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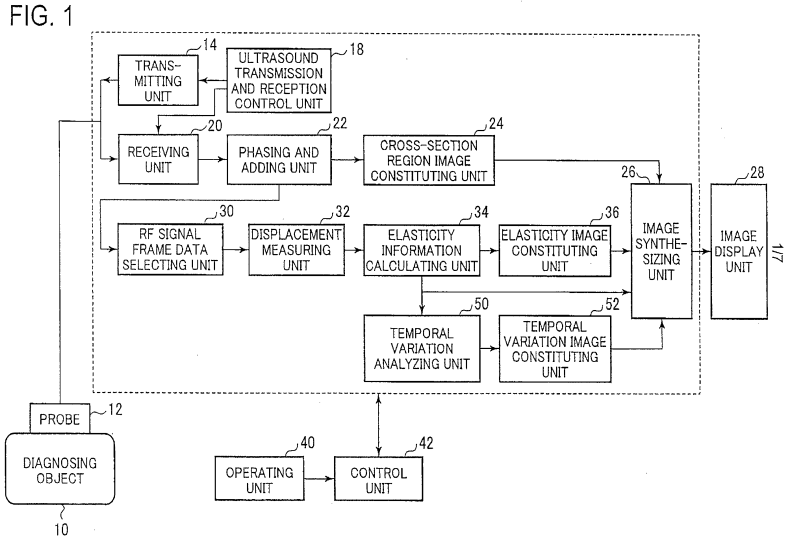
(54) ULTRASONIC DIAGNOSIS DEVICE AND IMAGE DISPLAY METHOD

(57) An ultrasonic diagnosis apparatus capable of calculating an index value of elasticity information at a stable measurement position without depending on an operator and an ultrasound measurement method are provided. The ultrasonic diagnosis apparatus including a cross-section region image constituting unit 24 configured to constitute a cross-section region image at a diagnosis portion of a diagnosing object through an ultrasound probe 12, an elasticity information calculating unit 34 configured to calculate elasticity information indicating hardness, an elasticity image constituting unit 36 configured to constitute an elasticity image based on the elasticity information calculated at the elasticity information calculating unit 34, and an image display unit 28 configured to display the cross-section region image and the elasticity image, includes a temporal variation analyzing unit 50 configured to analyze temporal variation at respective measurement points from the elasticity information calculated at the elasticity information calculating unit 34 and a temporal variation image constituting unit 52 configured to constitute a temporal variation image based on the temporal variation analyzed at the temporal variation analyzing unit, and the image display unit 28 displays the temporal variation image.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to an ultrasonic diagnosis apparatus which displays a cross-section region image inside a diagnosing object by utilizing an ultrasonic wave, and an image display method.

Background Art

[0002] An ultrasonic diagnosis apparatus transmits an ultrasonic wave to inside of a diagnosing object using an ultrasound probe, receives an ultrasound reflected echo signal according to a structure of biological tissue from the inside of the diagnosing object and constitutes and displays a cross-section region image of the inside of the diagnosing object.

[0003] Further, in the ultrasonic diagnosis apparatus, strain of tissue at a cross-section region portion of the diagnosing object is obtained, an elasticity image at the cross-section region portion is generated based on the strain and displayed on a display apparatus, a plurality of regions of interest are set in the cross-section region image displayed on the display apparatus or the elasticity image, elasticity information in each region of interest is indexed, and the index value is displayed at the display apparatus (see Patent Literature 1).

[0004] According to Patent Literature 1, it is possible to quantitatively evaluate hardness of biological tissue at a diagnosis portion.

Citation List

Patent Literature

[0005] Patent Literature 1: WO 06/013916

Summary of Invention

Technical Problem

[0006] However, since an operator manually sets a plurality of regions of interest in a cross-section region image or an elasticity image, the calculated index value of the elasticity information depends on settings by the operator. Further, the operator cannot confirm whether measurement is performed while regions of interest are set at stable measurement positions.

[0007] Therefore, an object of the present invention is to provide an ultrasonic diagnosis apparatus which can display a temporal variation image based on temporal variation of elasticity information and an image display method.

Solution to Problem

[0008] To solve the above-described problem, in an ultrasonic diagnosis apparatus comprising a cross-section region image constituting unit configured to constitute a cross-section region image at a diagnosis portion of a diagnosing object through an ultrasound probe, an elasticity information calculating unit configured to calculate elasticity information indicating hardness, an elasticity image constituting unit configured to constitute an elasticity image based on the elasticity information calculated at the elasticity information calculating unit, and an image display unit configured to display the cross-section region image and the elasticity image, the ultrasonic diagnosis apparatus includes a temporal variation analyzing unit configured to analyze temporal variation at respective measurement points from the elasticity information calculated at the elasticity information calculating unit, and a temporal variation image constituting unit configured to constitute a temporal variation image based on the temporal variation analyzed at the temporal variation analyzing unit, and the image display unit displays the temporal variation image.

[0009] Further, an image display method for displaying a cross-section region image and an elasticity image, includes a step of analyzing temporal variation at respective measurement points from elasticity information indicating hardness, a step of constituting a temporal variation image based on the temporal variation, and a step of displaying the temporal variation image.

Advantageous Effect of Invention

[0010] According to the present invention, it is possible to display a temporal variation image based on temporal

variation of elasticity information.

Brief Description of Drawings

[0011]

[Figure 1] Figure 1 is a block diagram illustrating a configuration of an ultrasonic diagnosis apparatus of the present invention.
[Figure 2] Figure 2 is a block diagram illustrating a configuration of a temporal variation analyzing unit of the present invention.
[Figure 3] Figure 3 is a diagram illustrating a display form of an image display unit of the present invention.
[Figure 4] Figure 4 is a diagram illustrating a display form of the image display unit of the present invention.
[Figure 5] Figure 5 is a flowchart illustrating operation of the present invention.
[Figure 6] Figure 6 is a block diagram illustrating a configuration of an ultrasonic diagnosis apparatus of the present invention.
[Figure 7] Figure 7 is a diagram illustrating a display form of the image display unit of the present invention.

Description of Embodiments

[0012] An ultrasonic diagnosis apparatus according to the present invention will be described below with reference to the drawings.

(First Embodiment)

[0013] Figure 1 is a block diagram illustrating an ultrasonic diagnosis apparatus according to a first embodiment of the present invention.

[0014] As illustrated in Figure 1, the ultrasonic diagnosis apparatus according to the present embodiment includes an ultrasound probe 12 used while being made to abut on a diagnosing object 10, a transmitting unit 14 configured to repeatedly transmit ultrasonic waves to the diagnosing object 10 through the ultrasound probe 12 at a time interval, a receiving unit 20 configured to receive time-series reflected echo signals generated at the diagnosing object 10, an ultrasonic wave transmission and reception control unit 18 configured to control the transmitting unit 14 and the receiving unit 20, a phasing and adding unit 22 configured to phase and add the received reflected echoes to generate RF signal frame data in a time-series manner, a cross-section region image constituting unit 24 configured to constitute a cross-section region image based on the RF signal frame data generated at the phasing and adding unit 22, an image synthesizing unit 26 configured to synthesize the cross-section region image, other images, numerical information, and the like, an image display unit 28 configured to display an image output from the image synthesizing unit 26, an RF signal frame data selecting unit 30 configured to select at least two pieces of RF signal frame data, a displacement measuring unit 32 configured to measure displacement of biological tissue of the diagnosing object 10 using the selected pieces of RF signal frame data, an elasticity information calculating unit 34 configured to obtain elasticity information from the displacement measured at the displacement measuring unit 32, an elasticity image constituting unit 36 configured to constitute an elasticity image from the elasticity information calculated at the elasticity information calculating unit 34, an operating unit 40 configured to allow an operator to perform operation, a control unit 42 configured to control respective components according to the operation at the operating unit 40, a temporal variation analyzing unit 50 configured to analyze temporal variation from the elasticity information calculated at the elasticity information calculating unit 34, and a temporal variation image constituting unit 52 configured to constitute a temporal variation image based on the temporal variation analyzed at the temporal variation analyzing unit 50. A dashed line illustrated in Figure 1 indicates a body of the ultrasonic diagnosis apparatus.

[0015] The ultrasound probe 12 which is formed so that a plurality of transducers are arranged, transmits and receives ultrasonic waves to and from the diagnosing object 10 with which the ultrasound probe 12 is brought into contact, through the transducers. The transmitting unit 14 generates a transmission pulse for driving the ultrasound probe 12 to generate ultrasonic waves and sets a convergence point of ultrasonic waves to be transmitted at certain depth, and repeatedly transmits the ultrasonic waves to the diagnosing object 10 through the ultrasound probe 12 at a time interval. The receiving unit 20 has a function of receiving time-series reflected echo signals generated from the diagnosing object 10 through the ultrasound probe 12 and amplifying the received reflected echo signals with a predetermined gain to generate an RF signal (received signal). The ultrasonic wave reception control unit 18 controls the transmitting unit 14 and the receiving unit 20 to transmit and receive ultrasonic waves to the diagnosing object 10 through the ultrasound probe 12. The phasing and adding unit 22 phases and adds the reflected echo signals received at the receiving unit 20. At this time, the phasing and adding unit 22 performs phase control on the RF signal amplified at the receiving unit 20 to form

an ultrasonic wave beam for one or a plurality of convergence points and generate time-series RF signal frame data which is ultrasonic wave cross-section region data.

