustrating a new straight line that is determined from the feature data obtained upon performing attenuation correction of the feature data related to a straight line illustrated in FIG. 7.

FIG. 10 is a diagram illustrating an overview of a coordinate value calculating operation performed by a display parameter assigning unit of the ultrasonic observation apparatus according to the first embodiment of the present invention.

FIG. 11 is a diagram that schematically illustrates a black-and-white image of an example of a feature data image displayed by the display unit

FIG. 12 is a diagram explaining the effect of attenuation correction performed in the first embodiment of the present invention.

FIG. 13 is a diagram that schematically illustrates a black-and-white image of the image of an example of a feature data image displayed by the display unit.

FIG. 14 is a flowchart explaining an overview of the operations performed by an ultrasonic observation apparatus according to a second embodiment of the present invention.

FIG. 15 is a diagram that schematically illustrates an overview of attenuation correction performed by the ultrasonic observation apparatus according to the second embodiment of the present invention.

FIG. 16 is a diagram that schematically illustrates an overview of [γ] correction performed by an ultrasonic observation apparatus according to another embodiment of the present invention.

Description of Embodiments

**[0026]** Exemplary illustrative embodiments of the present invention (hereinafter, referred to as "embodiments") are explained below in detail with reference to the accompanying drawings.

(First embodiment)

**[0027]** FIG. 1 is block diagram illustrating a configuration of an ultrasonic observation apparatus according to a first embodiment of the present invention. An ultrasonic observation apparatus 1 illustrated in FIG. 1 is an apparatus for observing a specimen using ultrasonic sound waves.

**[0028]** The ultrasonic observation apparatus 1 includes an ultrasonic probe 2 that outputs an ultrasonic pulse to the outside and receives an ultrasonic echo obtained by reflection on the outside; includes a transmitting-receiving unit 3 that transmits electrical signals to and receives electrical signals from the ultrasonic probe 2; a processing unit 4 that performs predetermined processing on electrical echo signals which are obtained by means of conversion of the ultrasonic echo; an image processing unit 5 that generates image data corresponding to the electrical echo signals which are obtained by means of conversion of the ultrasonic echo; an input unit 6 that is configured with an interface such as a keyboard, a mouse, or a touch-sensitive panel, and that receives input of a variety of information; a display unit 7 that is configured with a liquid crystal display panel or an organic EL display panel, and that is capable of displaying a variety of information including the images generated by the image processing unit 5; a memory unit 8 that is used to store information related to a plurality of known specimens as well as to store known specimens by grouping them into a plurality of groups; and a control unit 9 that controls the operations of the ultrasonic observation apparatus 1.

**[0029]** The ultrasonic probe 2 converts electrical pulse signals that are received from the transmitting-receiving unit 3 into ultrasonic pulse (acoustic pulse signals), and includes a signal converting unit 21 for converting the ultrasonic echo that is obtained by reflection from an outside specimen into electrical echo signals. Meanwhile, the ultrasonic probe 2 can be configured to have an ultrasonic transducer performing scanning in a mechanical manner or can be configured to have a plurality of ultrasonic transducers performing scanning in an electronic manner.

**[0030]** The transmitting-receiving unit 3 is electrically connected to the ultrasonic probe 2. With that, the transmitting-receiving unit 3 transmits pulse signals to the ultrasonic probe 2 and receives echo signals representing reception signals from the ultrasonic probe 2. More particularly, based on a predetermined waveform and a predetermined transmission timing, the transmitting-receiving unit 3 generates pulse signals and transmits those pulse signals to the ultrasonic probe 2.

**[0031]** The transmitting-receiving unit 3 is electrically connected to the ultrasonic probe 2. With that, the transmitting-receiving unit 3 transmits pulse signals to the ultrasonic probe 2 and receives echo signals from the ultrasonic probe 2. More particularly, based on a predetermined waveform and a predetermined transmission timing, the transmitting-receiving unit 3 generates pulse signals and transmits those pulse signals to the ultrasonic probe 2. Moreover, the transmitting-receiving unit 3 performs operations such as amplification and filtering on received echo signals, performs A/D conversion of that echo signals to generate digital RF signals, and outputs those digital RF signals. Meanwhile, when the ultrasonic probe 2 is configured to have a plurality of ultrasonic transducers performing scanning in an electronic manner, the transmitting-receiving unit 3 is configured to include a multichannel circuit for performing beam synthesis corresponding to the ultrasonic transducers.

**[0032]** The processing unit 4 includes a frequency analyzing unit 41 that performs frequency analysis of echo signals by carrying out fast Fourier transformation (FFT) of the digital RF signals that are output by the transmitting-receiving unit 3; includes a feature data extracting unit 42 that extracts feature data of the specimen by performing attenuation correction and approximation with respect to the frequency spectrum (power spectrum) calculated by the frequency analyzing unit 41 so that there is a decrease in the contribution of attenuation, which occurs due to the reception depth and the frequency of ultrasonic sound waves being propagated; and a display parameter assigning unit 43 that assigns display parameters, to be used during image display, to the feature data of the specimen.

**[0033]** The frequency analyzing unit 41 calculates a frequency spectrum with respect to each acoustic ray (line data) by performing fast Fourier transformation of an FFT data group having a predetermined volume of data. Depending on the tissue characterization of the specimen, the frequency spectrum demonstrates a different tendency. That is because of the fact that a frequency spectrum has a correlation with the size, the density, and the acoustic impedance of the specimen that serves as a scatterer which scatters the ultrasonic sound waves.

**[0034]** The feature data extracting unit 42 further includes an approximating unit 421, which performs approximation with respect to the frequency spectrum calculated by the frequency analyzing unit 41 and calculates pre-correction feature data that is the feature data prior to performing attenuation correction; and includes an attenuation correcting unit 422, which extracts feature data by performing attenuation correction with respect to the pre-correction feature data obtained by approximation by the approximating unit 421.

**[0035]** The approximating unit 421 performs linear approximation with respect to the frequency spectrum by means of regression analysis, and extracts feature data that characterizes the approximated linear expression. More particularly, by means of regression analysis, the approximating unit 421 calculates a gradient $a_0$ and an intercept $b_0$ of the linear expression, as well as calculates the intensity at a specific frequency within the frequency band of the frequency spectrum as the pre-correction feature data. In the first embodiment, it is assumed that, at the central frequency $f_{MID}=(f_{LOW}+f_{HIGH})/2$, the approximating unit 421 calculates $c_0=a_0f_{MID}+b_0$ as the intensity (Mid-band fit). However, that is only one example. Herein, the intensity indicates any one parameter of parameters such as voltage, power, acoustic pressure, and acoustic energy.

**[0036]** Of the three components of feature data, the gradient $a_0$ has a correlation with the size of the scatterer that scatters the ultrasonic sound waves. Generally, it is thought that larger the scatterer, smaller is the value of the gradient. The intercept $b_0$ has a correlation with the size of the scatterer, the difference in acoustic impedances, and the density (consistency) of the scatterer. More particularly, it is thought that larger the scatterer, greater is the value of the intercept $b_0$; greater the acoustic impedance, greater is the value of the intercept $b_0$; and greater the density (concentration) of the scatterer, greater is the value of the intercept $b_0$. The intensity $c_0$ at the central frequency $f_{MID}$ (hereinafter, simply referred to as "intensity $c_0$") is an indirect parameter derived from the gradient $a_0$ and the intercept $b_0$, and represents the spectrum intensity at the center of the valid frequency band. Thus, it is thought that the intensity $c_0$ has a correlation not only with the size of the scatterer, the difference in acoustic impedances, and the density of the scatterer, but also with the luminosity values of B-mode images to a certain extent. Meanwhile, the approximation polynomial calculated by the feature data extracting unit 42 is not limited to a linear expression. Alternatively, it is also possible to use an approximation polynomial of second-order or more.

**[0037]** The following explanation is given for the correction performed by the attenuation correcting unit 422. An attenuation amount A of ultrasonic sound waves can be expressed as:

$$A=2\alpha zf \qquad (1)$$

where, $\alpha$ represents the attenuation rate, z represents the reception depth of ultrasonic sound waves, and f represents the frequency. As is clear from Equation (1), the attenuation amount A is proportional to the frequency f. Regarding a living body, the specific value of the attenuation rate $\alpha$ is in the range of 0 to 1.0 (dB/cm/MHz) and desirably is in the range of 0.3 to 0.7 (dB/cm/MHz), and is determined according to the organ to be observed. For example, if the organ to be observed is pancreas, then the attenuation rate $\alpha$ is set to 0.6 (dB/cm/MHz). Meanwhile, in the first embodiment, the configuration can also be such that the value of the attenuation rate a can be modified by an input from the input unit 6.

**[0038]** The attenuation correcting unit 422 corrects the pre-correction feature data (the gradient $a_0$, the intercept $b_0$, and the intensity $c_0$), which has been calculated by the approximating unit 421, in the following manner:

$$a=a_0+2\alpha z \qquad (2)$$

$$b=b_0 \qquad (3)$$

$$c=c_0+2\alpha zf_{MID}\,(=af_{MID}+b) \qquad (4)$$

As is clear from Equations (2) and (4) too, greater the reception depth of ultrasonic sound waves, greater is the amount of correction during the correction performed by the attenuation correcting unit 422. Meanwhile, with reference to Equation (3), the correction related to the intercept indicates identical transformation. That is because of the fact that the intercept is a frequency component corresponding to the frequency 0 (Hz) and does not get attenuated.

**[0039]** In a feature data space having coordinate components in the form of the feature data extracted by the feature data extracting unit 42 and corrected by the attenuation correcting unit 422, the display parameter assigning unit 43 calculates coordinate values of the feature data in a second coordinate system that is set in order to satisfy predetermined conditions for reflecting the tissue characterization of the specimen, and assigns display parameters for determining the display form of images according to the calculated coordinate values. Herein, for example, "tissue characterization" indicates any one of a cancer, an endocrine tumor, a mucinous tumor, a normal tissue, and a vascular channel. If the specimen is pancreas, then chronic pancreatitis and autoimmune pancreatitis are also considered as tissue characterization. The information regarding the feature data space that includes the second coordinate system is stored in the memory unit 8 described later.

**[0040]** The image processing unit 5 includes a B-mode image data generating unit 51 that generates B-mode image data from echo signals; and includes a feature-data image data generating unit 52 that generates feature-data image data, which contains pixel values determined according to the B-mode image data generated by the B-mode image data generating unit 51 and contains the display parameters assigned by the display parameter assigning unit 43 to the feature data of the specimen.

**[0041]** The B-mode image data generating unit 51 generates B-mode image data by performing signal processing on digital signals using a known technology such as bandpass filtering, logarithmic conversion, gain processing, or contrast processing, and by performing data thinning according to the data step width that is decided in accordance to the display range of images in the display unit 7.

**[0042]** The feature-data image data generating unit 52 generates feature-data image data by making use of the B-mode image data generated by the B-mode image data generating unit 51, by making use of the feature data generated by the feature data extracting unit 42 and then corrected by the attenuation correcting unit 422, and by making use of display parameters assigned to the feature data by the display parameter assigning unit 43.

**[0043]** The memory unit 8 includes a known-specimen information storing unit 81 that is used to store known specimen information including the feature data of known specimens; includes a window function storing unit 82 that is used to store a window function used during frequency analysis performed by the frequency analyzing unit 41; includes a correction information storing unit 83 that is used to store correction information which is referred to by the attenuation correcting unit 422 while performing operations; a feature-data-space information storing unit 84 that is used to store information related to feature data space which is set on the basis of the feature data of known specimens stored in the known-specimen information storing unit 81; and a display-parameter information storing unit 85 that is used to store display parameter information including the relationship between coordinate values and display parameters of new coordinate axes calculated by the display parameter assigning unit 43.

**[0044]** The known-specimen information storing unit 81 is used to store the feature data of frequency spectrums extracted for known specimens and the tissue characterizations of those known specimens in a corresponding manner. Herein, it is assumed that the feature data of a known specimen is extracted by performing an operation similar to that explained in the first embodiment. However, the feature data extracting operation for a known specimen need not be performed in the ultrasonic observation apparatus 1. Meanwhile, with respect to feature data of the frequency spectrum related to a known specimen, the known-specimen information storing unit 81 is also used to store the average and the standard deviation calculated for each group, which is classified on the basis of the information including the tissue characterization of that known specimen, along with all feature data of that known specimen. In the first embodiment, the average and the standard deviation of feature data of a frequency spectrum of ultrasonic reception signals reflect the changes at a cellular level such as enlargement or anomaly of the nucleus in the specimen or reflect the tissue-level changes such as fibrotic growth in the interstitium or substitution of parenchymal tissues with fibers. In consideration of the fact that a unique value is indicated depending on the tissue characterization, the average and the standard deviation of feature data of the frequency spectrum of a known specimen are used to classify tissue characterizations.

**[0045]** The window function storing unit 82 is used to store at least one window function of the window functions such as Hamming, Hanning, and Blackman. The correction information storing unit 83 is used to store the information related to the conversion of Equations (2) to (4).

**[0046]** The feature-data-space information storing unit 84 is used to store, as the information related to the feature data space that is set on the basis of the known specimen information stored in the known-specimen information storing unit 81, the information related to the second coordinate system in which, when a plurality of representative points each representing one of a plurality of groups obtained by classification on the basis of the feature data of a plurality of known specimens is projected on a predetermined axis and when the sum of distances between adjacent representative points along that coordinate axis is considered for comparison, a new coordinate axis having a large sum of distances between adjacent representative points along the direction of that new coordinate axis is considered as one of the coordinate axes.

**[0047]** FIG. 2 is a diagram illustrating an overview of the feature data space information stored in the feature-data-space information storing unit 84. In the feature data space illustrated in FIG. 2, the horizontal axis represents the intercept b and the vertical axis represents the intensity c (see Equations (3) and (4)). Moreover, areas $G_\mu$, $G_\nu$, and $G_\rho$ represent groups in which a known specimen stored in the known-specimen information storing unit 81 has tissue characterizations of "$\mu$", "$\nu$", and "$\rho$", respectively. In the case illustrated in FIG. 2, in the feature data space, the three groups $G_\mu$, $G_\nu$, and $G_\rho$ are present in mutually exclusive areas. Thus, in the first embodiment, by classifying the groups with the feature data of the frequency spectrums, which is obtained during frequency analysis, serving as the index; it becomes possible to make distinction between mutually different groups. Particularly, in the first embodiment, attenuation correction is performed with respect to ultrasonic echo signals. Therefore, as compared to the case of not performing attenuation correction, each group in the feature data space can be obtained in a more distinctly separated state. Meanwhile, if the b-axis component and the c-axis component in the feature data space differ in scale by a large extent, it is desirable to appropriately perform weighting so that each distance contributes in a substantial equal manner.

