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(54) **ULTRASOUND OBSERVATION APPARATUS, ULTRASOUND OBSERVATION SYSTEM, AND ACTUATION METHOD FOR ULTRASOUND OBSERVATION APPARATUS**

(71) Applicant: **OLYMPUS CORPORATION**, Tokyo (JP)

(72) Inventor: **Tatsuya Miyake**, Tokyo (JP)

(73) Assignee: **OLYMPUS CORPORATION**, Tokyo (JP)

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(57) **ABSTRACT**

An ultrasound observation apparatus including a displacement calculating section that measures displacement of a subject based on an ultrasound signal, an elastic-image generating section that generates an elastic image based on the measured displacement, a memory section that stores generated one or more elastic images, a determination-region setting section that sets a proper-image determination region for proper image determination in the elastic image according to a size of an ROI, a characteristic calculating section that calculates a region characteristic of the proper-image determination region, and a proper-image determining section that determines based on the region characteristic whether the elastic image is a proper image.

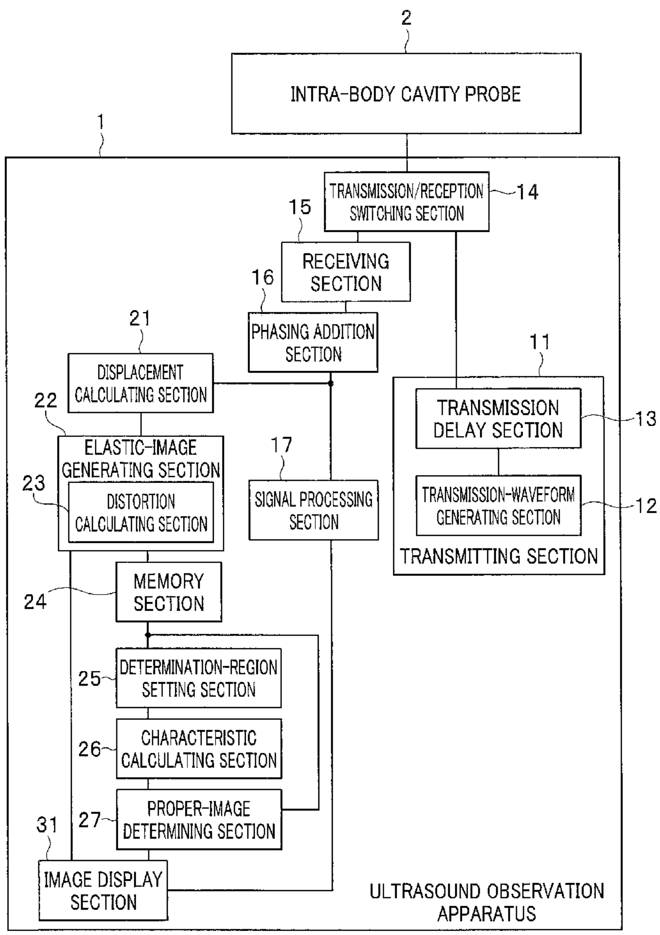


FIG. 1

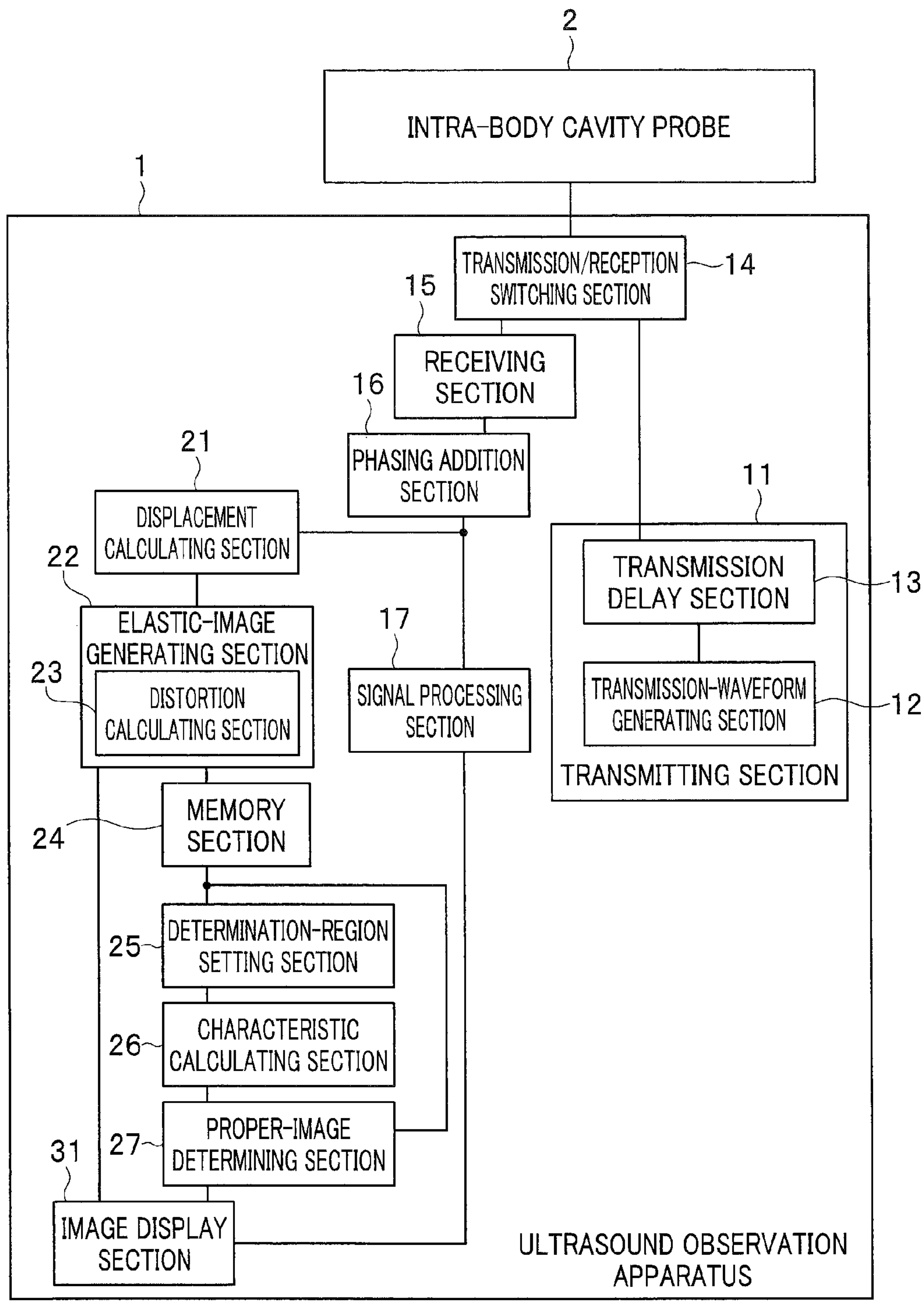

2
INTRA-BODY CAVITY PROBE
1
TRANSMISSION/RECEPTION SWITCHING SECTION
14
15
RECEIVING SECTION
16
PHASING ADDITION SECTION
21
DISPLACEMENT CALCULATING SECTION
11
22
ELASTIC-IMAGE GENERATING SECTION
23
DISTORTION CALCULATING SECTION
17
SIGNAL PROCESSING SECTION
TRANSMISSION DELAY SECTION
13
TRANSMISSION-WAVEFORM GENERATING SECTION
12
TRANSMITTING SECTION
24
MEMORY SECTION
25
DETERMINATION-REGION SETTING SECTION
26
CHARACTERISTIC CALCULATING SECTION
27
PROPER-IMAGE DETERMINING SECTION
31
IMAGE DISPLAY SECTION
ULTRASOUND OBSERVATION APPARATUS