[0016] The cross-section region image constituting unit 24 receives as input, data at a cross-section region portion of the diagnosing object 10, specifically, the RF signal frame data from the phasing and adding unit 22, performs signal processing such as gain correction, log compression, detection, contour enhancement and filtering processing to constitute cross-section region image data (for example, a monochrome gray-scale cross-section region image of the diagnosing object 10). Further, the cross-section region image constituting unit 24 is constituted to include an A/D converter configured to convert the cross-section region image data into a digital signal, a frame memory configured to store a plurality of pieces of converted cross-section region image data in a time-series manner, and a controller, which are not illustrated. The cross-section region image data of the inside of the diagnosing object 10 stored in the frame memory is acquired as one image, and the acquired cross-section region image data is read out in synchronization with TV.

[0017] The RF signal frame data selecting unit 30 stores the RF signal frame data output from the phasing and adding unit 22, and selects at least two pieces of (a pair of) RF signal frame data from the stored RF signal frame data group. For example, the RF signal frame data selecting unit 30 sequentially stores the RF signal frame data generated in a time-series manner from the phasing and adding unit 22, that is, based on a frame rate of an image, and selects the stored RF signal frame data (N) as first data, and selects one piece of RF signal frame data (X) from the RF signal frame data group (N-1, N-2, N-3, ..., N-M) stored temporally in the past. It should be noted that N, M and X are index numbers assigned to the respective pieces of the RF signal frame data and are natural numbers.

[0018] The displacement measuring unit 32 measures displacement of the biological tissue of the diagnosing object 10. To be specific, the displacement measuring unit 32 obtains a vector indicating the displacement at the biological tissue corresponding to the respective measurement points of the cross-section region image, that is, one-dimensional or two-dimensional displacement distribution regarding direction and magnitude of the displacement from the pair of data selected by the RF signal frame data selecting unit 30, that is, the RF signal frame data (N) and the RF signal frame data (X) by performing one-dimensional or two-dimensional correlation processing. Here, a block matching method or a phase gradient method is used to detect the vector. In the block matching method, the image is divided into blocks comprised of, for example, NxN pixels, attention is focused on a block within a predetermined region (for example, a parameter acquisition region which will be described later), a block most approximate to the block on which attention is focused in a current frame is searched from the previous frame, and predictive coding, that is, processing for determining a sample value using a difference is performed with reference to the block. By this means, a vector is detected by obtaining displacement at the respective measurement points of the cross-section region image. In the phase gradient method, a vector is detected by calculating a movement amount of a wave of the received signal from phase information of the wave and obtaining displacement at the respective measurement points of the cross-section region image.

[0019] A pressure measuring unit which is not illustrated, measures stress at measurement points inside the diagnosing object 10 based on pressure detected by a pressure sensor, or the like, provided between an ultrasonic wave transmission and reception face of the ultrasound probe 12 and the diagnosing object 10.

[0020] The elasticity information calculating unit 34 obtains strain or a modulus of elasticity of tissue at the cross-section region portion based on the ultrasound cross-section region data at the cross-section region portion of the diagnosing object 10. In the present embodiment, the elasticity information calculating unit 34 calculates strain or a modulus of elasticity of the biological tissue corresponding to the respective measurement points on the cross-section region image based on displacement information of the biological tissue measured at the displacement measuring unit 32, for example, a motion vector, using the RF signal frame data selected by the RF signal frame data selecting unit 30. It should be noted that when calculating the modulus of elasticity of the biological tissue, the elasticity information calculating unit 34 takes into account a pressure value output from the pressure measuring unit.

[0021] At this time, data of the strain is calculated by spatially differentiating a movement amount, for example, displacement of the biological tissue. Further, data of the modulus of elasticity is calculated by dividing change of the pressure by change of the strain. For example, given that the displacement measured by the displacement measuring unit 32 is L(X) and the pressure measured by the pressure measuring unit is P(X), because strain $\Delta S(X)$ can be calculated by spatially differentiating L(X), strain $\Delta S(X)$ can be obtained using an equation of $\Delta S(X) = \Delta L(X)/\Delta X$.

[0022] Further, a Young's modulus Ym(X) of the data of the modulus of elasticity can be obtained using an equation of $Ym = \Delta P(X)/\Delta S(X)$. Because the modulus of elasticity of the biological tissue corresponding to the respective measurement points of the cross-section region image can be obtained from this Young's modulus Ym, two-dimensional elasticity image data can be continuously obtained. It should be noted that the Young's modulus is a ratio of simple tensile stress applied to an object with respect to strain occurring in parallel to tension.

[0023] The elasticity image constituting unit 36 constitutes an elasticity image at the cross-section region portion based on the elasticity information obtained at the elasticity information calculating unit 34. The elasticity image constituting unit 36 which is constituted to include a frame memory and an image processing unit, stores the elasticity frame data in the frame memory, and performs image processing on the stored frame data.

[0024] Further, the elasticity image constituting unit 36 has a function of providing hue information to the elasticity

frame data, and converts the elasticity frame data into image data to which red (R), green (G) and blue (B) which are the three primary colors of light, are provided based on the elasticity frame data. For example, the elasticity image constituting unit 36 converts elasticity data including large strain into a red code, and converts elasticity data including small strain into a blue code.

[0025] The temporal variation analyzing unit 50 analyzes temporal variation at the respective measurement points (respective pixels) from the elasticity information calculated at the elasticity information calculating unit 34. The temporal variation analyzing unit 50 analyzes temporal variation at the respective measurement points from a plurality of frames of the elasticity information and calculates a measurement point at which temporal variation is greater than a threshold. The measurement point at which temporal variation is great is a measurement point where an index value of the elasticity information between the plurality of frames of the elasticity information is not stable (varies), and is a measurement point at which measurement cannot be performed using the index value of the elasticity information. The index value of the elasticity information is a value indexed using a ratio of the elasticity information, difference of the elasticity information, or the like.

[0026] The temporal variation image constituting unit 52 constitutes a temporal variation image indicating a degree of temporal variation based on the temporal variation analyzed at the temporal variation analyzing unit 50. The temporal variation image constituting unit 52 constitutes a temporal variation image for a measurement point at which temporal variation is greater than the threshold, while not constituting a temporal variation image for a measurement point at which temporal variation is smaller than the threshold.

[0027] The image synthesizing unit 26 which is constituted to include a frame memory, an image processing unit and an image selecting unit, creates a synthetic image of the cross-section region image and the elasticity image and a synthesis image of the cross-section region image and the temporal variation image using a method typified by α blending. The frame memory stores the cross-section region image data from the cross-section region image constituting unit 24, the elasticity image data from the elasticity image constituting unit 36 and the temporal variation image data from the temporal variation image constituting unit 52.

[0028] Further, the image processing unit synthesizes the cross-section region image data and the elasticity image data stored in the frame memory while changing a synthesis ratio, and synthesizes the cross-section region image data and the temporal variation image data stored in the frame memory while changing a synthesis ratio. Brightness information and hue information of each pixel of the synthetic images are obtained by adding respective information of the images to be synthesized at the respective synthesis ratios. Further, the image selecting unit selects an image to be displayed among the cross-section region image data, the elasticity image data and the temporal variation image data within the frame memory, and the synthetic image data in the image processing unit, and makes the image display unit 28 display the selected image.

[0029] It should be noted that the image synthesizing unit 26 is controlled by the control unit 42 based on image display conditions, or the like, set through the operating unit 40. The operating unit 40 includes operation devices such as a mouse, a keyboard, a track ball, a touch pen and a joystick, and can set the image display conditions, or the like.

[0030] The image display unit 28 displays the cross-section region image, the elasticity image, the temporal variation image, or the like, selected by the image selecting unit of the image synthesizing unit 26.

[0031] Here, the temporal variation analyzing unit 50 will be described using Figure 2. The temporal variation analyzing unit 50 has an elasticity information frame storing unit 60 configured to store a plurality of frames of the elasticity information, and a temporal variation calculating unit 62 configured to calculate temporal variation from the plurality of frames of the elasticity information.

[0032] The elasticity information calculating unit 34 obtains strain of the tissue at the respective measurement points at the cross-section region portion or the elasticity information of the modulus of elasticity for each frame based on the ultrasound cross-section region data of the cross-section region portion of the diagnosing object 10. The elasticity information frame storing unit 60 stores a plurality of frames of the elasticity information, for example, the elasticity information of ten frames, output from the elasticity information calculating unit 34. The number of frames stored in the elasticity information frame storing unit 60 can be set arbitrarily through the operating unit 40.

[0033] The number of frames to be stored in the elasticity information frame storing unit 60 can be also set in accordance with a compression cycle of the ultrasound probe 12. When the number of frames is set in accordance with the compression cycle of the ultrasound probe 12, the elasticity information frame storing unit 60 stores frames of the elasticity information corresponding to one cycle of compression.

[0034] Further, there is a method for deforming tissue using ultrasonic radiation pressure and measuring elasticity information from the displacement. The number of frames to be stored in the elasticity information frame storing unit 60 can be also set in accordance with exposure time of ultrasonic radiation pressure. When the number of frames is set in accordance with the exposure time of the ultrasonic radiation pressure, the elasticity information frame storing unit 60 stores frames of the elastic information being irradiated with ultrasound radiation pressure.