**[0048]** In FIG. 2, apart from a first coordinate system (b, c); a second coordinate system (h, v) is also illustrated. Herein, for points $\mu_0$, $\nu_0$, and $\rho_0$ (hereinafter, referred to as "representative points"), the average intercept b and the average intensity c of the frequency spectrums of an FFT data group included in the groups $G_\mu$, G $G_\nu$, and $G_\rho$, respectively, serve as the coordinates in the feature data space. When those representative points $\mu_0$, $\nu_0$, and $\rho_0$ are projected; the coordinate axis h indicates the axis (new coordinate axis) having the maximum sum of distances between adjacent representative points along the direction of projection. Thus, when the components in the h-axis direction of the representative points $\mu_0$, $\nu_0$, and $\rho_0$ are $\mu_{0h}$, $\nu_{0h}$, and $\rho_{0h}$, respectively; the h-axis is defined as the axis along the direction in which $|\mu_0-\nu_0| + |\nu_0-\rho_0|$ is the largest. Meanwhile, the v axis (second new coordinate axis) that is orthogonal to the h axis need not be set.

**[0049]** The display-parameter information storing unit 85 is used to store the coordinate values of the abovementioned new coordinate axis and the display parameters, which determine the display form of images, in a corresponding manner in the feature data space stored in the feature-data-space information storing unit 84. In the first embodiment, for example, the coordinate values in the h axis are stored in a corresponding manner to hues, which serve as one of the three attributes of light. Moreover, in the first embodiment, the coordinate values in the v axis are stored in a corresponding manner to the luminosity values, which serve as one of the three attributes of light and which are fixed independent of hues. Meanwhile, the display parameters are not limited to the abovementioned attributes of light. For example, as the display parameters, it is possible to use the color intensity values, which serve as the remaining attribute of the three attributes of light, or to use variables (such as variables of the RGB color system or a complementary color system) that constitute a color space in general. Alternatively, patterns can also be considered as the display parameters. In the case of using patterns as the display parameters, the setting can be such that the pattern changes for each band of coordinate values.

**[0050]** Meanwhile, the memory unit 8 is put into practice with a ROM, which is used to store in advance operating programs of the ultrasonic observation apparatus 1 according to the first embodiment and to store programs for running a predetermined OS; and with a RAM, which is used to store operating parameters and data of each operation.

**[0051]** In the ultrasonic observation apparatus 1 having the abovementioned functional configuration, the constituent elements other than the ultrasonic probe 2 are put into practice with a computer that includes a CPU for performing processing and control. The CPU in the ultrasonic observation apparatus 1 reads, from the memory unit 8, the information and various programs including the operating programs of the ultrasonic observation apparatus 1; and performs processing related to the operation method of the ultrasonic observation apparatus 1 according to the first embodiment.

**[0052]** The operating programs of the ultrasonic observation apparatus 1 can also be recorded in a computer readable recording medium such as a hard disk, a flash memory, a CD-ROM, a DVD-ROM, or a flexible disk for the purpose of distribution.

**[0053]** FIG. 3 is a flowchart illustrating an overview of the operations performed by the ultrasonic observation apparatus 1 having the configuration explained above. With reference to FIG. 3, firstly, the ultrasonic observation apparatus 1 makes a measurement of a new specimen using the ultrasonic probe 2 (Step S1).

**[0054]** Then, the B-mode image data generating unit 51 generates B-mode image data using echo signals for B-mode images output by the transmitting-receiving unit 3 (Step S2).

**[0055]** Subsequently, the control unit 9 performs control so that the display unit 7 displays the B-mode images corresponding to the B-mode image data generated by the B-mode image data generating unit 51 (Step S3). FIG. 4 is a diagram illustrating an example of a B-mode image displayed by the display unit 7. A B-mode image 100 illustrated in FIG. 4 is a grayscale image in which variables R (red), G (green), and B (blue), which are variables when the RGB color system is adopted as the color space, have identical values.

**[0056]** Then, the frequency analyzing unit 41 performs frequency analysis by means of FFT and calculates a frequency spectrum (Step S4). Herein, the operation performed by the frequency analyzing unit 41 at Step S4 is explained in detail with reference to a flowchart illustrated in FIG. 5. Firstly, the frequency analyzing unit 41 sets an acoustic ray number L of the acoustic ray to be initially analyzed to an initial value $L_0$ (Step S21). The initial value $L_0$ can be assigned, for example, to the acoustic ray received at the start by the transmitting-receiving unit 3 or to the acoustic ray corresponding to the border position on any one of the left and right sides of the area of concern set via the input unit 6.

**[0057]** Then, the frequency analyzing unit 41 calculates the frequency spectrum of all data positions set on a single acoustic ray. Regarding that, firstly, the frequency analyzing unit 41 sets an initial value $Z_0$ of a data position Z (equivalent to reception depth) that is representative of a sequence of data groups (FFT data groups) obtained for the purpose of

FFT (Step S22). FIG. 6 is a diagram that schematically illustrates data arrangement of a single acoustic ray. In an acoustic ray LD illustrated in FIG. 6, a white rectangle or a black rectangle represents a single set of data. The acoustic ray LD is discretized by time intervals corresponding to the sampling frequency (such as 50 MHz) used during A/D conversion performed by the transmitting-receiving unit 3. In FIG. 6, it is illustrated that the first set of data on the acoustic ray LD is set as the initial value $Z_0$ of the data position Z. Meanwhile, FIG. 6 is only an example, and the position of the initial value $Z_0$ can be set in an arbitrary manner. For example, the data position Z corresponding to the position at the top edge of the area of concern can be set as the initial value $Z_0$.

**[0058]** Then, the frequency analyzing unit 41 obtains the FFT data group at the data position Z (Step S23) and implements the window function, which is stored in the window function storing unit 82, to the FFT data group that has been obtained (Step S24). By implementing the window function to the FFT data group, it becomes possible to avoid discontinuity at the borders in the FFT data group. As a result, artifacts can be prevented from occurring.

**[0059]** Subsequently, the frequency analyzing unit 41 determines whether or not the FFT data group at the data position Z is a normal data group (Step S25). Herein, it is necessary that the number of sets of data in a FFT data group is in power-of-two. In the following explanation, it is assumed that the number of sets of data in the FFT data group is $2^n$ (where n is a positive integer). When a FFT data group is normal, it means that the data position Z is the $2^{n-1}$-th position from the front of the FFT data group. In other words, when a FFT data group is normal, it means that there are $2^{n-1}-1$ (=N) number of sets of data prior to the data position Z, and there are $2^{n-1}$ (=M) number of sets of data subsequent to the data position Z. In the example illustrated in FIG. 6, FFT data groups $F_2$, $F_3$, and $F_{K-1}$ are normal data groups; while FFT data groups $F_1$ and $F_K$ are abnormal data groups. However, in FIG. 6, it is assumed that n=4 (N=7, M=8).

**[0060]** If the determination result of Step S25 indicates that the FFT data group at the data position Z is normal (Yes at Step S25), then the system control proceeds to Step S27 described later.

**[0061]** If the determination result of Step S25 indicates that the FFT data group at the data position Z is not normal (No at Step S25), then the frequency analyzing unit 41 inserts zero data equivalent to the deficit and generates a normal FFT data group (Step S26). To the FFT data group that is determined to be not normal at Step S25, the function window is implemented prior to the addition of zero data. Hence, even if zero data is inserted, discontinuity in data does not occur. Once the operation at Step S26 is completed, the system control proceeds to Step S27.

**[0062]** At Step S27, the frequency analyzing unit 41 performs FFT using the FFT data groups and obtains the frequency spectrum (Step S27). FIG. 7 and FIG. 8 are diagrams illustrating examples of the frequency spectrum calculated by the frequency analyzing unit 41. In FIG. 7 and FIG. 8, the horizontal axis f represents the frequency and the vertical axis I represents the intensity. In frequency spectrum curves $C_1$ and $C_2$ illustrated in FIG. 7 and FIG. 8, respectively; a lower limit frequency $f_{LOW}$ and a high limit frequency $f_{HIGH}$ of the frequency spectrum are parameters determined on the basis of the frequency band of the ultrasonic probe 2 and the frequency band of the pulse signals transmitted by the transmitting-receiving unit 3. For example, $f_{LOW}$ is equal to 3 MHz and $f_{HIGH}$ is equal to 10 MHz. Meanwhile, regarding a straight line $L_1$ illustrated in FIG. 7 and a straight line $L_2$ illustrated in FIG. 8, the explanation is given later while explaining the feature data extracting operation. In the first embodiment, curve lines and straight lines are formed of sets of discreet points. The same is the case in other embodiments described later.

**[0063]** Subsequently, the frequency analyzing unit 41 adds a predetermined data step width D to the data position Z, and calculates the data position Z at the FFT data group to be analyzed next (Step S28). Herein, it is desirable that the data step width D is matched with the data step width used at the time when the B-mode image data generating unit 51 generates B-mode image data. However, when the object is to reduce the amount of operations in the frequency analyzing unit 41, it is also possible to set the data step width D to a larger value than the data step width used by the B-mode image data generating unit 51. In FIG. 6, it is illustrated that D=15.

**[0064]** Subsequently, the frequency analyzing unit 41 determines whether or not the data position Z is greater than a final data position $Z_{max}$ (Step S29). Herein, the final data position $Z_{max}$ can be set to the data length of the acoustic ray LD or to the data position corresponding to the lower edge of the area of concern. If the determination result indicates that the data position Z is greater than the final data position $Z_{max}$ (Yes at Step S29), then the frequency analyzing unit 41 increments the acoustic ray number L by 1 (Step S30). On the other hand, if the determination result indicates that the data position Z is equal to or smaller than the final data position $Z_{max}$ (No at Step S29), then the system control returns to Step S23. In this way, with respect to a single acoustic ray LD, the frequency analyzing unit 41 performs FFT for $[\{(Z_{max}-Z_0)/D\}+1]$ (=K) number of FFT data groups. Herein, [X] represents the largest integer not exceeding X.

**[0065]** If the acoustic number L that has been incremented at Step S30 is greater than a final acoustic number $L_{max}$ (Yes at Step S31), then the system control returns to the main routine illustrated in FIG. 3. On the other hand, if the acoustic number L that has been incremented at Step S30 is equal to or smaller than the final acoustic number $L_{max}$ (No at Step S31), then the system control returns to Step S22.

**[0066]** In this way, the frequency analyzing unit 41 performs FFT for K number of times with respect to each of $(L_{max}-L_0+1)$ number of acoustic rays. For example, the final acoustic ray number $L_{max}$ can be assigned to the final acoustic ray received by the transmitting-receiving unit 3 or to the acoustic ray corresponding to the border position on any one of the left and right sides of the area of concern. In the following explanation, the total number of times for which the frequency analyzing unit 41 performs FFT with respect to all acoustic rays is $(L_{max}-L_0+1)\times K$ and is referred to as "P".

**[0067]** Subsequent to the frequency analyzing operation performed at Step S4 as described above, the approximating unit 421 performs, as an approximation operation, regression analysis of the P number of frequency spectrums calculated by the frequency analyzing unit 41 and extracts the pre-correction feature data (Step S5). More particularly, the approximating unit 421 performs regression analysis and calculates the linear expression for approximation of the frequency spectrums in the frequency band of $f_{LOW}<f<f_{HIGH}$; and then calculates the gradient $a_0$, the intercept $b_0$, and the intensity $c_0$, which characterize the linear expression, as the pre-correction feature data. The straight line $L_1$ illustrated in FIG. 7 and the straight line $L_2$ illustrated in FIG. 8 are regression lines obtained by performing regression analysis of the frequency spectrum curve $C_1$ and the frequency spectrum curve $C_2$, respectively, at Step S5.

**[0068]** Then, the attenuation correcting unit 422 performs attenuation correction of the pre-correction feature data extracted by the approximating unit 421 (Step S6). For example, when the data sampling frequency is 50 MHz, the time interval for data sampling is 20 (nsec). If the velocity of sound is assumed to be 1530 (m/sec), then the spacing among data sampling is equal to 1530 (m/sex)x20 (nsec)/2=0.0153 (mm). If "k" is assumed to be the number of data steps from the first set of data of the acoustic ray LD up to the data position of the FFT data group to be processed, then the data position Z thereof is equal to 0.0153k (mm). The attenuation correcting unit 422 substitutes the value of the data position Z, which is obtained in the manner described above, in the reception depth z specified in Equations (2) to (4) mentioned above, and calculates the gradient a, the intercept b, and the intensity c. FIG. 9 is a diagram illustrating a straight line that is determined from the feature data obtained upon performing attenuation correction of the feature data related to the straight line $L_1$ illustrated in FIG. 7. A straight line $L_1$' illustrated in FIG. 9 can be expressed as:

$$I=af+b=(a_0+2\alpha Z)f+b_0 \qquad (5)$$

**[0069]** As is clear from Equation (5), as compared to the straight line $L_1$, the straight line $L_1$' has a greater gradient with the same intercept value.

**[0070]** Subsequently, based on the feature data extracted by the feature data extracting unit 42 and corrected by the attenuation correcting unit 422 as well as based on the known specimen information stored in the known-specimen information storing unit 81 and the feature data space information stored in the feature-data-space information storing unit 84, the display parameter assigning unit 43 calculates the coordinate values in the second coordinate system of the feature data of the specimen (Step S7). FIG. 10 is a diagram illustrating an overview of a coordinate value calculating operation performed in this case. More particularly, in FIG. 10, it is illustrated that, in the feature data space illustrated in FIG. 2, regarding a point Sp representing the feature data extracted for the specimen to be observed (herein, referred to as "specimen point Sp"), coordinate values (hs, vs) in the second coordinate system of the specimen point Sp is calculated.

**[0071]** Then, the display parameter assigning unit 43 assigns display parameters corresponding to the coordinate values of the second coordinate system calculated at Step S7 (Step S8). At that time, the display parameter assigning unit 43 assigns the display parameters by referring to the information stored in the display-parameter information storing unit 85.

**[0072]** Once the operation at Step S8 is completed, the feature-data image data generating unit 52 generates feature-data image data using the B-mode image data, which is generated by the B-mode image data generating unit 51, and the display parameters, which are assigned on a pixel-by-pixel basis by the display parameter assigning unit 43 (Step S9).