[0035] A calculation method of the temporal variation calculating unit 62 will be described using Figure 3. As illustrated in the left side of Figure 3, the image display unit 28 displays a synthetic image of the cross-section region image and

the elasticity image. It should be noted that the image display unit 28 may display only the cross-section region image.

[0036] In the synthetic image of the cross-section region image and the elasticity image, in addition to normal tissue 70 and tumor tissue 72 which are morphologic information in the cross-section region image, sclerotic tissue 74 which is hardness information in the elasticity information is displayed while being superimposed on the tumor tissue 72 in the cross-section region image. Given that the tumor tissue 72 is displayed in black and the sclerotic tissue 74 is displayed in blue, a portion where the tumor tissue 72 is superimposed on the sclerotic tissue 74 is displayed in deep blue. The operator can observe a portion displayed in deep blue as a portion which is likely to be a malignant tumor.

[0037] The operator sets a region including the tumor tissue 72 as a region of interest 80 using the operating unit 40. Measurement points 82 are respectively set at respective measurement points (X1 to Xn, Y1 to Yn) in the synthetic image of the cross-section region image and the elasticity image. n is a natural number. The region of interest 80 is a region on which the operator focuses attention and is a region which is a target of comparison for a ratio of the elasticity information.

[0038] It is possible to make the region of interest 80 set at the operating unit 40 correspond to the plurality of frames of the elasticity information stored in the elasticity information frame storing unit 60. That is, it is possible to make a coordinate of the region of interest 80 set at the operating unit 40 correspond to coordinates of the plurality of frames of the elasticity information stored in the elasticity information frame storing unit 60. Therefore, the region of interest is set at the same position as the positions of the plurality of frames of the elasticity information.

[0039] The temporal variation calculating unit 62 makes the region of interest 80 set in the synthetic image of the cross-section region image and the elasticity image correspond to the plurality of frames of the elasticity information stored in the elasticity information frame storing unit 60. Then, the temporal variation calculating unit 62 respectively calculates the region of interest 80 set in the synthetic image of the cross-section region image and the elasticity image and the index value of the elasticity information at the respective measurement points 82 in the plurality of frames of the elasticity information. Here, description will be provided using an example of a ratio of the elasticity information as an index value of the elasticity information. The temporal variation calculating unit 62 calculates temporal variation at the respective measurement points based on the ratio of the elasticity information.

[0040] As illustrated in the lower side of Figure. 3, the image display unit 28 can also display temporal change of the ratio of the elasticity information at the respective measurement points using a graph. Here, description will be provided using an example of strain which is the elasticity information. The strain of the region of interest 80 is ε_1, and the strain at the measurement points 82 is ε_2. The strain ε_1 of the region of interest 80 and the strain ε_2 of the measurement points 82 are respectively average values of the strain in the respective regions. The temporal variation calculating unit 62 calculates a ratio of strain $\varepsilon_2/\varepsilon_1$ (ε_{ratio}). The ratio of strain $\varepsilon_2/\varepsilon_1$ calculated at the temporal variation calculating unit 62 is displayed at the image display unit 28 along with the time. It should be noted that while description has been provided using an example of the strain of the elasticity information, parameters such as displacement, a modulus of elasticity and viscosity may be used.

[0041] Here, the temporal variation calculating unit 62 calculates variation of the index value of the elasticity information (ratio of the elasticity information) at the respective measurement points in the plurality of frames of the elasticity information. The temporal variation calculating unit 62 calculates a difference D1 between an upper limit value and a lower limit value of the ratio of the elasticity information at the respective measurement points in the plurality of frames of the elasticity information. When the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is greater than a predefined threshold Th1, the temporal variation calculating unit 62 calculates that the temporal variation is great. When the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is smaller than the predefined threshold Th1, the temporal variation calculating unit 62 calculates that the temporal variation is small.

[0042] Specifically, at the measurement points (X1, Y1), the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is smaller than the predefined threshold Th1, and variation of the ratio of the elasticity information is small. The temporal variation calculating unit 62 calculates that the measurement points (X1, Y1) are measurement points at which temporal variation is small. At the measurement points (X2, Y2), the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is greater than the predefined threshold Th1, and variation of the ratio of the elasticity information is great. The temporal variation calculating unit 62 calculates that the measurement points (X2, Y2) are measurement points at which temporal variation is great. In this way, the temporal variation calculating unit 62 compares the difference between the upper limit value and the lower limit value of the ratio of the elasticity information at the respective measurement points (X1 to Xn, Y1 to Yn) in the synthetic image of the cross-section region image and the elasticity image with the predefined threshold Th1 to calculate variation of the ratio of the elasticity information at the respective measurement points.

[0043] While the temporal variation calculating unit 62 calculates temporal variation using the difference between the upper limit value and the lower limit value of the ratio of the elasticity information at the respective measurement points, the temporal variation may be obtained using the following equation which uses standard deviation of the elasticity information in a time direction at the respective measurement points.

[Equation 1]

$$\partial_{xy\square} = \sqrt{\frac{\sum_{t=1}^{T}\left(\varepsilon_{ratioxy}(t) - \bar{\varepsilon}_{ratioxy}\right)^2}{T}}$$

$\partial_{xy\square}$: time standard deviation at the respective measurement point

$\varepsilon_{ratioxy}$: a ratio of elasticity information at the respective measurement point

$\bar{\varepsilon}_{ratioxy}$ time average of a ratio of elasticity information at the respective measurement point

T : time or frame

[0044] Further, the temporal variation calculating unit 62 can use variance, a coefficient of variation, or the like, in place of the above. The temporal variation calculating unit 62 calculates temporal variation based on magnitude of dispersion of the elasticity information or calculates temporal variation based on magnitude of a coefficient of variation of the elasticity information.

[0045] As illustrated in the right side of Figure 3, the temporal variation image constituting unit 52 constitutes a temporal variation image 86 indicating that temporal variation is greater than the threshold for the measurement point at which temporal variation analyzed at the temporal variation analyzing unit 50 is greater than the threshold. Specifically, the temporal variation image constituting unit 52 constitutes the temporal variation image 86 based on a temporal variation display bar 84 where measurement points at which temporal variation is greater than the threshold are identified.

[0046] The temporal variation display bar 84 is set so as to display the temporal variation image for the measurement points at which temporal variation is great. For example, the temporal variation display bar 84 is set so as to display the temporal variation image when the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is greater than the predefined threshold Th1 and not to display the temporal variation image when the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is smaller than the predefined threshold Th1.

[0047] That is, when the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is greater than the predefined threshold Th1, the temporal variation image constituting unit 52 constitutes a temporal variation image and makes the image display unit 28 display the temporal variation image. When the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is smaller than the predefined threshold Th1, the temporal variation image constituting unit 52 does not constitute a temporal variation image.

[0048] As illustrated in the right side of Figure 3, the image display unit 28 displays a synthetic image of the cross-section region image and the temporal variation image. The operator can confirm that a region in which the temporal variation image is displayed is a region where there is temporal variation.

[0049] Another calculation method at the temporal variation calculating unit 62 will be described using Figure 4. As illustrated in the left side of Figure 4, the image display unit 28 displays a synthetic image of the cross-section region image and the elasticity image.

[0050] The operator sets a region of interest 90 using the operating unit 40. When the region of interest 90 is set, in the synthetic image of the cross-section region image and the elasticity image, in addition to the normal tissue 70 and the tumor tissue 72 which are morphologic information in the cross-section region image, sclerotic tissue 74 which is hardness information in the elasticity information is displayed while being superimposed on the tumor tissue 72 in the cross-section region image.

[0051] Measurement points 82 are respectively set at respective measurement points (Xa to Xm, Ya to Ym) in the region of interest 90 of the synthetic image of the cross-section region image and the elasticity image. a and m are natural numbers, and a<m.

[0052] The temporal variation calculating unit 62 calculates elasticity information in the set region of interest 90 and the measurement points 82 in a plurality of frames of the elasticity information stored in the elasticity information frame storing unit 60. The temporal variation calculating unit 62 calculates temporal variation at the respective measuring points based on displacement of the elasticity information.

[0053] As illustrated in the lower side of Figure 4, the image display unit 28 can also display the displacement of the elasticity information at the respective measurement points using a graph. Here, strain which is the elasticity information will be described as an example. The strain of the measurement points 82 is ε_3. At the image display unit 28, the strain ε_3 calculated at the temporal variation calculating unit 62 is displayed along with time. It should be noted that while an example of the strain of the elasticity information has been described, parameters such as displacement, a modulus of elasticity and viscosity may be used.

[0054] Here, the temporal variation calculating unit 62 calculates variation of the elasticity information at the respective

measurement points in the plurality of frames of the elasticity information. The temporal variation calculating unit 62 calculates displacement D2 of the elasticity information at the respective measurement points in the plurality of frames of the elasticity information. When the displacement D2 of the elasticity information is greater than a predefined threshold Th2, the temporal variation calculating unit 62 calculates that temporal variation is great. When the displacement D2 of the elasticity information is smaller than the predefined threshold Th2, the temporal variation calculating unit 62 calculates that temporal variation is small.

[0055] Specifically, at the measurement points (X3, Y3), the displacement D2 of the elasticity information is smaller than the predefined threshold Th2, and the variation of the elasticity information is small. The temporal variation calculating unit 62 calculates that the measurement points (X3, Y3) are measurement points at which temporal variation is small. At the measurement points (X4, Y4), the displacement D2 of the elasticity information is greater than the predefined threshold Th2, and the variation of the elasticity information is great. The temporal variation calculating unit 62 calculates that the measurement points (X4, Y4) are measurement points at which temporal variation is great. In this way, the temporal variation calculating unit 62 compares the displacement of the elasticity information at the respective measurement points (Xa to Xm, Ya to Ym) in the region of interest 90 which is a display region of the elasticity image with the predefined threshold Th2 to calculate variation of the elasticity information at the respective measurement points.

[0056] As illustrated in the right side of Figure 4, the temporal variation image constituting unit 52 constitutes a temporal variation image 96 indicating that the temporal variation is great for the measurement points at which the temporal variation analyzed at the temporal variation analyzing unit 50 is great. A display region 92 for displaying the temporal variation image 96 is the same region as the region of interest 90 which is displayed as the display region of the elasticity image.

[0057] Specifically, the temporal variation image constituting unit 52 constitutes the temporal variation image 96 based on a temporal variation display bar 94 where the measurement points at which the temporal variation is great are identified. The temporal variation display bar 94 is set so as to display the temporal variation image for the measurement points at which the temporal variation is great.

[0058] As illustrated in the right side of Figure 4, the image display unit 28 displays a synthetic image of the cross-section region image and the temporal variation image. The operator can confirm that a region where the temporal variation image is displayed is a region where there is temporal variation.

[0059] Therefore, because the operator can recognize that the region where the temporal variation image is displayed is a region where there is temporal variation, the elasticity information calculating unit 34 can calculate an index value of the elasticity information in a region other than the region where the temporal variation image is displayed in the plurality of frames of the elasticity information stored in the elasticity information frame storing unit 60. Therefore, if the operator sets a region other than the region where the temporal variation image is displayed as a region of interest for which an index value of the elasticity information is calculated, it is possible to calculate an index value of the elasticity information without being affected by temporal variation. That is, it is possible to calculate an index value of the elasticity information at a stable measurement position.

[0060] It should be noted that when the temporal variation image is equal to or greater than a predetermined region (for example, equal to or greater than half of a screen) and it is inappropriate that the elasticity information calculating unit 34 calculates an index value of the elasticity information, the control unit 42 makes the image display unit 28 display an alarm for shooting an image again. When an image is shot again and the temporal variation image is smaller than the predetermined region (for example, smaller than the half of the screen), the control unit 42 regards that the elasticity image become stable, and the elasticity information calculating unit 34 calculates an index value of the elasticity information. The temporal variation image constituting unit 52 can also constitute a temporal variation image at the time when the image is shot again and make the image display unit 28 display the updated temporal variation image.

[0061] Operation of the present embodiment will be described next using Figure 5.

[0062] (S100) The image display unit 28 displays a synthetic image of the cross-section region image constituted by the cross-section region image constituting unit 24 and the elasticity image based on strain or a modulus of elasticity, constituted by the elasticity image constituting unit 36.

[0063] (S102) It is selected whether or not an index value of the elasticity information is calculated at a predetermined measurement position on the synthetic image of the cross-section region image and the elasticity image. When the index value of the elasticity information is calculated, the flow proceeds to S104. When the index value of the elasticity information is not calculated, the flow ends.

[0064] (S104) The region of interest 80 is set using the operating unit 40. The region of interest 90 may be set as the display region of the elasticity image.

[0065] (S106) The temporal variation analyzing unit 50 calculates an index value or displacement of the elasticity information at the set region of interest and measurement points in the plurality of frames of the elasticity information. The temporal variation analyzing unit 50 compares the index value or the displacement of the elasticity information with a predefined threshold to calculate variation of the elasticity information at the respective measurement points.

[0066] (S108) The temporal variation image constituting unit 52 constitutes temporal variation images 86 and 96

indicating that the temporal variation is great for the measurement points at which the temporal variation analyzed at the temporal variation analyzing unit 50 is great.

[0067] (S110) The operator sets a region other than the region where the temporal variation image is displayed as a region of interest for which an index value of the elasticity information is calculated, and the elasticity information calculating unit 34 calculates an index value of the elasticity information.

[0068] It should be noted that the region of interest for which an index value of the elasticity information is calculated can be automatically set in a region other than the region where the temporal variation image is displayed. Specifically, the control unit 42 recognizes the region where the temporal variation image is displayed and sets a region other than the region where the temporal variation image is displayed as the region of interest. The control unit 42 sets sclerotic tissue 74 which is hardness information in the elasticity image in a region other than the region where the temporal variation image is displayed as a first region of interest, and sets a region other than the sclerotic tissue 74 and other than the region where the temporal variation image is displayed as a second region of interest. The elasticity information calculating unit 34 calculates an index value of the elasticity information (for example, a ratio of the elasticity information) in the first region of interest and the second region of interest set by the control unit 42 in the plurality of frames of the elasticity information stored in the elasticity information frame storing unit 60. The index value of the elasticity information calculated by the elasticity information calculating unit 34 is displayed at the image display unit 28 through the image synthesizing unit 26.

[0069] Further, the first region of interest and the second region of interest are set in advance through the operating unit 40, and when the temporal variation image constituted by the temporal variation image constituting unit 52 is superimposed on the first region of interest and the second region of interest, the elasticity information calculating unit 34 does not calculate an index value of the elasticity information in the first region of interest and the second region of interest. The control unit 42 makes the image display unit 28 display an alarm for shooting an image again. When the temporal variation image constituted by the temporal variation image constituting unit 52 is not superimposed on the first region of interest and the second region of interest, the elasticity information calculating unit 34 calculates an index value of the elasticity information in the first region of interest and the second region of interest. The index value of the elasticity information calculated by the elasticity information calculating unit 34 is displayed at the image display unit 28 through the image synthesizing unit 26.

[0070] As described above, according to the present embodiment, the ultrasonic diagnosis apparatus including the cross-section region image constituting unit 24 configured to constitute a cross-section region image of a diagnosis portion of the diagnosing object through the ultrasound probe 12, the elasticity information calculating unit 34 configured to calculate the elasticity information indicating hardness, the elasticity image constituting unit 36 configured to constitute the elasticity image based on the elasticity information calculated at the elasticity information calculating unit 34, and the image display unit 28 configured to display the cross-section region image and the elasticity image, further includes the temporal variation analyzing unit 50 configured to analyze temporal variation at the respective measurement points from the elasticity information calculated at the elasticity information calculating unit 34 and the temporal variation image constituting unit 52 configured to constitute a temporal variation image based on the temporal variation analyzed at the temporal variation analyzing unit, and the image display unit 28 displays the temporal variation image.

[0071] It is therefore possible to display the temporal variation image based on the temporal variation of the elasticity information. Further, it is possible to calculate an index value of the elasticity information at a stable measurement position in a region other than the region where the temporal variation image is displayed. That is, it is possible to calculate an index value of the elasticity information at a stable measurement position without depending on the operator.

(Second Embodiment)

[0072] A second embodiment will be described using Figure 6 and Figure 7. As illustrated in Figure 6, the second embodiment is different from the first embodiment in that a calculation time setting unit 100 for setting a calculation time during which an index value of the elasticity information is calculated by the elasticity information calculating unit 34 is provided.

[0073] As illustrated in Figure 7, the temporal variation calculating unit 62 of the temporal variation analyzing unit 50 calculates variation of the index value of the elasticity information (ratio of the elasticity information) at the respective measurement points in the plurality of frames of the elasticity information as described in the first embodiment.

[0074] As illustrated in Figure 3, at the measurement points (X2, Y2), the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is greater than the predefined threshold Th1, and the variation of the ratio of the elasticity information is great. While the temporal variation calculating unit 62 calculates that the measurement points (X2, Y2) are measurement points at which the temporal variation is great, the index value is stable in a time period between time t1 and time t2. The time period between time t1 and time t2 during which the index value is stable is a time period during which the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is smaller than the predefined threshold Th1.

[0075] As illustrated in Figure 7, the time period 110 between time t1 and time t2 is a time period during which the difference D1 between the upper limit value and the lower limit value of the ratio of the elasticity information is smaller than the predefined threshold Th1. That is, the time period 110 between time t1 and time t2 can be regarded as a time period during which the index value is stable. Therefore, the calculation time setting unit 100 selects the time period between time t1 and time t2 during which the index value is stable and sets the time period 110 between the time t1 and time t2 during which the index value is stable as calculation time of the calculation time setting unit 100. The image display unit 28 displays the time period 110 between time t1 and time t2 during which the index value is stable.

[0076] The elasticity information calculating unit 34 calculates an index value of the elasticity information in the time period 110 between time t1 and time t2 set by the calculation time setting unit 100. It is also possible to select a plurality of frames from the time period between time t1 and time t2 and calculate an index value of the elasticity information in the selected frames 112. The image display unit 28 displays the selected frames 112.

[0077] The elasticity information calculating unit 34 can calculate an index value of the elasticity information according to the number of frames if the number of frames to be selected from the time period between time t1 and time t2 is determined in advance. For example, if the number of frames is set at ten, it is possible to select ten frames from the time period between time t1 and time t2, and the elasticity information calculating unit 34 can calculate an index value of the elasticity information from the selected ten frames.