**[0073]** Subsequently, the display unit 7 displays a feature data image generated by the feature-data image data generating unit 52 (Step S10). FIG. 11 is a diagram that schematically illustrates a black-and-white image of an example of a feature data image displayed by the display unit 7. As compared to the B-mode image 100, a feature data image 200 illustrated in FIG. 11 is colorized in such a manner that there is a clear difference in colors according to the groups. The feature data image 200 can be broadly divided into a greenish area 200g and a reddish area 200r, with the boundary portion between those two portions displayed in a yellowish color (not illustrated in FIG. 12). As illustrated in FIG. 11, it is not the case that each area is made of only a single color. For example, the greenish area 200g is an area including pixels having colors close to the green color. Similarly, the reddish area 200r is an area including pixels having colors close to the red color. Thus, the observer who observes the feature data image 200 can clearly recognize the differences in groups, that is, clearly recognizes the differences in tissue characterizations.

**[0074]** FIG. 12 is a diagram explaining the effect of attenuation correction performed in the first embodiment. An image 300 illustrated in FIG. 12 is a feature data image not subjected to attenuation correction. In such a case, in contrast to a B-mode image generated by the B-mode image data generating unit 51, the feature data image is a greyscale image in which the intercept b is equally assigned among R (red), G (green), and B (blue). In the feature data image 300, in the area having a large reception depth (the lower area in FIG. 12), the signal intensity decreases due to the effect of attenuation, thereby making the image darker. In contrast, regarding a feature data image 400 for which attenuation correction is performed using the same B-mode image, it can be seen that the image has got a uniform brightness throughout the screen.

**[0075]** As described above, according to the first embodiment of the present invention, in a feature data space including a first coordinate system that has at least some of a plurality of sets of feature data, each of which being extracted with respect to one of a plurality of known specimens, as coordinate components; when a plurality of representative points each representing one of a plurality of groups obtained by classification on the basis of the information regarding each of a plurality of known specimens is projected on a predetermined axis, a new coordinate axis having a large sum of distances between adjacent representative points along a predetermined direction in the first coordinate system is considered as one of the coordinate axes of a second coordinate system, and the coordinate values of the feature data of a specimen in that second coordinate system are calculated and display parameters corresponding to the calculated coordinate values are assigned. Hence, it becomes possible to make clear distinction between different groups. As a result, the specimen can be observed with more accuracy as well as the observation result can be enhanced in terms of reliability.

**[0076]** Moreover, according to the first embodiment, since the coordinate values of the feature data of the specimen in the second coordinate system are calculated, since display parameters corresponding to the coordinate values are assigned, and since feature-data image data having pixel values determined according to the assigned display parameters is generated and displayed; it becomes possible for the user to clearly recognize the differences in the groups in an image.

**[0077]** Furthermore, according to the first embodiment, since attenuation correction is performed on the pre-correction feature data that is extracted from a frequency spectrum, it becomes possible to eliminate the effect of attenuation that occurs during the propagation of ultrasonic sound waves. That makes it possible to perform observation with a higher degree of accuracy.

**[0078]** Meanwhile, in the first embodiment, after the attenuation correcting unit 422 performs attenuation correction of the feature data at Step S6 illustrated in FIG. 3; it is also possible to determine, before proceeding to Step S7, the tissue characterization of the specimen on the basis of the feature data. However, in this case, it is necessary that the feature data of a known specimen and the tissue characterization are stored in a corresponding manner in the known-specimen information storing unit 81.

**[0079]** Explained below is a specific operation performed by the ultrasonic observation apparatus 1 to determine the tissue characterization. The processing unit 4 of the ultrasonic observation apparatus 1 calculates the distances from the specimen point Sp in the feature data space to the representative points $\mu_0$, $\nu_0$, and $\rho_0$ of the groups; and determines that the specimen point Sp belongs to the group having the smallest distance.

**[0080]** In case the distances between the coordinate values and representative points are extremely large; then, even if the smallest value is obtained, the result of determining the tissue characterization is low in terms of reliability. In that regard, when the distances between the specimen point Sp and the representative points are greater than a predetermined threshold value, the ultrasonic observation apparatus 1 can be configured to output an error signal. Moreover, when there are two or more of that smallest value of distances between the specimen point Sp and the representative points, the ultrasonic observation apparatus 1 can be configured to select all tissue characterizations corresponding to the smallest values or to select only one tissue characterization according to predetermined rules. In the latter case, for example, a method can be implemented in which the tissue of a high-grade cancer is set to have a high priority. Meanwhile, alternatively, when there are two or more of that smallest value of distances between the specimen point Sp and the representative points, the ultrasonic observation apparatus 1 can be configured to output an error signal.

**[0081]** FIG. 13 is a diagram that schematically illustrates a black-and-white image of a diagram of a determination result display image that is displayed by the display unit 7 when the ultrasonic observation apparatus 1 determines the tissue characterization based on the feature data. A determination result display image 500 illustrated in FIG. 13 includes an information displaying portion 501, which is used for displaying a variety of related information including the tissue characterization determination result, and an image displaying portion 502, which is used for displaying a feature data image. In FIG. 13, in the image displaying portion 502 is displayed the same feature data image 200 that is illustrated in FIG. 11.

**[0082]** In the information displaying portion 501, for example, following information is displayed: identification information (ID number, name, gender) of a specimen; the tissue characterization determination result; feature data information used in performing tissue characterization determination; and ultrasonic image quality information such as gain and contrast. Herein, as the feature data information, the display can be performed using the average and the standard deviation of feature data of the frequency spectrums of Q number of FFT data groups present inside the area of concern. More particularly, in the information displaying portion 501, for example, it is possible to display the following information: gradient= 1.5+-0.3 (dB/MHz); intercept=-60+-2 (dB); and intensity=-50+-1.5 (dB).

**[0083]** When the display unit 7 displays the determination result display image 500 having the abovementioned configuration, the operator can correctly understand the tissue characterization of the area of concern. However, determination result display images are not limited to the abovementioned configuration. Alternatively, for example, as a determination result display image, it is possible to display side-by-side a tissue characterization weighted image and a B-mode image. With that, the differences in the two images become recognizable on the same screen.

(Second embodiment)

**[0084]** In a second embodiment of the present invention, the feature data extracting operation performed by a feature data extracting unit is different than the first embodiment. The configuration of an ultrasonic observation apparatus according to the second embodiment is same as the configuration of the ultrasonic observation apparatus 1 according to the first embodiment. Thus, in the following explanation, the constituent elements identical to those in the ultrasonic observation apparatus 1 are referred to by the same reference numerals.

**[0085]** During the feature data extracting operation according to the second embodiment, firstly, the attenuation correcting unit 422 performs attenuation correction with respect to the frequency spectrum calculated by the frequency analyzing unit 41. Then, the approximating unit 421 performs approximation with respect to the frequency spectrum that has been subjected to attenuation correction by the attenuation correcting unit 422, and extracts the feature data of the frequency spectrum.

**[0086]** FIG. 14 is a flowchart explaining an overview of the operations performed by the ultrasonic observation apparatus according to the second embodiment. With reference to FIG. 14, the operations performed at Step S41 to S44 are respectively identical to the operations performed at Step S1 to S4 illustrated in FIG. 3.

**[0087]** At Step S45, the attenuation correcting unit 422 performs attenuation correction with respect to a frequency spectrum that is calculated by the frequency analyzing unit 41 by means of FFT (Step S45). FIG. 15 is a diagram that schematically illustrates an overview of the operation performed at Step S45. As illustrated in FIG. 15, with respect to a frequency spectrum curves C3, the attenuation correcting unit 422 performs correction in the form of adding the attenuation amount A given in Equation (1) to the intensity I for all frequencies f, and obtains a new frequency spectrum curve C3'. As a result, it becomes possible to obtain a frequency spectrum in which the contribution of attenuation occurring due to the propagation of ultrasonic sound waves is reduced.

**[0088]** Subsequently, the approximating unit 421 performs regression analysis of all frequency spectrums that are subjected to attenuation correction by the attenuation correcting unit 422, and extracts the feature data of the frequency spectrums (Step S46). More particularly, the approximating unit 421 performs regression analysis and calculates the gradient a, the intercept b, and the intensity c at the central frequency FMID, which characterize the linear expression. A straight line L3 illustrated in FIG. 15 is a regression line (intercept b3) obtained by performing the feature data extracting operation on the frequency spectrum curve C3 at Step 546.

**[0089]** The operations performed at Step S47 to Step S50 are respectively identical to the operations performed at Step S7 to Step S10 illustrated in FIG. 3.

**[0090]** As described above, according to the second embodiment of the present invention, in a feature data space including a first coordinate system that has at least some of a plurality of sets of feature data, each of which being extracted with respect to one of a plurality of known specimens, as coordinate components; when a plurality of representative points each representing one of a plurality of groups obtained by classification on the basis of the information regarding each of a plurality of known specimens is projected on a predetermined axis, a new coordinate axis having a large sum of distances between adjacent representative points along a predetermined direction in the first coordinate system is considered as one of the coordinate axes of a second coordinate system; and the coordinate values of the feature data of a specimen in that second coordinate system are calculated and display parameters corresponding to the calculated coordinate values are assigned. Hence, it becomes possible to make clear distinction between different groups. As a result, the specimen can be observed with more accuracy as well as the observation result can be enhanced in terms of reliability.

**[0091]** Moreover, according to the second embodiment, since the coordinate values of the feature data of the specimen in the second coordinate system are calculated, since display parameters corresponding to the coordinate values are assigned, and since feature-data image data having pixel values determined according to the assigned display parameters is generated and displayed; it becomes possible for the user to clearly recognize the differences in the groups in an image.

**[0092]** Furthermore, according to the second embodiment, since the feature data is extracted after performing attenuation correction with respect to the frequency spectrums, it becomes possible to eliminate the effect of attenuation that occurs during the propagation of ultrasonic sound waves. That makes it possible to perform observation with a higher degree of accuracy.

**[0093]** Thus far, although the invention is described with reference to the abovementioned embodiments, the appended claims are not to be thus limited to the first and second embodiments explained above.

**[0094]** For example, when there is a bias in the distribution of representative points in the feature data space, it is also possible to perform $\gamma$ correction. FIG. 16 is a diagram that schematically illustrates an overview of $\gamma$ correction performed by an ultrasonic observation apparatus according to another embodiment of the present invention. With reference to

FIG. 18, a point Sp1 is a specimen point; and points μ1, v1, and ρ1 are representative points of each group obtained by grouping a plurality of known specimens in the feature space. As illustrated in the upper diagram in FIG. 18, of the representative points μ1, v1, and ρ1 of each group, the distance between the representative point μ1 and the representative point v1 in the h-axis direction is smaller than the distance between the representative point v1 and the representative point ρ1 in the h-axis direction. In that regard, as illustrated in FIG. 18, the ultrasonic observation apparatus performs γ correction on the points in the feature data space in such a way that the distribution in the area in which feature data h is small is dispersive in nature (positive γ correction). As a result, as illustrated in the lower diagram in FIG. 18, a point Sp1' becomes the specimen point, and the distance between a representative point $\mu'_1$ and a representative point $\nu'_1$ in the h-axis direction increases. On the other hand, the distance between the representative point $\nu'_1$ and a representative point $\rho'_1$ in the h-axis direction decreases. As a result, a distribution is obtained in which the three representative points are dispersed along the h-axis direction in a substantially uniform manner.

**[0095]** In this way, when the ultrasonic observation apparatus performs γ correction in an appropriate manner; then, even if there is a bias in the distribution of a plurality of groups in the feature data space, it becomes possible to make clear distinction between different groups.

**[0096]** Meanwhile, although the explanation is given for performing gamma correction on the feature data, it is also possible to perform γ correction in advance on the h-axis. Moreover, γ correction can be performed not only on the components in the h-axis direction but also on the components in the v-axis direction.

Reference Signs List

**[0097]**

| | |
|---|---|
| 1 | ULTRASONIC OBSERVATION APPARATUS |
| 2 | ULTRASONIC PROBE |
| 3 | TRANSMITTING-RECEIVING UNIT |
| 4 | PROCESSING UNIT |
| 5 | IMAGE PROCESSING UNIT |
| 6 | INPUT UNIT |
| 7 | DISPLAY UNIT |
| 8 | MEMORY UNIT |
| 9 | CONTROL UNIT |
| 21 | SIGNAL CONVERTING UNIT |
| 41 | FREQUENCY ANALYZING UNIT |
| 42 | FEATURE DATA EXTRACTING UNIT |
| 43 | DISPLAY PARAMETER ASSIGNING UNIT |
| 51 | B-MODE IMAGE DATA GENERATING UNIT |
| 52 | FEATURE-DATA IMAGE DATA GENERATING UNIT |
| 81 | KNOWN-SPECIMEN INFORMATION STORING UNIT |
| 82 | WINDOW FUNCTION STORING UNIT |
| 83 | CORRECTION INFORMATION STORING UNIT |

| | |
|---|---|
| 84 | FEATURE-DATA-SPACE INFORMATION STORING UNIT |
| 85 | DISPLAY-PARAMETER INFORMATION STORING UNIT |
| 100 | B-MODE IMAGE |
| 200, 300, 400 | FEATURE DATA IMAGE |
| 200g | GREENISH AREA |
| 200r | REDDISH AREA |
| 421 | APPROXIMATING UNIT |
| 422 | ATTENUATION CORRECTING UNIT |
| 500 | DETERMINATION RESULT DISPLAY IMAGE |
| 501 | INFORMATION DISPLAYING PORTION |
| 502 | IMAGE DISPLAYING PORTION |

## Claims

**1.** An ultrasonic observation apparatus (1) adapted to transmit ultrasonic sound waves to a specimen and receive ultrasonic sound waves reflected from the specimen, the ultrasonic observation apparatus (1) comprising:

a frequency analyzing unit (41) adapted to analyze frequencies of the received ultrasonic sound waves and calculate a frequency spectrum;
a feature data extracting unit (42) adapted to perform approximation with respect to the frequency spectrum calculated by the frequency analyzing unit (41) and extract a plurality of sets of feature data of the frequency spectrum; and **characterised by** comprising
a display parameter assigning unit (43) adapted to, in a feature data space including a first coordinate system that contains at least some of sets of feature data being respectively extracted for known specimens as its coordinate components, calculate coordinate values of the feature data of the specimen in a second coordinate system and assign display parameters corresponding to the calculated coordinate values, the second coordinate system having a new coordinate axis as one of its coordinate axes, the new coordinate axis being an axis on which sum of distances between adjacent representative points is largest, the representative points representing respective groups obtained by classifying the known specimens on the basis of information regarding each known specimen, the distances being obtained when the adjacent representative points, which are adjacent along a predetermined coordinate axis in the first coordinate system, are projected on a predetermined axis.

**2.** The ultrasonic observation apparatus (1) according to claim 1, further comprising:

an image processing unit (5) adapted to generate feature-data image data which has pixel values determined according to the display parameters assigned by the display parameter assigning unit (43) to the feature data of the specimen; and
a display unit (7) adapted to display images corresponding to feature-data image data generated by the image processing unit (5).