[0078] According to the present embodiment, it is possible to calculate an index value of the elasticity information at a stable measurement position in a region other than the region where the temporal variation image is displayed and during the time period during which an index value is stable. That is, it is possible to calculate an index value of the elasticity information at a stable measurement position without depending on the operator.

Reference Signs List

[0079]

10 Diagnosing object
12 Ultrasound probe
14 Transmitting unit
18 Ultrasound transmission and reception control unit
20 Receiving unit
22 Phasing and adding unit
24 Cross-section region image constituting unit
26 Image synthesizing unit
28 Image display unit
30 RF signal frame data selecting unit
32 Displacement measuring unit
34 Elasticity information calculating unit
36 Elasticity image constituting unit
40 Operating unit
42 Control unit
50 Temporal variation analyzing unit
52 Temporal variation image constituting unit
60 Elasticity information frame storing unit
62 Temporal variation calculating unit

Claims

1. An ultrasonic diagnosis apparatus comprising a cross-section region image constituting unit configured to constitute a cross-section region image of a diagnosis portion of a diagnosing object through an ultrasound probe, an elasticity information calculating unit configured to calculate elasticity information indicating hardness, an elasticity image constituting unit configured to constitute an elasticity image based on the elasticity information calculated at the elasticity information calculating unit, and an image display unit configured to display the cross-section region image and the elasticity image, the ultrasonic diagnosis apparatus comprising:

a temporal variation analyzing unit configured to analyze temporal variation at respective measurement points from the elasticity information calculated at the elasticity information calculating unit; and
a temporal variation image constituting unit configured to constitute a temporal variation image based on the

temporal variation analyzed at the temporal variation analyzing unit, wherein the image display unit displays the temporal variation image.

2. The ultrasonic diagnosis apparatus according to claim 1, wherein the temporal variation image constituting unit constitutes the temporal variation image for a measurement point at which the temporal variation is greater than a threshold, and does not constitute the temporal variation image for a measurement point at which the temporal variation is smaller than the threshold.

3. The ultrasonic diagnosis apparatus according to claim 1, wherein the temporal variation analyzing unit comprises:

an elasticity information frame storing unit configured to store a plurality of frames of elasticity information; and a temporal variation calculating unit configured to calculate temporal variation from the plurality of frames of the elasticity information.

4. The ultrasonic diagnosis apparatus according to claim 3, wherein the temporal variation calculating unit calculates the temporal variation using any one of a ratio, a difference, standard deviation, dispersion and a coefficient of variation of the elasticity information.

5. The ultrasonic diagnosis apparatus according to claim 3, wherein the temporal variation calculating unit calculates an index value of the elasticity information at a region of interest and respective measurement points set in a synthetic image of the cross-section region image and the elasticity image in the plurality of frames of the elasticity information and calculates variation of the index value of the elasticity information at the respective measurement points.

6. The ultrasonic diagnosis apparatus according to claim 3, wherein the temporal variation calculating unit calculates a difference between an upper limit value and a lower limit value of a ratio of the elasticity information at the respective measurement points in the plurality of frames of the elasticity information, and, when the difference between the upper limit value and the lower limit value of the ratio of the elasticity information is greater than a predefined threshold, calculates that temporal variation is great.

7. The ultrasonic diagnosis apparatus according to claim 3, wherein, when the difference between the upper limit value and the lower limit value of the ratio of the elasticity information is greater than the predefined threshold, the temporal variation image constituting unit constitutes the temporal variation image and makes the image display unit display the temporal variation image.

8. The ultrasonic diagnosis apparatus according to claim 3, wherein, when displacement of the elasticity information is greater than a predefined threshold, the temporal variation calculating unit calculates that temporal variation is great.

9. The ultrasonic diagnosis apparatus according to claim 1, wherein the image display unit displays a synthetic image of the cross-section region image and the temporal variation image.

10. The ultrasonic diagnosis apparatus according to claim 1, further comprising a control unit configured to make the image display unit display an alarm for shooting an image again when the temporal variation image is equal to or greater than a predetermined region.

11. The ultrasonic diagnosis apparatus according to claim 1, further comprising a control unit configured to recognize a region where the temporal variation image is displayed and set a region other than the region where the temporal variation image is displayed as a region of interest.

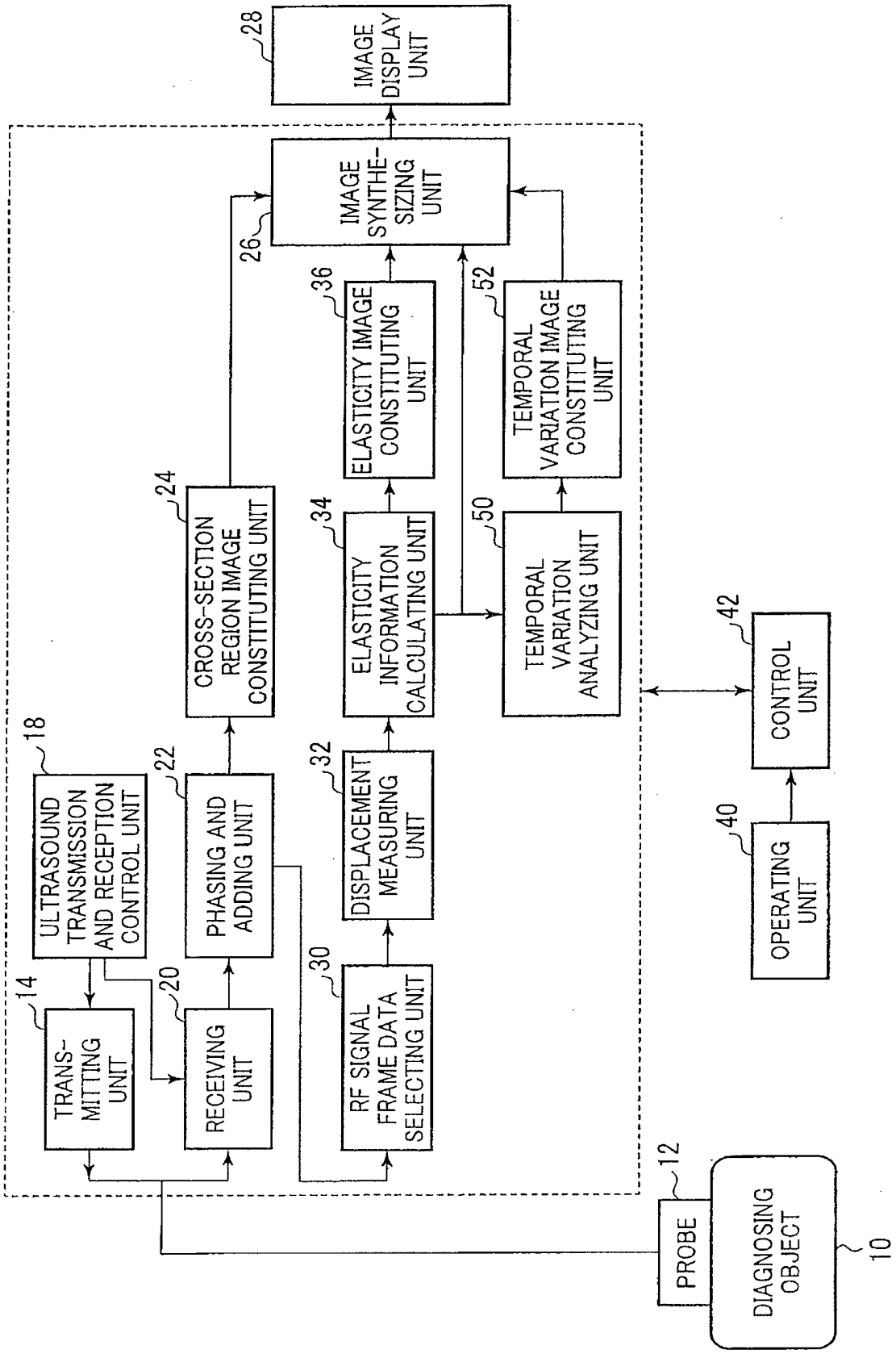
12. The ultrasonic diagnosis apparatus according to claim 1, wherein a first region of interest and a second region of interest are set in advance, and, when the temporal variation image constituted by the temporal variation image constituting unit is superimposed on the first region of interest and the second region of interest, the elasticity information calculating unit does not calculate an index value of the elasticity information in the first region of interest and the second region of interest.

13. The ultrasonic diagnosis apparatus according to claim 1, further comprising a calculation time setting unit configured to set a calculation time during which an index value of the elasticity information is calculated at the elasticity information calculating unit.

14. An image display method for displaying a cross-section region image and an elasticity image, the method comprising:

analyzing temporal variation at respective measurement points from elasticity information indicating hardness;
constituting a temporal variation image based on the temporal variation; and
displaying the temporal variation image.

FIG. 1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PROBE
12
TRANS-MITTING UNIT
14
RECEIVING UNIT
20
ULTRASOUND TRANSMISSION AND RECEPTION CONTROL UNIT
18
PHASING AND ADDING UNIT
22
RF SIGNAL FRAME DATA SELECTING UNIT
30
DISPLACEMENT MEASURING UNIT
32
CROSS-SECTION REGION IMAGE CONSTITUTING UNIT
24
ELASTICITY INFORMATION CALCULATING UNIT
34
TEMPORAL VARIATION ANALYZING UNIT
50
ELASTICITY IMAGE CONSTITUTING UNIT
36
TEMPORAL VARIATION IMAGE CONSTITUTING UNIT
52
IMAGE SYNTHE-SIZING UNIT
26
IMAGE DISPLAY UNIT
28
CONTROL UNIT
42
OPERATING UNIT
40

FIG. 2

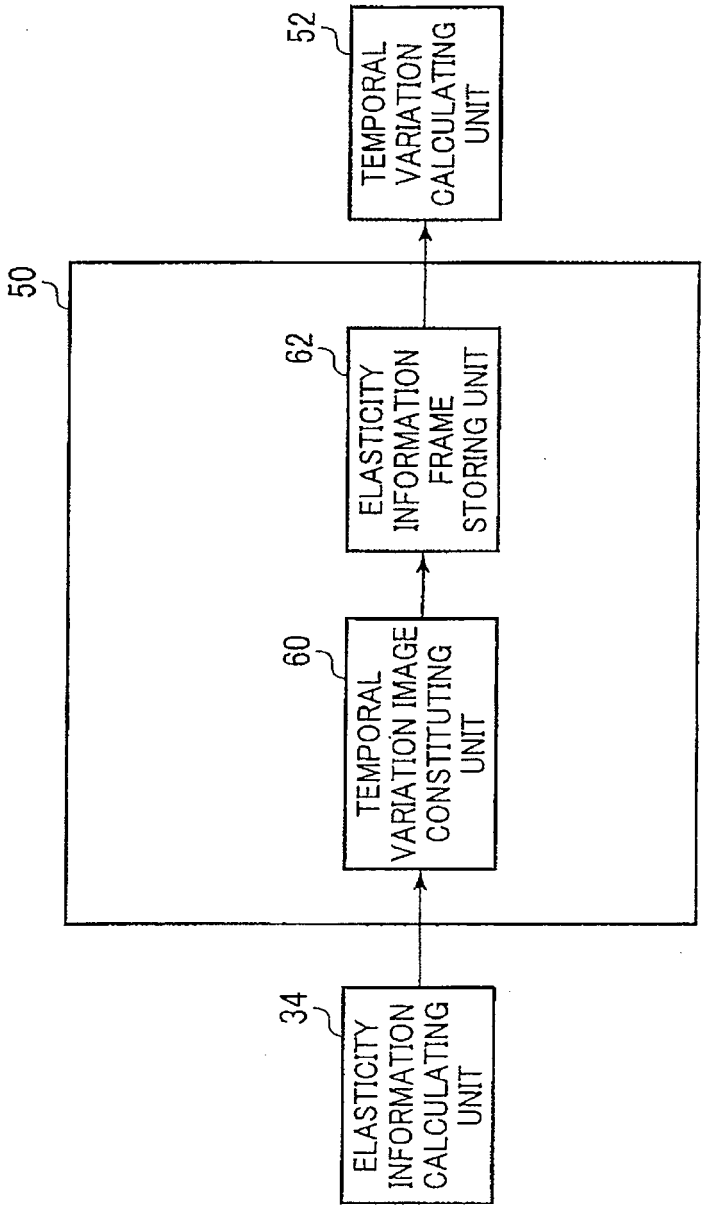

52
TEMPORAL VARIATION CALCULATING UNIT
50
62
ELASTICITY INFORMATION FRAME STORING UNIT
60
TEMPORAL VARIATION IMAGE CONSTITUTING UNIT
34
ELASTICITY INFORMATION CALCULATING UNIT

FIG. 3

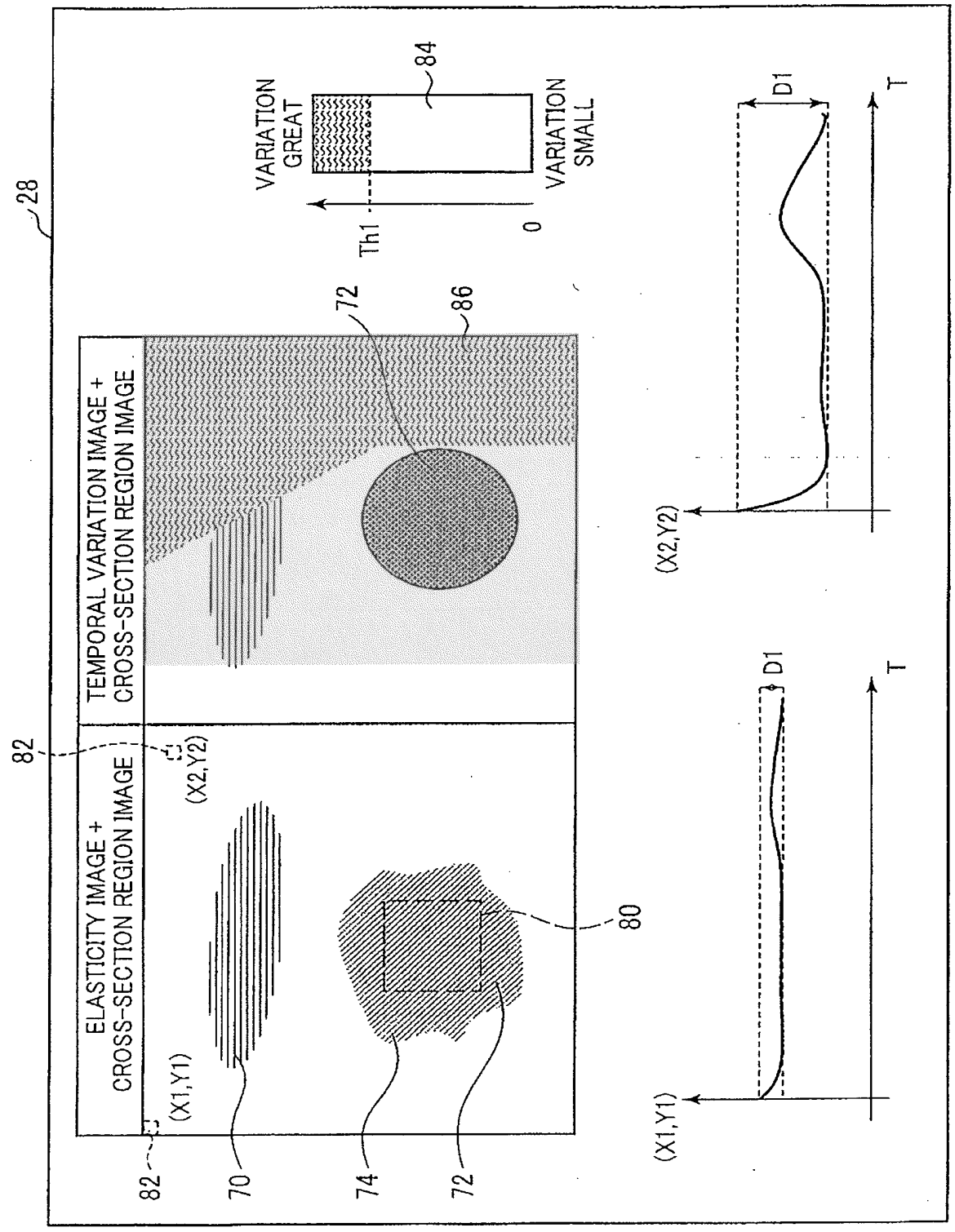
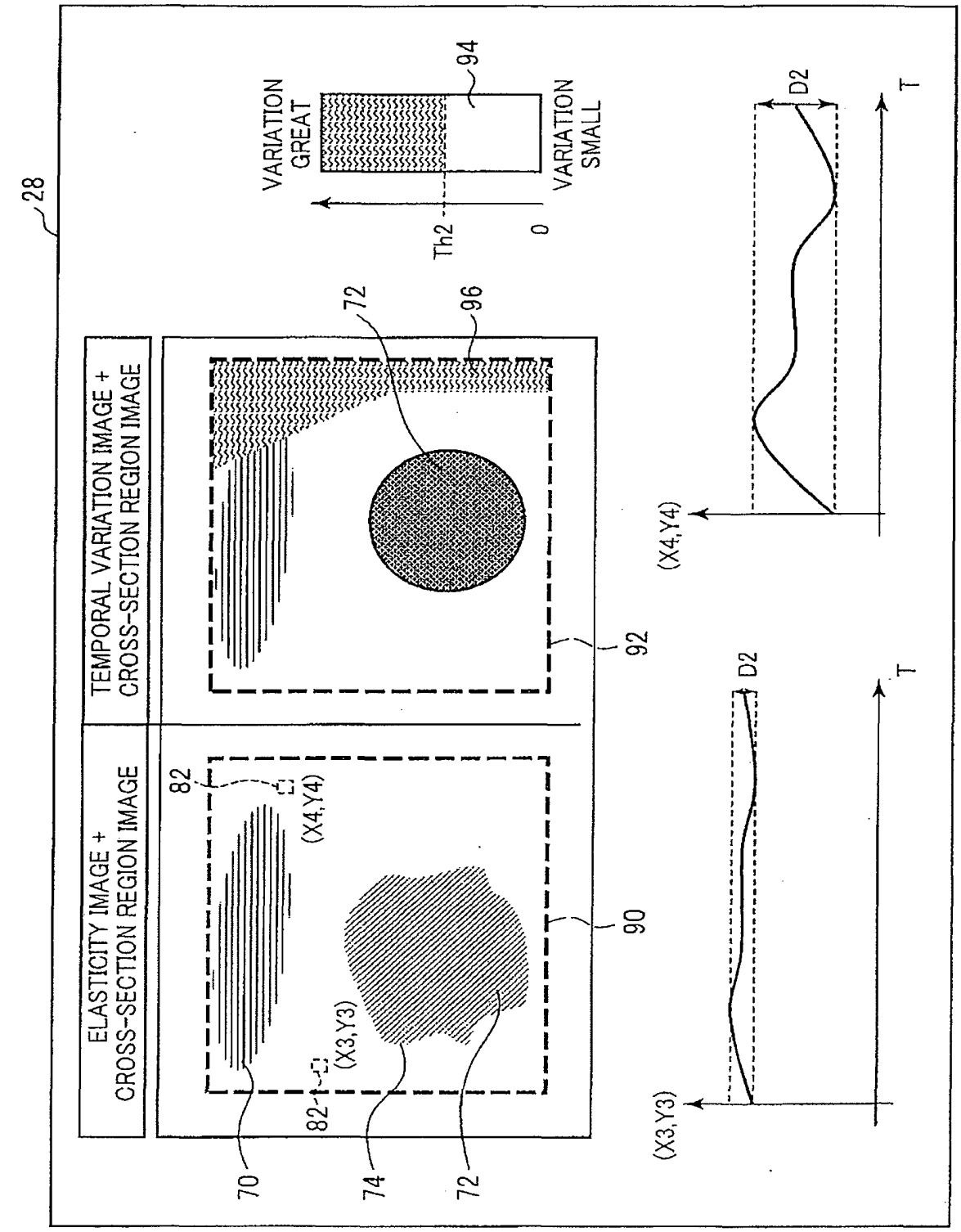