**3.** The ultrasonic observation apparatus (1) according to any one of claims 1 to 2, wherein the display parameters are variables constituting a color space.

**4.** The ultrasonic observation apparatus (1) according to claim 3, wherein the variables constituting the color space are either one of specific components of a primary color system, specific components of a complementary color system, hues, color intensity values, and luminosity values.

5. The ultrasonic observation apparatus (1) according to any one of claims 1 to 4, wherein the image processing unit (5) is adapted to generate feature-data image data further using second-type display parameters that are associated with the coordinate values of the feature data of the specimen in a second new coordinate axis orthogonal to the new coordinate axis and that determine the display form of images independent of the display parameters.

6. The ultrasonic observation apparatus (1) according to claim 5, wherein the second display parameters are variables constituting a color space.

7. The ultrasonic observation apparatus (1) according to claim 6, wherein the variables constituting the color space are either one of specific components of a primary color system, specific components of a complementary color system, hues, color intensity values, and luminosity values.

8. The ultrasonic observation apparatus (1) according to any one of claims 1 to 7, wherein a plurality of specimens, each having feature data belonging to same group, has mutually same tissue characterization.

9. The ultrasonic observation apparatus (1) according to any one of claims 1 to 8, wherein the feature data extracting unit (42) includes
an approximating unit (421) adapted to perform an approximation operation with respect to the frequency spectrum calculated by the frequency analyzing unit (41) and extract pre-correction feature data as feature data prior to performing attenuation correction by which there is a decrease in the contribution of attenuation, which occurs due to the reception depth and the frequency of ultrasonic sound waves being propagated, with respect to the frequency spectrum; and
an attenuation correcting unit (422) adapted to perform the attenuation correction with respect to the pre-correction feature data extracted by the approximating unit (421), and extract feature data of the frequency spectrum.

10. The ultrasonic observation apparatus (1) according to any one of claims 1 to 8, wherein the feature data extracting unit (42) includes
an attenuation correcting unit (422) adapted to perform the attenuation correction with respect to the frequency spectrum; and
an approximating unit (421) adapted to perform the approximation operation with respect to the frequency spectrum corrected by the attenuation correcting unit (422) and extract feature data of the frequency spectrum.

11. The ultrasonic observation apparatus (1) according to claim 9 or 10, wherein the feature data extracting unit (42) is adapted to perform polynomial approximation with respect to the frequency spectrum by means of regression analysis.

12. The ultrasonic observation apparatus (1) according to claim 11, wherein the approximating unit (421) is adapted to perform linear approximation with respect to the frequency spectrum and extract a plurality of sets of feature data that include at least two components from among a gradient of the linear expression, an intercept of the linear expression, and an intensity that is determined using the gradient, the intercept, and a specific frequency included in the frequency band of the frequency spectrum.

13. The ultrasonic observation apparatus (1) according to any one of claims 9 to 12, wherein, greater the reception depth of ultrasonic sound waves, greater is the extent of correction performed by the attenuation correcting unit (422).

14. An operation method of an ultrasonic observation apparatus (1) that transmits ultrasonic sound waves to a specimen and receives ultrasonic sound waves reflected from the specimen, the operation method comprising:

a frequency analyzing step including analyzing frequencies of the received ultrasonic sound waves and calculating a frequency spectrum by a frequency analyzing unit (41);
a feature data extracting step including performing approximation with respect to the frequency spectrum that has been calculated at the frequency analyzing step and extracting sets of feature data of the frequency spectrum by a feature data extracting unit (42); and **characterised by** comprising
a display parameter assigning step including calculating, in a feature data space including a first coordinate system that contains at least some of sets of feature data being respectively extracted for known specimens as its coordinate components, coordinate values of the feature data of the specimen in a second coordinate system and assigning display parameters corresponding to the calculated coordinate values by a display parameter assigning unit (43), the second coordinate system having a new coordinate axis as one of its coordinate

axes, the new coordinate axis being an axis on which sum of distances between adjacent representative points is largest, the representative points representing respective groups obtained by classifying the known specimens on the basis of information regarding each known specimen, the distances being obtained when the adjacent representative points, which are adjacent along a predetermined coordinate axis in the first coordinate system, are projected on a predetermined axis.

**15.** An operation program of an ultrasonic observation apparatus (1) that transmits ultrasonic sound waves to a specimen and receives ultrasonic sound waves reflected from the specimen, wherein the operation program instructs the ultrasonic observation apparatus (1) to perform:

a frequency analyzing step including analyzing frequencies of the received ultrasonic sound waves and calculating a frequency spectrum by a frequency analyzing unit (41);
a feature data extracting step including performing approximation with respect to the frequency spectrum that has been calculated at the frequency analyzing step and extracting sets of feature data of the frequency spectrum by a feature data extracting unit (42); and **characterised by** comprising
a display parameter assigning step including calculating, in a feature data space including a first coordinate system that contains at least some of sets of feature data being respectively extracted for known specimens as its coordinate components, coordinate values of the feature data of the specimen in a second coordinate system and assigning display parameters corresponding to the calculated coordinate values by a display parameter assigning unit (43), the second coordinate system having a new coordinate axis as one of its coordinate axes, the new coordinate axis being an axis on which sum of distances between adjacent representative points is largest, the representative points representing respective groups obtained by classifying the known specimens on the basis of information regarding each known specimen, the distances being obtained when the adjacent representative points, which are adjacent along a predetermined coordinate axis in the first coordinate system, are projected on a predetermined axis.

## Patentansprüche

**1.** Ultraschallbeobachtungsvorrichtung (1), die dazu ausgebildet ist, Ultraschallwellen zu einer Probe zu senden und von der Probe reflektierte Ultraschallwellen zu empfangen, wobei die Ultraschallbeobachtungsvorrichtung (1) umfasst:

eine Frequenzanalyseeinheit (41), die dazu ausgebildet ist, Frequenzen der empfangenen Ultraschallwellen zu analysieren und ein Frequenzspektrum zu berechnen;
eine Merkmalsdaten-Extraktionseinheit (42), die dazu ausgebildet ist, eine Näherung bezüglich des durch die Frequenzanalyseeinheit (41) berechneten Frequenzspektrums auszuführen und eine Mehrzahl von Merkmalsdatensätzen des Frequenzspektrums zu extrahieren; und
**dadurch gekennzeichnet ist, dass** sie umfasst:

eine Displayparameter-Zuordnungseinheit (43), die dazu ausgebildet ist, in einem Merkmalsdatenraum, der ein erstes Koordinatensystem aufweist, das wenigstens einige der jeweils für bekannte Proben extrahierten Merkmalsdatensätze als seine Koordinatenkomponenten enthält, Koordinatenwerte der Merkmalsdaten der Probe in einem zweiten Koordinatensystem zu berechnen und Displayparameter entsprechend der berechneten Koordinatenwerte zuzuordnen, wobei das zweite Koordinatensystem eine neue Koordinatenachse als eine seiner Koordinatenachsen aufweist, und die neue Koordinatenachse eine Achse ist, auf der die Summe der Abstände zwischen benachbarten repräsentativen Punkten am größten ist, wobei die repräsentativen Punkte jeweilige Gruppen darstellen, die durch eine Klassifizierung der bekannten Proben auf der Basis von jede bekannte Probe betreffenden Informationen erhalten werden, und wobei die Abstände erhalten werden, wenn die benachbarten repräsentativen Punkte, die entlang einer vorbestimmten Koordinatenachse in dem ersten Koordinatensystem zueinander benachbart sind, auf eine vorbestimmte Achse projiziert werden.

**2.** Ultraschallbeobachtungsvorrichtung (1) nach Anspruch 1, die ferner umfasst:

eine Bildverarbeitungseinheit (5), die dazu ausgebildet ist, Merkmalsdaten-Bilddaten zu erzeugen, die Pixelwerte aufweisen, die entsprechend der von der Displayparameter-Zuordnungseinheit (43) den Merkmalsdaten der Probe zugeordneten Displayparametern bestimmt werden; und eine Anzeigeeinheit (7), die dazu ausgebildet ist, Bilder, die den von der Bildverarbeitungseinheit (5) erzeugten Merkmalsdaten-Bilddaten entsprechen, anzuzeigen.

3. Ultraschallbeobachtungsvorrichtung (1) nach einem beliebigen der Ansprüche 1 bis 2, wobei die Displayparameter einen Farbraum darstellende Größen sind.

4. Ultraschallbeobachtungsvorrichtung (1) nach Anspruch 3, wobei die den Farbraum darstellenden Größen spezielle Komponenten eines Primärfarbensystems oder spezielle Komponenten eines Komplementärfarbensystems oder Farbtöne oder Farbintensitätswerte oder Leuchtdichtewerte sind.

5. Ultraschallbeobachtungsvorrichtung (1) nach einem beliebigen der Ansprüche 1 bis 4, wobei die Bildverarbeitungseinheit (5) dazu ausgebildet ist, Merkmalsdaten-Bilddaten zu erzeugen, indem sie zusätzlich eine zweite Art von Displayparametern verwendet, die den Koordinatenwerten der Merkmalsdaten der Probe auf einer zweiten neuen Koordinatenachse, die sich orthogonal zu der neuen Koordinatenachse erstreckt, zugeordnet sind, und die die Form der zur Anzeige gebrachten Bilder unabhängig von den Displayparametern bestimmen.

6. Ultraschallbeobachtungsvorrichtung (1) nach Anspruch 5, wobei die zweiten Displayparameter einen Farbraum darstellende Größen sind.

7. Ultraschallbeobachtungsvorrichtung (1) nach Anspruch 6, wobei die den Farbraum darstellenden Größen spezielle Komponenten eines Primärfarbensystems oder spezielle Komponenten eines Komplementärfarbensystems oder Farbtöne oder Farbintensitätswerte oder Leuchtdichtewerte sind.

8. Ultraschallbeobachtungsvorrichtung (1) nach einem beliebigen der Ansprüche 1 bis 7, wobei eine Mehrzahl von Proben, von denen jede der selben Gruppe zugehörige Merkmalsdaten aufweist, untereinander gleiche Gewebecharakterisierungen aufweisen.

9. Ultraschallbeobachtungsvorrichtung (1) nach einem beliebigen der Ansprüche 1 bis 8, wobei die Merkmalsdaten-Extraktionseinheit (42) aufweist:

eine Näherungseinheit (421), ausgebildet zum Ausführen eines Näherungsvorgangs bezüglich des durch die Frequenzanalyseeinheit (41) berechneten Frequenzspektrums und zum Extrahierten von Vorkorrektur-Merkmalsdaten als Merkmalsdaten vor dem Durchführen der Dämpfungskorrektur, durch die der Beitrag der Dämpfung, die aufgrund der Eindringtiefe und der Frequenz von sich ausbreitenden Ultraschallwellen auftritt, bezüglich des Frequenzspektrums abnimmt; und
eine Dämpfungskorrektureinheit (422), die dazu ausgebildet, die Dämpfungskorrektur bezüglich der von der Näherungseinheit (421) extrahierten Vorkorrektur-Merkmalsdaten auszuführen und Merkmalsdaten aus dem Frequenzspektrum zu extrahieren.

10. Ultraschallbeobachtungsvorrichtung (1) nach einem beliebigen der Ansprüche 1 bis 8, wobei die Merkmalsdaten-Extraktionseinheit (42) aufweist:

eine Dämpfungskorrektureinheit (422), die dazu ausgebildet, die Dämpfungskorrektur bezüglich des Frequenzspektrums auszuführen; und
eine Näherungseinheit (421), die dazu ausgebildet ist, den Näherungsvorgang bezüglich des durch die Dämpfungskorrektureinheit (422) korrigierten Frequenzspektrums auszuführen und Merkmalsdaten aus dem Frequenzspektrum zu extrahieren.

11. Ultraschallbeobachtungsvorrichtung (1) nach Anspruch 9 oder 10, wobei die Merkmalsdaten-Extraktionseinheit (42) dazu ausgebildet, eine polynominale Näherung bezüglich des Frequenzspektrums mittels einer Regressionsanalyse auszuführen.

12. Ultraschallbeobachtungsvorrichtung (1) nach Anspruch 11, wobei die Näherungseinheit (421) dazu ausgebildet ist, eine lineare Näherung bezüglich des Frequenzspektrums auszuführen und eine Mehrzahl von Merkmalsdatensätzen zu extrahieren, die mindestens zwei Komponenten aus einem Gradienten des linearen Ausdrucks, einem Achsenabschnitt des linearen Ausdrucks und einer Intensität aufweisen, die unter Verwendung des Gradienten, des Achsenabschnitts und einer speziellen im Frequenzband des Frequenzspektrums enthaltenen Frequenz bestimmt wird.

13. Ultraschallbeobachtungsvorrichtung (1) nach einem beliebigen der Ansprüche 9 bis 12, wobei das Ausmaß der von der Dämpfungskorrektureinheit (422) vorgenommenen Korrektur umso größer ist, je größer die Eindringtiefe der Ultraschallwellen ist.

14. Verfahren zum Betreiben einer Ultraschallbeobachtungsvorrichtung (1), die Ultraschallwellen zu einer Probe sendet und von der Probe reflektierte Ultraschallwellen empfängt, wobei das Betriebsverfahren umfasst:

einen Frequenzanalyseschritt, der ein Analysieren von Frequenzen der empfangenen Ultraschallwellen und ein Berechnen eines Frequenzspektrums durch eine Frequenzanalyseeinheit (41) beinhaltet;
einen Merkmalsdaten-Extraktionsschritt, der das Ausführen einer Näherung hinsichtlich des im Frequenzanalyseschritt berechneten Frequenzspektrums und das Extrahieren von Merkmalsdatensätzen des Frequenzspektrums durch eine Merkmalsdaten-Extraktionseinheit (42) beinhaltet; und
**dadurch gekennzeichnet ist, dass** es umfasst:
einen Displayparameter-Zuordnungsschritt, bei dem in einem Merkmalsdatenraum, der ein erstes Koordinatensystem aufweist, das wenigstens einige der jeweils für bekannte Proben extrahierten Merkmalsdatensätze als seine Koordinatenkomponenten enthält, Koordinatenwerte der Merkmalsdaten der Probe in einem zweiten Koordinatensystem berechnet werden, und bei dem Displayparameter, die den berechneten Koordinatenwerten entsprechen, durch eine Displayparameter-Zuordnungseinheit (43) zugeordnet werden, wobei das zweite Koordinatensystem eine neue Koordinatenachse als eine seiner Koordinatenachsen aufweist, und die neue Koordinatenachse eine Achse ist, auf der die Summe der Abstände zwischen benachbarten repräsentativen Punkten am größten ist, wobei die repräsentativen Punkte jeweilige Gruppen darstellen, die durch eine Klassifizierung der bekannten Proben auf der Basis von jede bekannte Probe betreffenden Informationen erhalten werden, und wobei die Abstände erhalten werden, wenn die benachbarten repräsentativen Punkte, die entlang einer vorbestimmten Koordinatenachse in dem ersten Koordinatensystem zueinander benachbart sind, auf eine vorbestimmte Achse projiziert werden.