28
TEMPORAL VARIATION IMAGE + CROSS-SECTION REGION IMAGE
ELASTICITY IMAGE + CROSS-SECTION REGION IMAGE
82
(X1,Y1)
(X2,Y2)
70
74
72
80
86
84
VARIATION GREAT
VARIATION SMALL
Th1
0
D1
T

FIG. 4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TEMPORAL VARIATION IMAGE + CROSS-SECTION REGION IMAGE
VARIATION GREAT
VARIATION SMALL
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0
72
96
92
90
82
82
(X4,Y4)
(X3,Y3)
70
74
72
D2
T
(X4,Y4)
D2
T
(X3,Y3)

FIG. 5

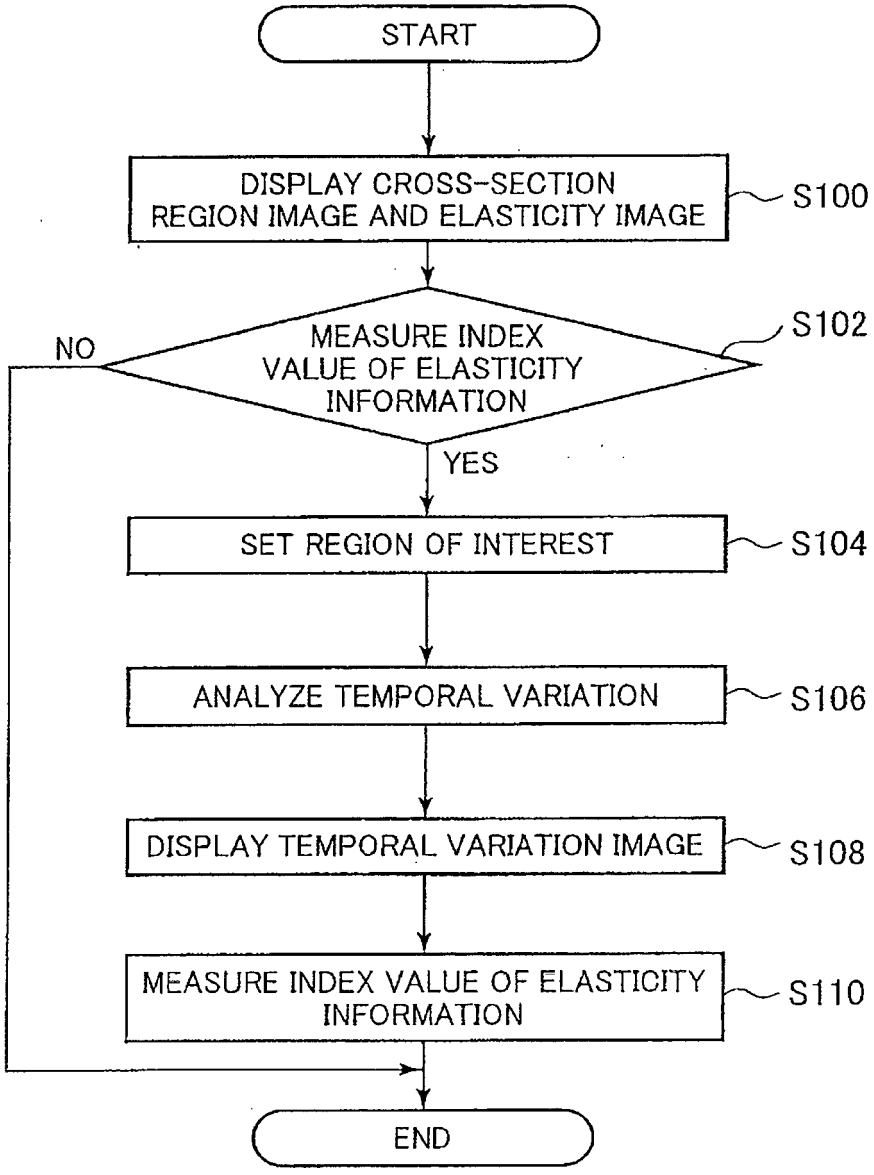

START
DISPLAY CROSS-SECTION REGION IMAGE AND ELASTICITY IMAGE
S100
MEASURE INDEX VALUE OF ELASTICITY INFORMATION
S102
NO
YES
SET REGION OF INTEREST
S104
ANALYZE TEMPORAL VARIATION
S106
DISPLAY TEMPORAL VARIATION IMAGE
S108
MEASURE INDEX VALUE OF ELASTICITY INFORMATION
S110
END