15. Betriebsprogramm einer Ultraschallbeobachtungsvorrichtung (1), die Ultraschallwellen zu einer Probe sendet und von der Probe reflektierte Ultraschallwellen empfängt, wobei das Betriebsprogramm die Ultraschallbeobachtungsvorrichtung (1) anweist die folgenden Schritte auszuführen:

einen Frequenzanalyseschritt, der ein Analysieren von Frequenzen der empfangenen Ultraschallwellen und ein Berechnen eines Frequenzspektrums durch eine Frequenzanalyseeinheit (41) beinhaltet;
einen Merkmalsdaten-Extraktionsschritt, der das Ausführen einer Näherung hinsichtlich des im Frequenzanalyseschritt berechneten Frequenzspektrums und das Extrahieren von Merkmalsdatensätzen des Frequenzspektrums durch eine Merkmalsdaten-Extraktionseinheit (42) beinhaltet; und
**dadurch gekennzeichnet ist, dass** es umfasst:
einen Displayparameter-Zuordnungsschritt, bei dem in einem Merkmalsdatenraum, der ein erstes Koordinatensystem aufweist, das wenigstens einige der jeweils für bekannte Proben extrahierten Merkmalsdatensätze als seine Koordinatenkomponenten enthält, Koordinatenwerte der Merkmalsdaten der Probe in einem zweiten Koordinatensystem berechnet werden, und bei dem Displayparameter, die den berechneten Koordinatenwerten entsprechen, durch eine Displayparameter-Zuordnungseinheit (43) zugeordnet werden, wobei das zweite Koordinatensystem eine neue Koordinatenachse als eine seiner Koordinatenachsen aufweist, und die neue Koordinatenachse eine Achse ist, auf der die Summe der Abstände zwischen benachbarten repräsentativen Punkten am größten ist, wobei die repräsentativen Punkte jeweilige Gruppen darstellen, die durch eine Klassifizierung der bekannten Proben auf der Basis von jede bekannte Probe betreffenden Informationen erhalten werden, und wobei die Abstände erhalten werden, wenn die benachbarten repräsentativen Punkte, die entlang einer vorbestimmten Koordinatenachse in dem ersten Koordinatensystem zueinander benachbart sind, auf eine vorbestimmte Achse projiziert werden.

## Revendications

1. Appareil d'observation par ultrasons (1) adapté pour transmettre des ondes sonores à ultrasons vers un spécimen et recevoir les ondes sonores à ultrasons réfléchies du spécimen, l'appareil d'observation par ultrasons (1) comprenant :

une unité d'analyse de fréquence (41) adaptée pour analyser les fréquences des ondes sonores à ultrasons reçues et calculer un spectre de fréquence ;

une unité d'extraction de données de caractéristiques (42) adaptée pour réaliser une approximation par rapport au spectre de fréquence calculé par l'unité d'analyse de fréquence (41) et extraire une pluralité d'ensembles de données de caractéristiques du spectre de fréquence ; et

**caractérisé en ce qu'**il comprend

une unité d'attribution de paramètres d'affichage (43) adaptée pour, dans un espace de données de caractéristiques incluant un premier système de coordonnées qui contient au moins certains des ensembles de données de caractéristiques étant respectivement extraites pour des spécimens connus en tant que leurs composantes de coordonnées, calculer des valeurs de coordonnées des données de caractéristiques du spécimen dans un deuxième système de coordonnées et attribuer des paramètres d'affichage correspondant aux valeurs de coordonnées calculées, le deuxième système de coordonnées comportant un nouvel axe de coordonnées comme l'un de ses axes de coordonnées, le nouvel axe de coordonnées étant un axe sur lequel la somme des distances entre des points représentatifs adjacents est la plus importante, les points représentatifs représentant des groupes respectifs obtenus en classifiant les spécimens connus sur la base d'informations concernant chaque spécimen connu, les distances étant obtenues lorsque les points représentatifs adjacents, qui sont adjacents le long d'un axe de coordonnées prédéterminé dans le premier système de coordonnées, sont projetés sur un axe prédéterminé.

**2.** Appareil d'observation par ultrasons (1) selon la revendication 1, comprenant en outre :

une unité de traitement d'image (5) adaptée pour générer des données d'image de données de caractéristiques qui présentent des valeurs de pixels déterminées conformément aux paramètres d'affichage attribués par l'unité d'attribution de paramètres d'affichage (43) aux données de caractéristiques du spécimen ; et

une unité d'affichage (7) adaptée pour afficher des images correspondant aux données d'image de données de caractéristiques générées par l'unité de traitement d'image (5).

**3.** Appareil d'observation par ultrasons (1) selon l'une quelconque des revendications 1 à 2, dans lequel les paramètres d'affichage sont des variables constituant un espace de couleurs.

**4.** Appareil d'observation par ultrasons (1) selon la revendication 3, dans lequel les variables constituant l'espace de couleurs sont n'importe lesquelles parmi des composantes spécifiques d'un système de couleurs primaires, des composantes spécifiques d'un système de couleurs complémentaires, des teintes, des valeurs d'intensité de couleur, et des valeurs de luminosité.

**5.** Appareil d'observation par ultrasons (1) selon l'une quelconque des revendications 1 à 4, dans lequel l'unité de traitement d'image (5) est adaptée pour générer des données d'image de données de caractéristiques utilisant en outre des paramètres d'affichage de deuxième type qui sont associés aux valeurs de coordonnées des données de caractéristiques du spécimen dans un deuxième nouvel axe de coordonnées orthogonal au nouvel axe de coordonnées et qui déterminent la forme d'affichage des images indépendamment des paramètres d'affichage.

**6.** Appareil d'observation par ultrasons (1) selon la revendication 5, dans lequel les deuxièmes paramètres d'affichage sont des variables constituant un espace de couleurs.

**7.** Appareil d'observation par ultrasons (1) selon la revendication 6, dans lequel les variables constituant l'espace de couleurs sont n'importe lesquelles parmi des composantes spécifiques d'un système de couleurs primaires, des composantes spécifiques d'un système de couleurs complémentaires, des teintes, des valeurs d'intensité de couleur, et des valeurs de luminosité.

**8.** Appareil d'observation par ultrasons (1) selon l'une quelconque des revendications 1 à 7, dans lequel une pluralité de spécimens, chacun comportant des données de caractéristiques appartenant au même groupe, présentent mutuellement une même caractérisation tissulaire.

**9.** Appareil d'observation par ultrasons (1) selon l'une quelconque des revendications 1 à 8, dans lequel l'unité d'extraction de données de caractéristiques (42) comprend

une unité d'approximation (421) adaptée pour réaliser une opération d'approximation par rapport au spectre de fréquence calculé par l'unité d'analyse de fréquence (41) et extraire des données de caractéristiques de pré-correction en tant que données de caractéristiques avant d'exécuter une correction d'atténuation par laquelle il existe une diminution de la contribution d'atténuation, qui se produit en raison de la profondeur de réception et de la fréquence des ondes sonores à ultrasons étant propagées, par rapport au spectre de fréquence ; et une unité de correction d'atténuation (422) adaptée pour réaliser la correction d'atténuation par rapport aux données de caractéristiques de pré-correction extraites par l'unité d'approximation (421), et extraire des données de caractéristiques du spectre de fréquence.

**10.** Appareil d'observation par ultrasons (1) selon l'une quelconque des revendications 1 à 8, dans lequel l'unité d'extraction de données de caractéristiques (42) comprend
une unité de correction d'atténuation (422) adaptée pour réaliser la correction d'atténuation par rapport au spectre de fréquence ; et
une unité d'approximation (421) adaptée pour réaliser l'opération d'approximation par rapport au spectre de fréquence corrigé par l'unité de correction d'atténuation (422) et extraire des données de caractéristiques du spectre de fréquence.

**11.** Appareil d'observation par ultrasons (1) selon la revendication 9 ou 10, dans lequel l'unité d'extraction de données de caractéristiques (42) est adaptée pour réaliser une approximation polynomiale par rapport au spectre de fréquence au moyen d'une analyse de régression.

**12.** Appareil d'observation par ultrasons (1) selon la revendication 11, dans lequel l'unité d'approximation (421) est adaptée pour réaliser une approximation linéaire par rapport au spectre de fréquence et extraire une pluralité d'ensembles de données de caractéristiques qui comprennent au moins deux composantes parmi un gradient de l'expression linéaire, un point d'intersection de l'expression linéaire, et une intensité qui est déterminée en utilisant le gradient, le point d'intersection, et une fréquence spécifique contenue dans la bande de fréquences du spectre de fréquence.

**13.** Appareil d'observation par ultrasons (1) selon l'une quelconque des revendications 9 à 12, dans lequel, plus la profondeur de réception des ondes sonores à ultrasons est importante, plus l'étendue de correction réalisée par l'unité de correction d'atténuation (422) est importante.

**14.** Procédé de fonctionnement d'un appareil d'observation par ultrasons (1) qui transmet des ondes sonores à ultrasons vers un spécimen et reçoit les ondes sonores à ultrasons réfléchies du spécimen, le procédé de fonctionnement comprenant :

une étape d'analyse de fréquence incluant l'analyse des fréquences des ondes sonores à ultrasons reçues et le calcul d'un spectre de fréquence par une unité d'analyse de fréquence (41) ;
une étape d'extraction de données de caractéristiques incluant la réalisation d'une approximation par rapport au spectre de fréquence qui a été calculé à l'étape d'analyse de fréquence et l'extraction d'ensembles de données de caractéristiques du spectre de fréquence par une unité d'extraction de données de caractéristiques (42) ; et
**caractérisé en ce qu'**il comprend
une étape d'attribution de paramètres d'affichage incluant le calcul, dans un espace de données de caractéristiques incluant un premier système de coordonnées qui contient au moins certains des ensembles de données de caractéristiques étant respectivement extraites pour des spécimens connus en tant que leurs composantes de coordonnées, des valeurs de coordonnées des données de caractéristiques du spécimen dans un deuxième système de coordonnées et l'attribution des paramètres d'affichage correspondant aux valeurs de coordonnées calculées par une unité d'attribution de paramètres d'affichage (43), le deuxième système de coordonnées comportant un nouvel axe de coordonnées en tant que l'un de ses axes de coordonnées, le nouvel axe de coordonnées étant un axe sur lequel la somme des distances entre des points représentatifs adjacents est la plus importante, les points représentatifs représentant des groupes respectifs obtenus en classifiant les spécimens connus sur la base d'informations concernant chaque spécimen connu, les distances étant obtenues lorsque les points représentatifs adjacents, qui sont adjacents le long d'un axe de coordonnées prédéterminé dans le premier système de coordonnées, sont projetés sur un axe prédéterminé.

**15.** Programme de fonctionnement d'un appareil d'observation par ultrasons (1) qui transmet des ondes sonores à ultrasons vers un spécimen et reçoit les ondes sonores à ultrasons réfléchies du spécimen, dans lequel le programme de fonctionnement délivre une instruction à l'appareil d'observation par ultrasons (1) pour exécuter :

une étape d'analyse de fréquence incluant l'analyse des fréquences des ondes sonores à ultrasons reçues et le calcul d'un spectre de fréquence par une unité d'analyse de fréquence (41) ;
une étape d'extraction de données de caractéristiques incluant la réalisation d'une approximation par rapport

au spectre de fréquence qui a été calculé à l'étape d'analyse de fréquence et l'extraction d'ensembles de données de caractéristiques du spectre de fréquence par une unité d'extraction de données de caractéristiques (42) ; et

**caractérisé en ce qu'**il comprend

une étape d'attribution de paramètres d'affichage incluant le calcul, dans un espace de données de caractéristiques incluant un premier système de coordonnées qui contient au moins certains des ensembles de données de caractéristiques étant respectivement extraites pour des spécimens connus en tant que leurs composantes de coordonnées, des valeurs de coordonnées des données de caractéristiques du spécimen dans un deuxième système de coordonnées et l'attribution de paramètres d'affichage correspondant aux valeurs de coordonnées calculées par une unité d'attribution de paramètres d'affichage (43), le deuxième système de coordonnées comportant un nouvel axe de coordonnées en tant que l'un de ses axes de coordonnées, le nouvel axe de coordonnées étant un axe sur lequel la somme des distances entre des points représentatifs adjacents est la plus importante, les points représentatifs représentant des groupes respectifs obtenus en classifiant les spécimens connus sur la base d'informations concernant chaque spécimen connu, les distances étant obtenues lorsque les points représentatifs adjacents, qui sont adjacents le long d'un axe de coordonnées prédéterminé dans le premier système de coordonnées, sont projetés sur un axe prédéterminé.