FIG. 6

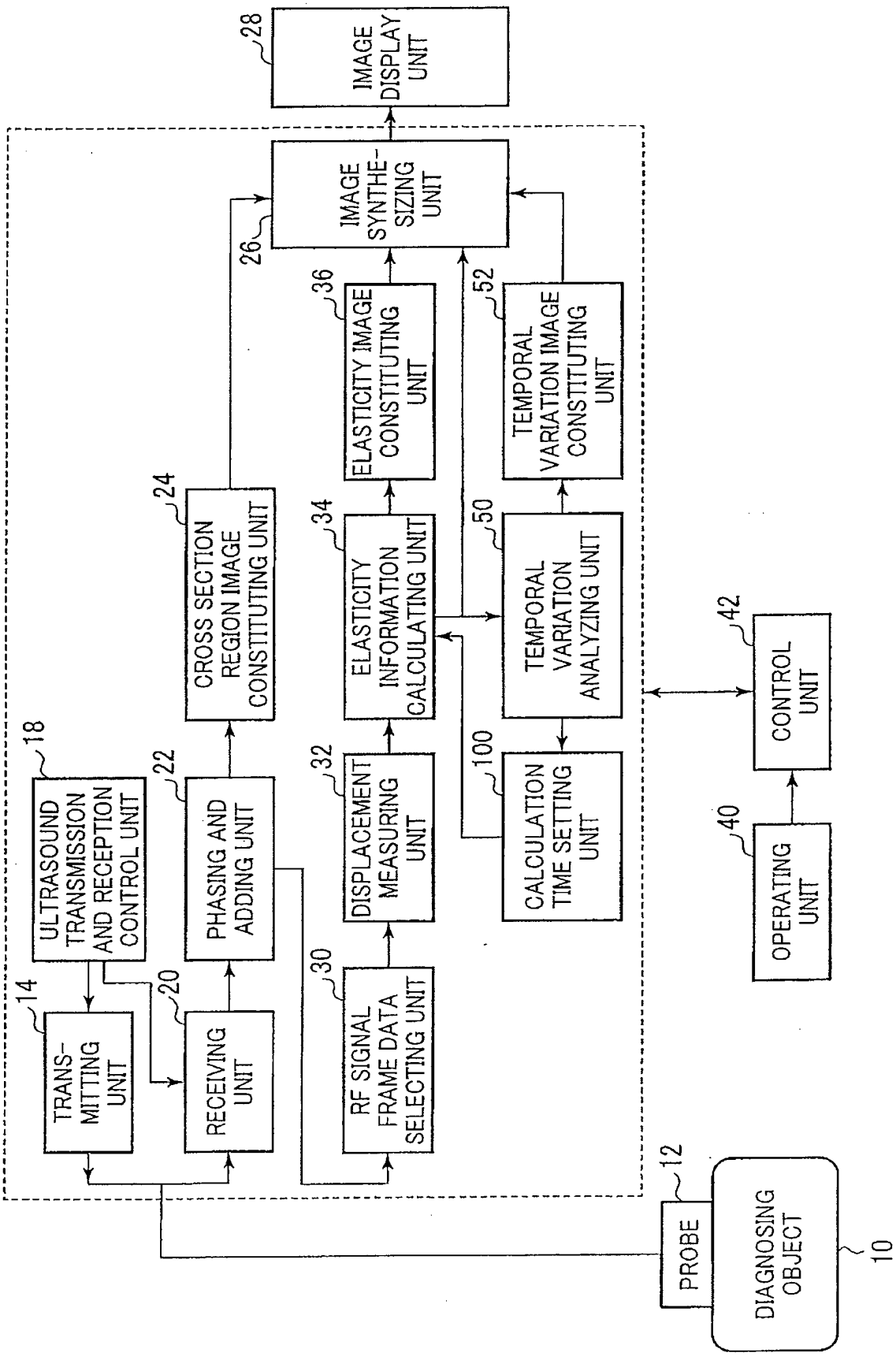
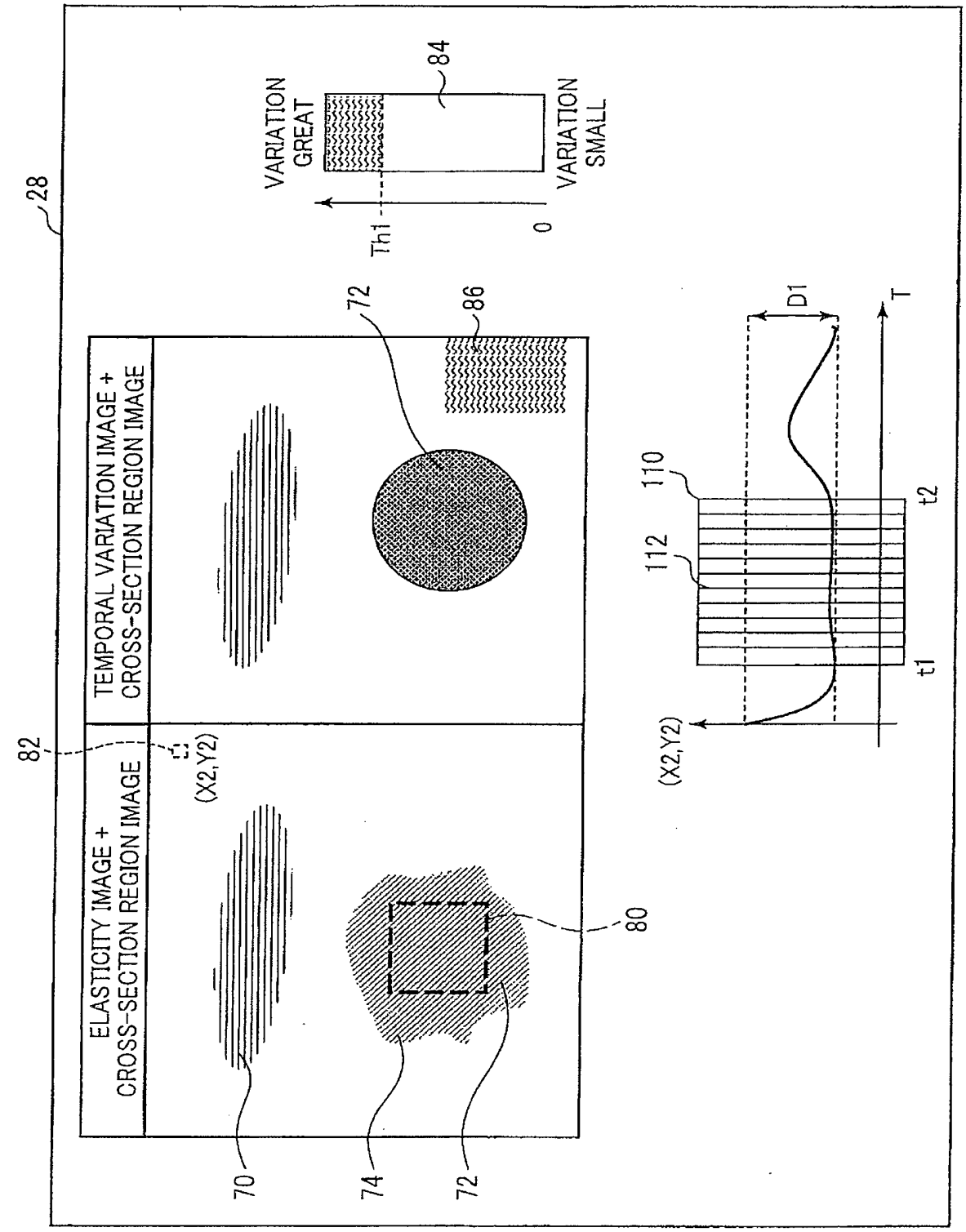

DIAGNOSING OBJECT
10
PROBE
12
TRANS-MITTING UNIT
14
RECEIVING UNIT
20
ULTRASOUND TRANSMISSION AND RECEPTION CONTROL UNIT
18
PHASING AND ADDING UNIT
22
CROSS SECTION REGION IMAGE CONSTITUTING UNIT
24
IMAGE SYNTHE-SIZING UNIT
26
IMAGE DISPLAY UNIT
28
RF SIGNAL FRAME DATA SELECTING UNIT
30
DISPLACEMENT MEASURING UNIT
32
ELASTICITY INFORMATION CALCULATING UNIT
34
ELASTICITY IMAGE CONSTITUTING UNIT
36
CALCULATION TIME SETTING UNIT
100
TEMPORAL VARIATION ANALYZING UNIT
50
TEMPORAL VARIATION IMAGE CONSTITUTING UNIT
52
OPERATING UNIT
40
CONTROL UNIT
42

FIG. 7


28
VARIATION GREAT
84
VARIATION SMALL
Th1
0
72
86
TEMPORAL VARIATION IMAGE + CROSS-SECTION REGION IMAGE
82
(X2,Y2)
ELASTICITY IMAGE + CROSS-SECTION REGION IMAGE
80
70
74
72
110
112
D1
T
t2
t1
(X2,Y2)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/074271

A. CLASSIFICATION OF SUBJECT MATTER
A61B8/08(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B8/00-8/15

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2010-99292 A (GE Medical Systems Global Technology Company, L.L.C.), 06 May 2010 (06.05.2010), paragraphs [0017] to [0039]; fig. 1 to 5 (Family: none)	1,3-5,9,14 2,6-8,10-13
A	WO 2006/068079 A1 (Matsushita Electric Industrial Co., Ltd.), 29 June 2006 (29.06.2006), paragraphs [0098] to [0105]; fig. 2 & JP 4667394 B & US 2008/0103392 A1	1-14
A	JP 2007-312958 A (Hitachi Medical Corp.), 06 December 2007 (06.12.2007), abstract (Family: none)	1-14

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 September, 2013 (25.09.13)	08 October, 2013 (08.10.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/074271

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011/010626 A1 (Hitachi Medical Corp.), 27 January 2011 (27.01.2011), paragraphs [0013], [0014] & US 2012/0253195 A1	1-14
A	WO 2011/102401 A1 (Hitachi Medical Corp.), 25 August 2011 (25.08.2011), paragraph [0053] & US 2012/0321165 A1	1-14
A	WO 2004/105615 A1 (Hitachi Medical Corp.), 09 December 2004 (09.12.2004), page 46, lines 1 to 9 & JP 2004-351062 A & US 2007/0032726 A1 & EP 1629777 A1 & CN 1798524 A	1-14
A	WO 2009/072292 A1 (Panasonic Corp.), 11 June 2009 (11.06.2009), paragraph [0075] & JP 2011-36271 A	1-14

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 06013916 A **[0005]**

专利名称(译)	超声波诊断装置和图像显示方法		
公开(公告)号	EP2910191A4	公开(公告)日	2016-06-29
申请号	EP2013847624	申请日	2013-09-09
[标]申请(专利权)人(译)	日立阿洛卡医疗株式会社		
申请(专利权)人(译)	日立ALOKA MEDICAL.，LTD.		
当前申请(专利权)人(译)	日立ALOKA MEDICAL.，LTD.		
[标]发明人	WAKI KOJI		
发明人	WAKI, KOJI		
IPC分类号	A61B8/08		
CPC分类号	G06T7/0012 A61B8/463 A61B8/485 A61B8/5207 A61B8/5223 G06K9/46 G06K9/52 G06K2009/4666 G06T11/60 G06T2207/10132		
优先权	2012230488 2012-10-18 JP		
其他公开文献	EP2910191A1		
外部链接	Espacenet		

摘要(译)

本发明提供一种能够在不依赖于操作者和超声波测量方法的情况下计算稳定测量位置处的弹性信息的指标值的超声波诊断装置。超声波诊断装置包括：截面区域图像构成单元24，被配置为通过超声波探头12在诊断对象的诊断部分处构成截面区域图像;弹性信息计算单元34，被配置为计算表示硬度的弹性信息，弹性图像构成单元36，被配置为基于在弹性信息计算单元34处计算的弹性信息构成弹性图像，并且图像显示单元28被配置为显示截面区域图像和弹性图像，包括时间变化分析单元50，被配置为根据在弹性信息计算单元34处计算的弹性信息和时间变化图像构成单元52分析各个测量点处的时间变化，该时间变化图像构成单元52被配置为基于在分析时分析的时间变化来构成时间变化图像时间变化分析单元和图像显示单元28显示时间变化图像。