FIG.1

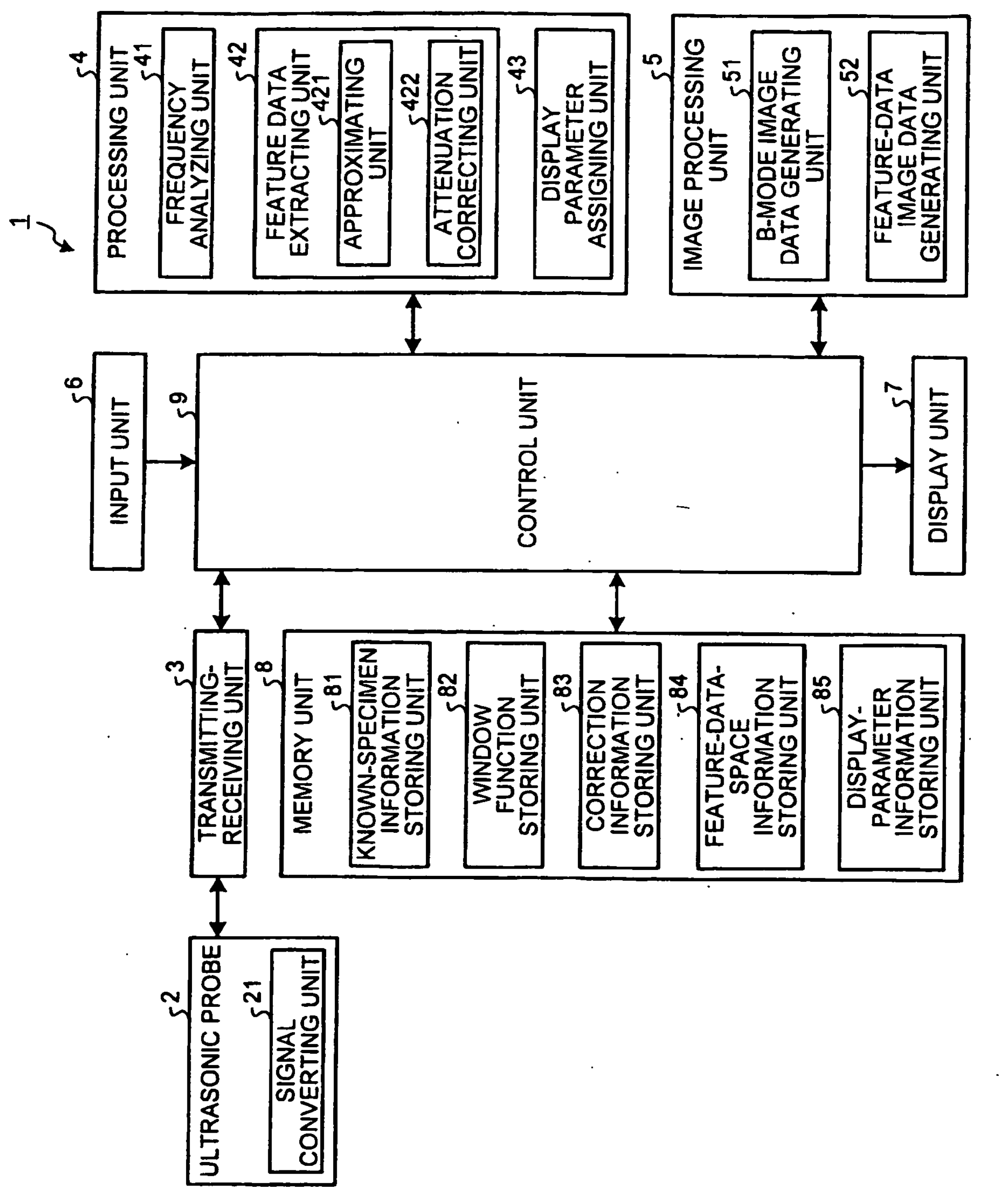

1
PROCESSING UNIT
4
FREQUENCY ANALYZING UNIT
41
FEATURE DATA EXTRACTING UNIT
42
APPROXIMATING UNIT
421
ATTENUATION CORRECTING UNIT
422
DISPLAY PARAMETER ASSIGNING UNIT
43
IMAGE PROCESSING UNIT
5
B-MODE IMAGE DATA GENERATING UNIT
51
FEATURE-DATA IMAGE DATA GENERATING UNIT
52
INPUT UNIT
6
CONTROL UNIT
9
DISPLAY UNIT
7
ULTRASONIC PROBE
2
SIGNAL CONVERTING UNIT
21
TRANSMITTING-RECEIVING UNIT
3
MEMORY UNIT
8
KNOWN-SPECIMEN INFORMATION STORING UNIT
81
WINDOW FUNCTION STORING UNIT
82
CORRECTION INFORMATION STORING UNIT
83
FEATURE-DATA-SPACE INFORMATION STORING UNIT
84
DISPLAY-PARAMETER INFORMATION STORING UNIT
85

FIG.2

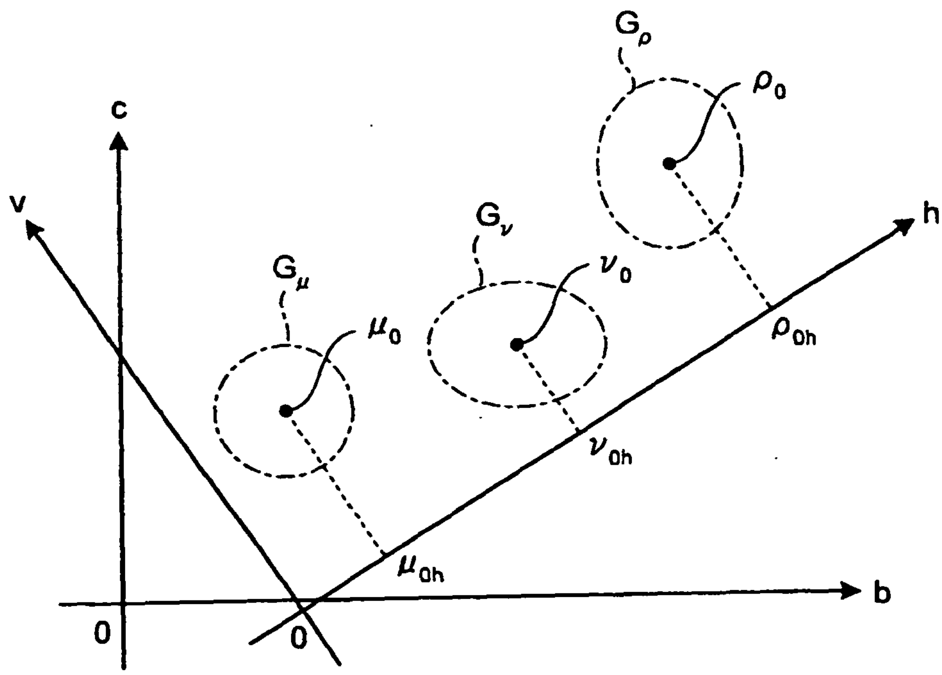


FIG.3

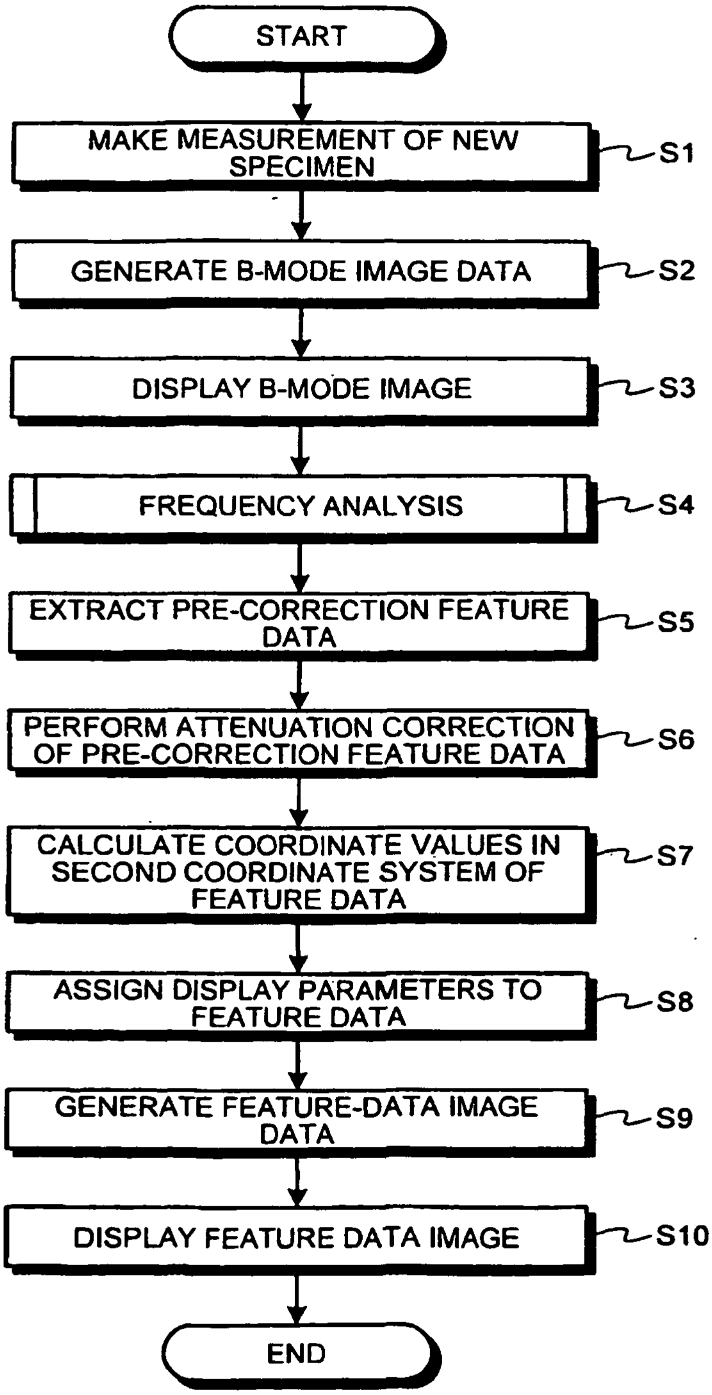
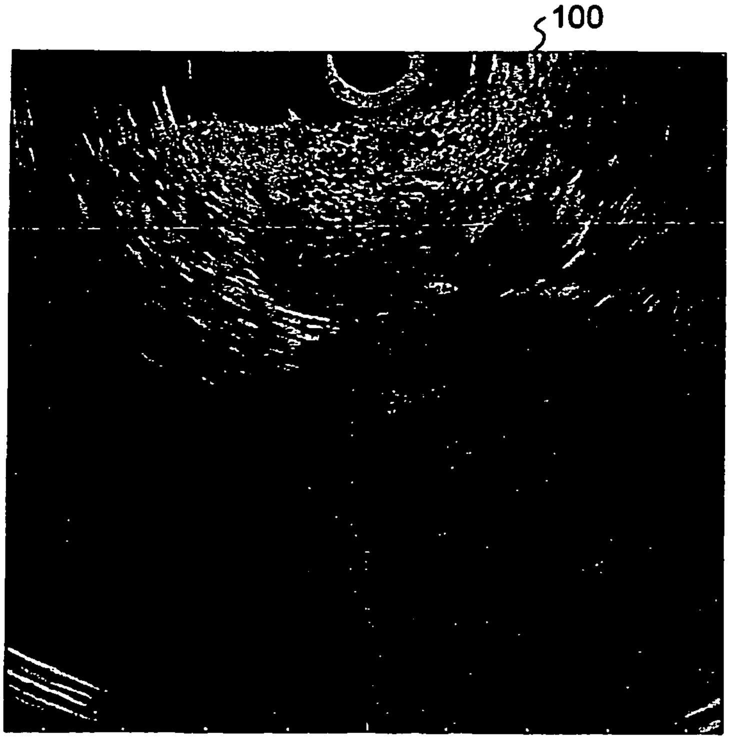

START
MAKE MEASUREMENT OF NEW SPECIMEN
S1
GENERATE B-MODE IMAGE DATA
S2
DISPLAY B-MODE IMAGE
S3
FREQUENCY ANALYSIS
S4
EXTRACT PRE-CORRECTION FEATURE DATA
S5
PERFORM ATTENUATION CORRECTION OF PRE-CORRECTION FEATURE DATA
S6
CALCULATE COORDINATE VALUES IN SECOND COORDINATE SYSTEM OF FEATURE DATA
S7
ASSIGN DISPLAY PARAMETERS TO FEATURE DATA
S8
GENERATE FEATURE-DATA IMAGE DATA
S9
DISPLAY FEATURE DATA IMAGE
S10
END

FIG.4



# FIG.5

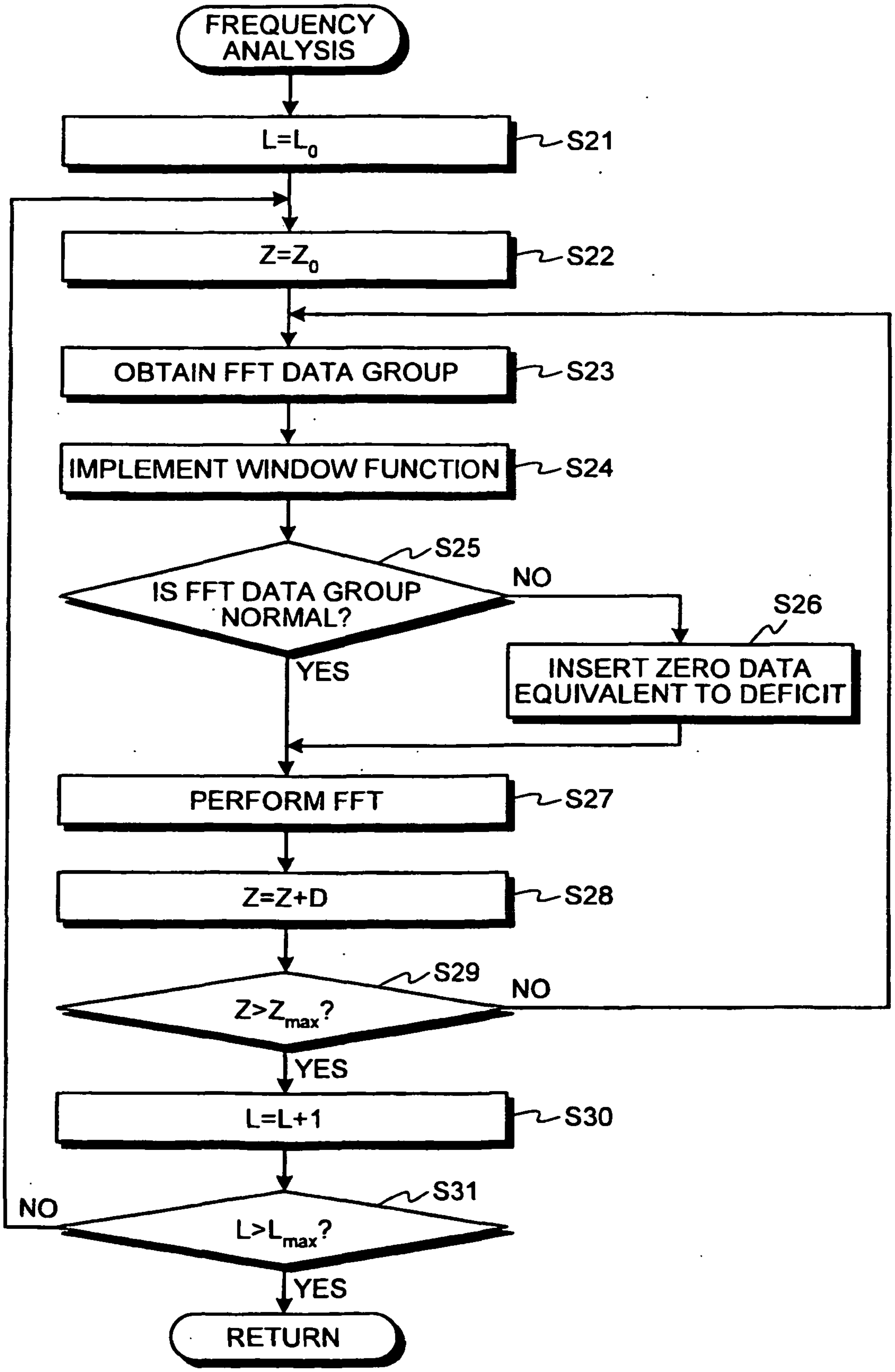

FREQUENCY ANALYSIS
L=L0
S21
Z=Z0
S22
OBTAIN FFT DATA GROUP
S23
IMPLEMENT WINDOW FUNCTION
S24
S25
IS FFT DATA GROUP NORMAL?
NO
YES
S26
INSERT ZERO DATA EQUIVALENT TO DEFICIT
PERFORM FFT
S27
Z=Z+D
S28
S29
Z>Zmax?
NO
YES
L=L+1
S30
S31
NO
L>Lmax?
YES
RETURN

FIG.6

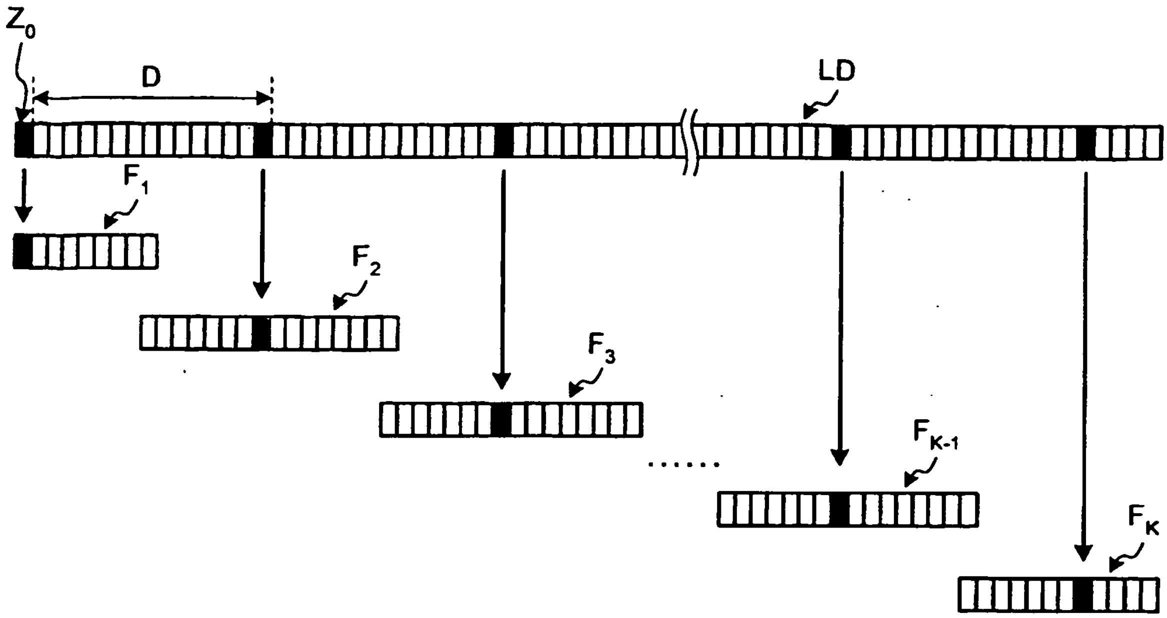
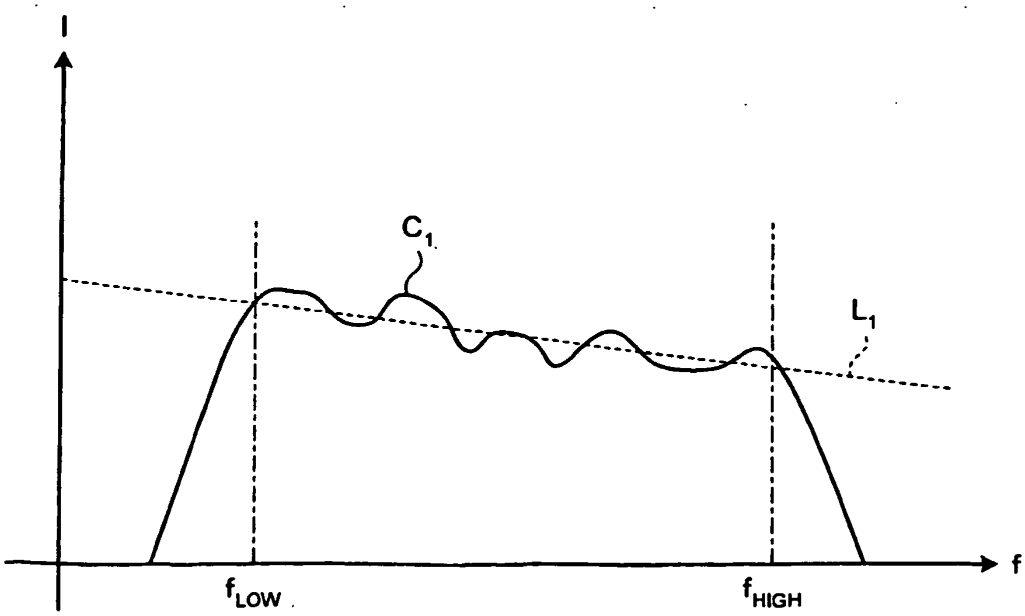
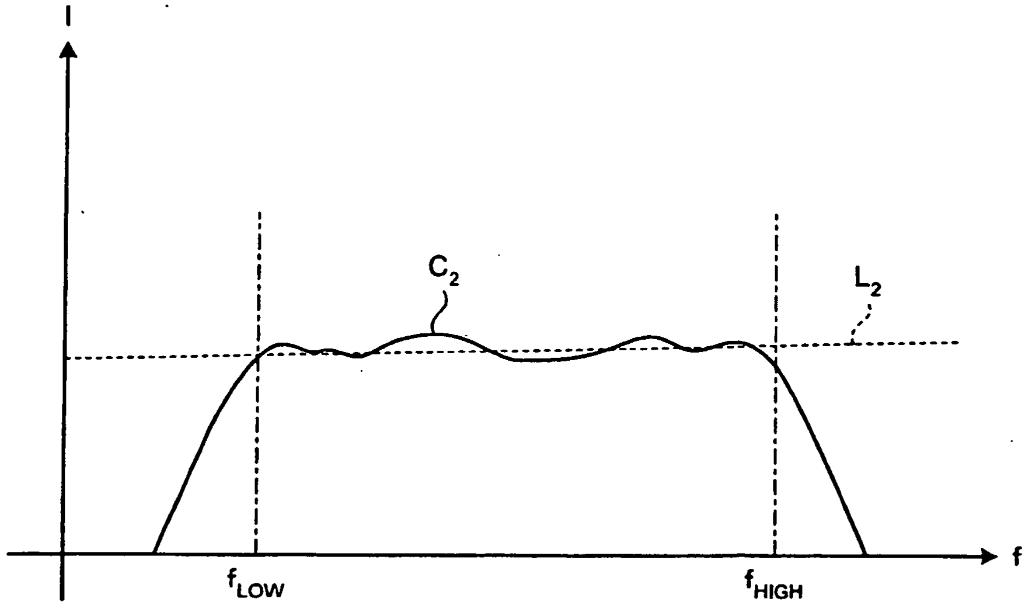



FIG.7



# FIG.8




# FIG.9

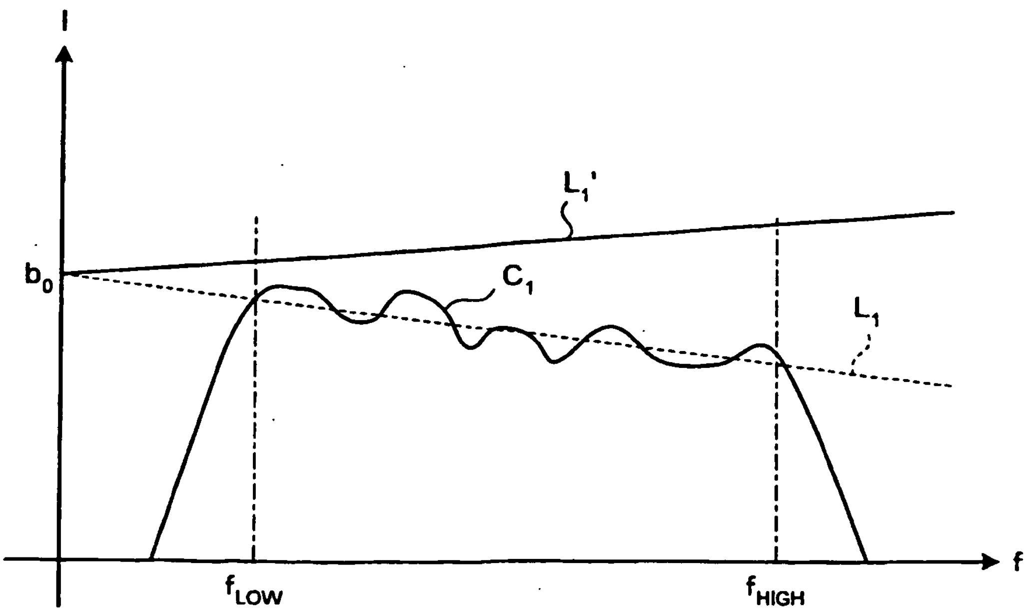


FIG.10

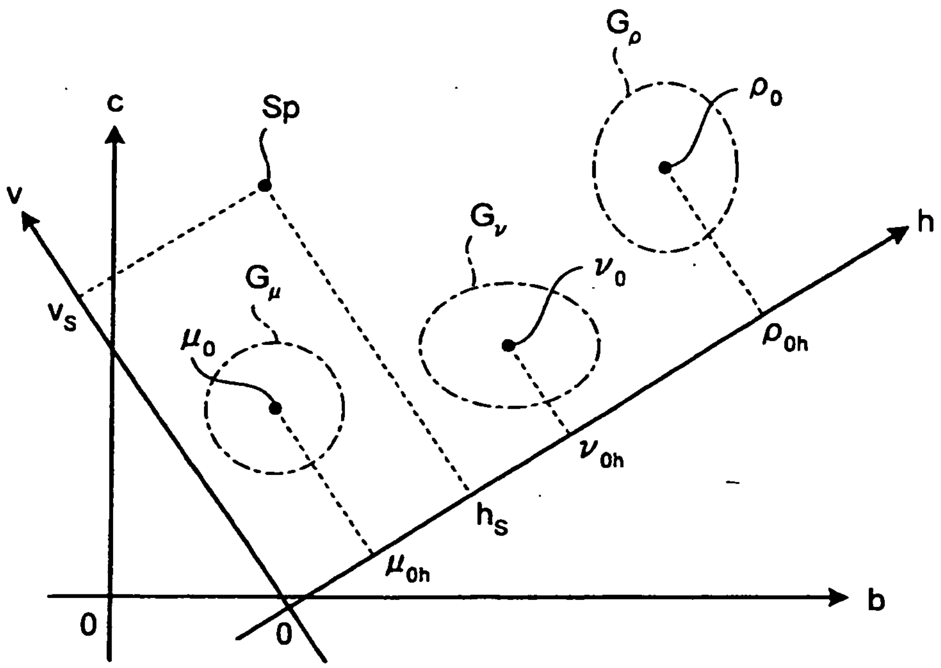


FIG.11

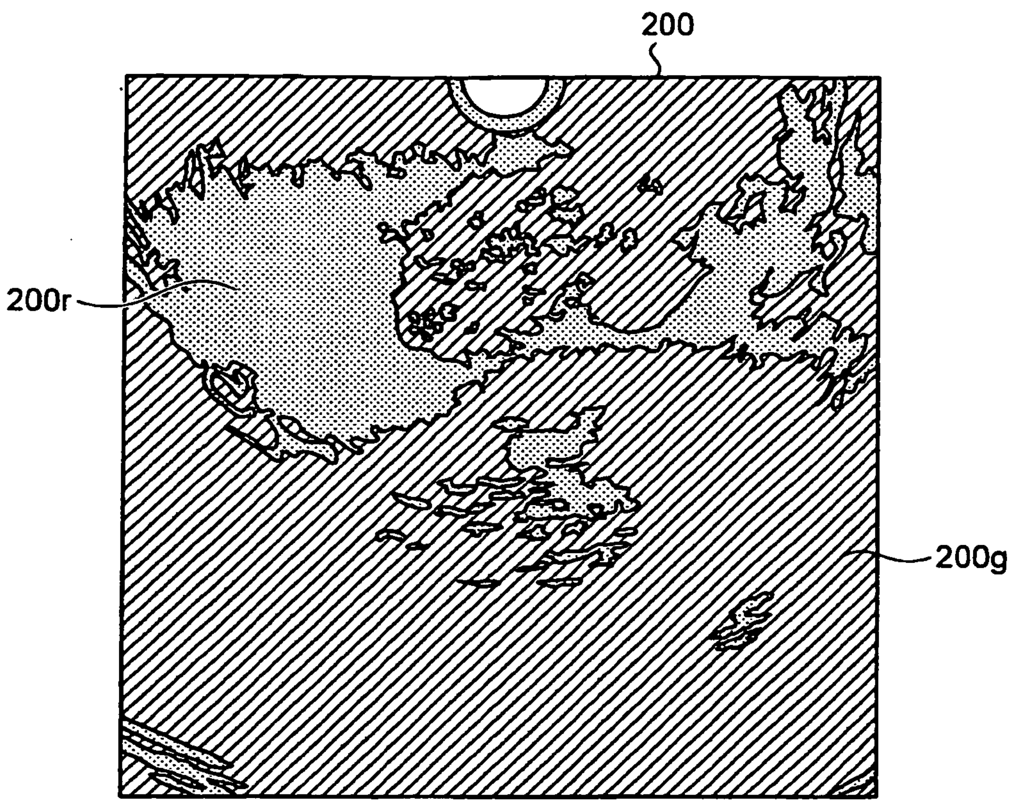


FIG.12

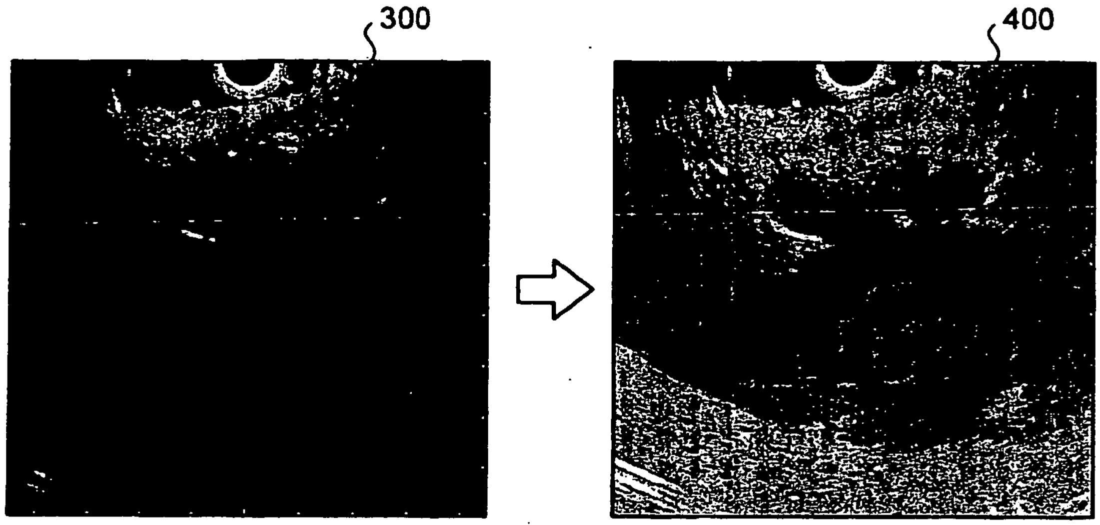


FIG.13

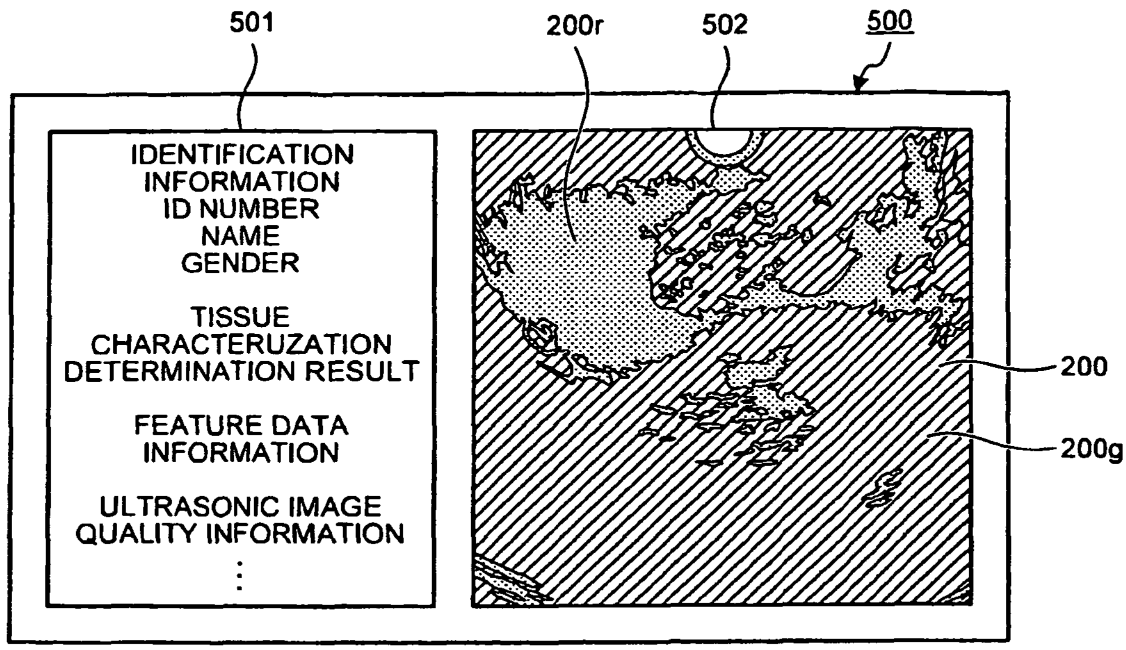

501
200r
502
500
IDENTIFICATION INFORMATION
ID NUMBER
NAME
GENDER
TISSUE CHARACTERUZATION DETERMINATION RESULT
FEATURE DATA INFORMATION
ULTRASONIC IMAGE QUALITY INFORMATION
⋮
200
200g

FIG.14

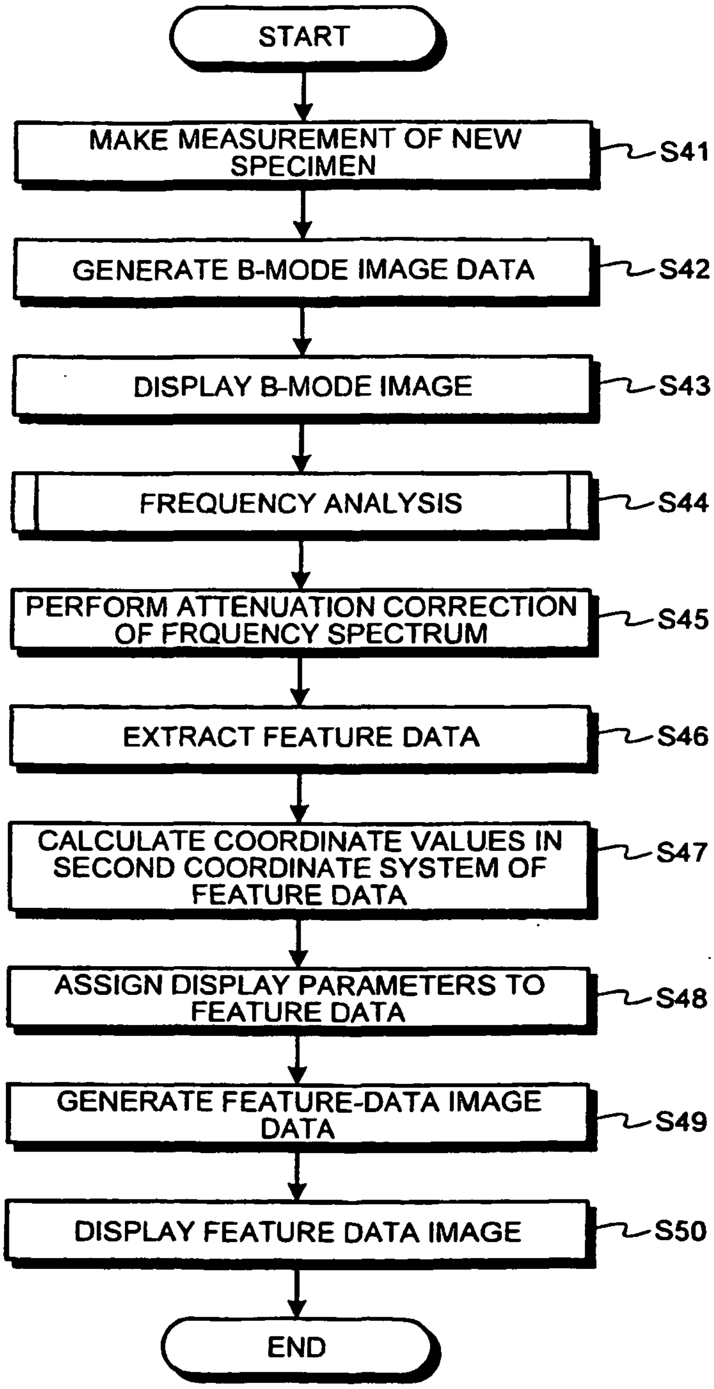

START
MAKE MEASUREMENT OF NEW SPECIMEN
S41
GENERATE B-MODE IMAGE DATA
S42
DISPLAY B-MODE IMAGE
S43
FREQUENCY ANALYSIS
S44
PERFORM ATTENUATION CORRECTION OF FRQUENCY SPECTRUM
S45
EXTRACT FEATURE DATA
S46
CALCULATE COORDINATE VALUES IN SECOND COORDINATE SYSTEM OF FEATURE DATA
S47
ASSIGN DISPLAY PARAMETERS TO FEATURE DATA
S48
GENERATE FEATURE-DATA IMAGE DATA
S49
DISPLAY FEATURE DATA IMAGE
S50
END

FIG.15

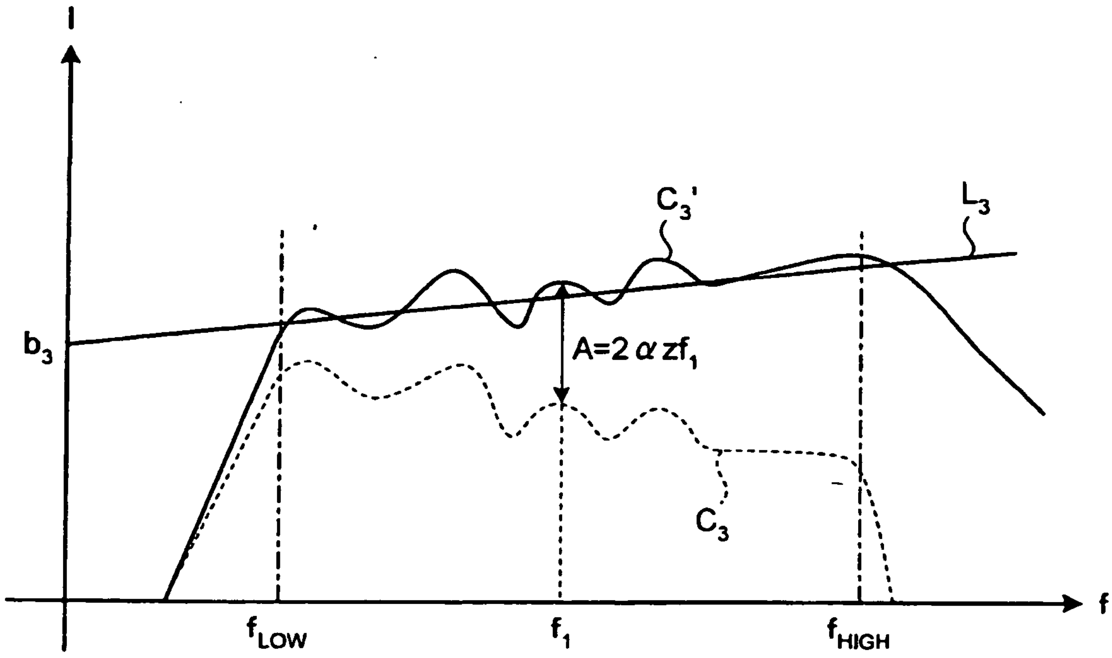
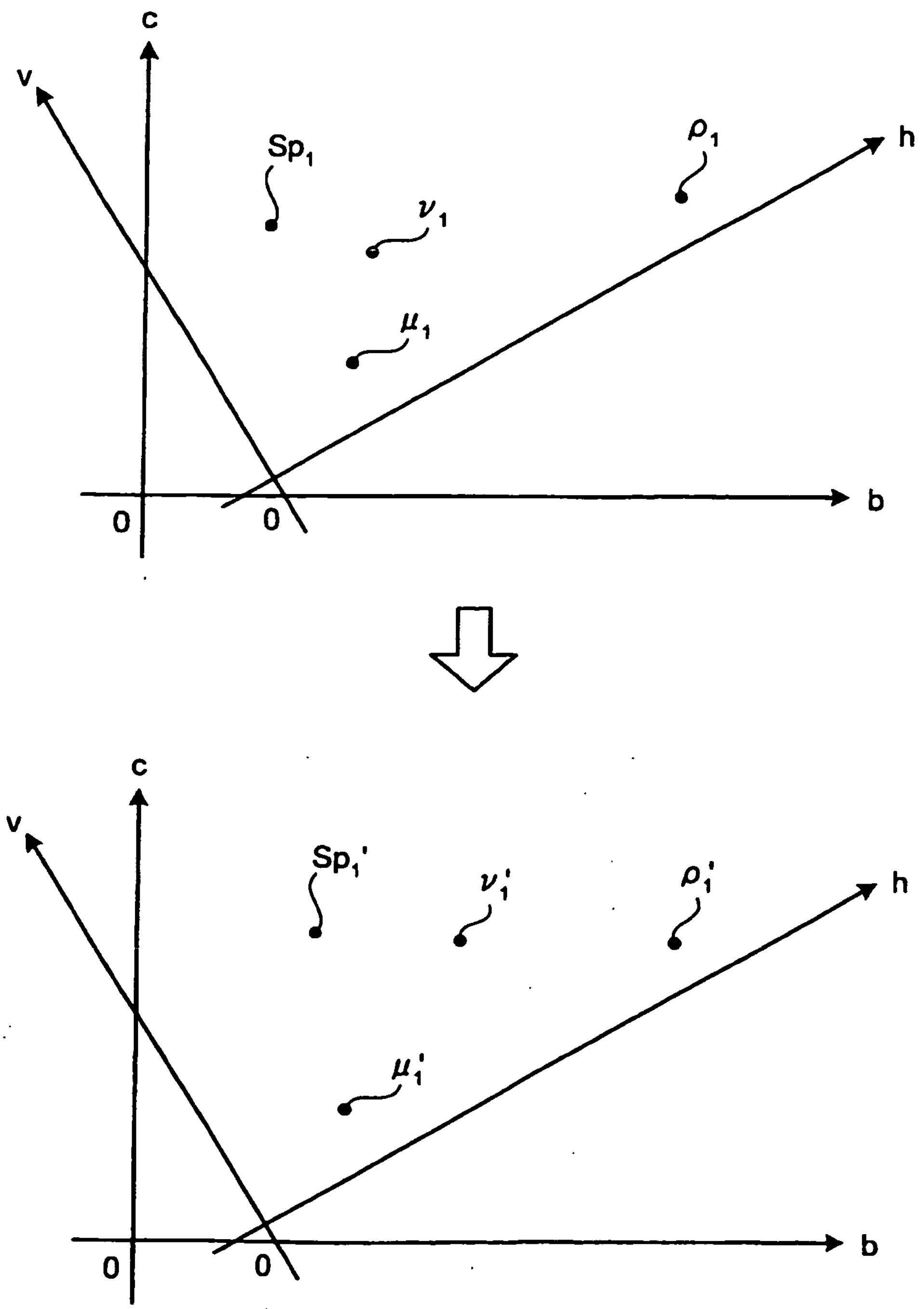


FIG.16



## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- WO 2005122906 A **[0003]**
- US 2007239007 A1 **[0024]**

| | | | |
|---|---|---|---|
| 专利名称(译) | 超声波观察装置及其操作方法和操作程序 | | |
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| 优先权 | 2010253288 2010-11-11 JP | | |
| 其他公开文献 | EP2548515A4<br>EP2548515A1 | | |
| 外部链接 | Espacenet | | |


摘要(译)

在包括第一坐标系的特征数据空间中，超声观察装置计算第二坐标系中的样本的特征数据的坐标值，该第一坐标系包含分别针对已知样本提取的至少一些特征数据集作为其坐标分量。分配对应于计算出的坐标值的显示参数，其中第二坐标系具有作为其坐标轴之一的新坐标轴，新坐标轴是相邻代表点之间的距离之和大的轴，代表点代表通过基于关于每个已知样本的信息对已知样本进行分类而获得的各个组，当在第一坐标系中沿预定坐标轴相邻的相邻代表点投影在预定轴上时获得距离。