FIG. 2

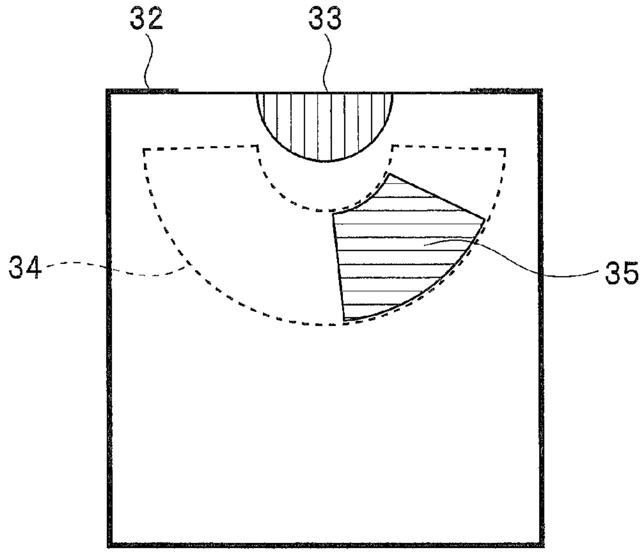


FIG. 3

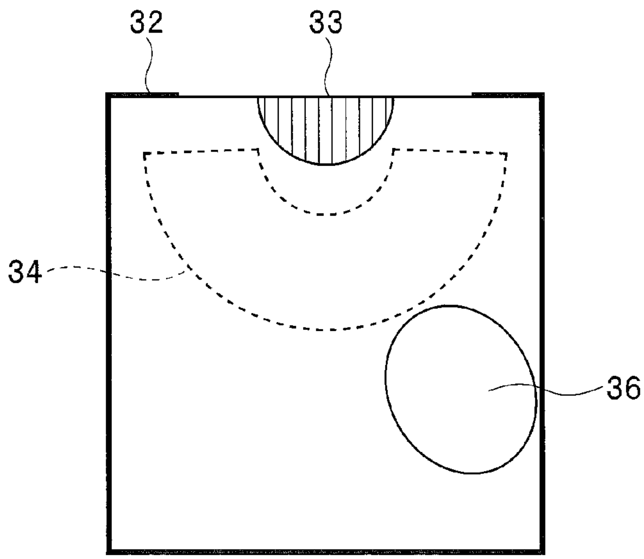


FIG. 4

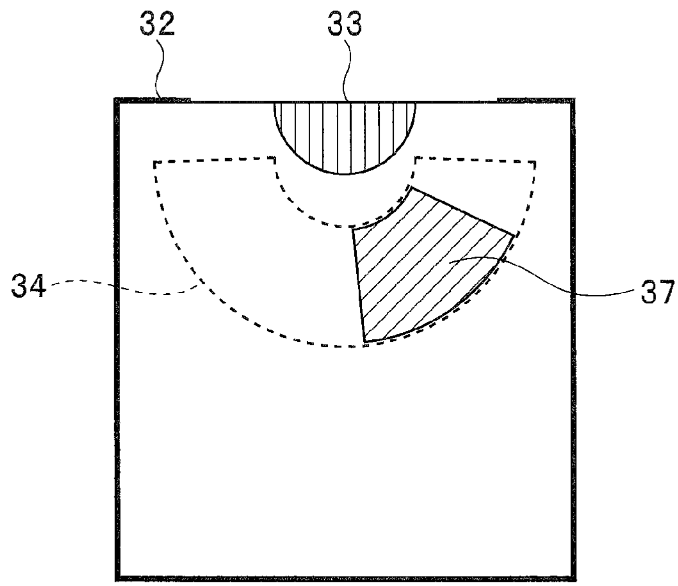


FIG. 5

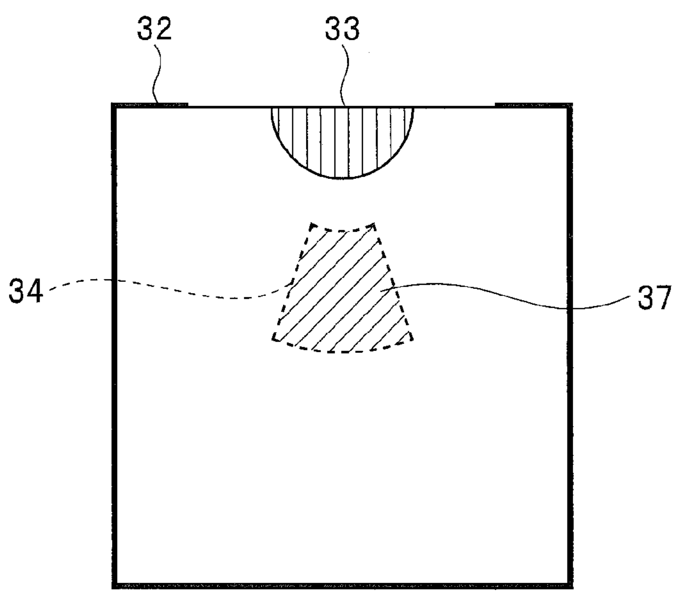


FIG. 6

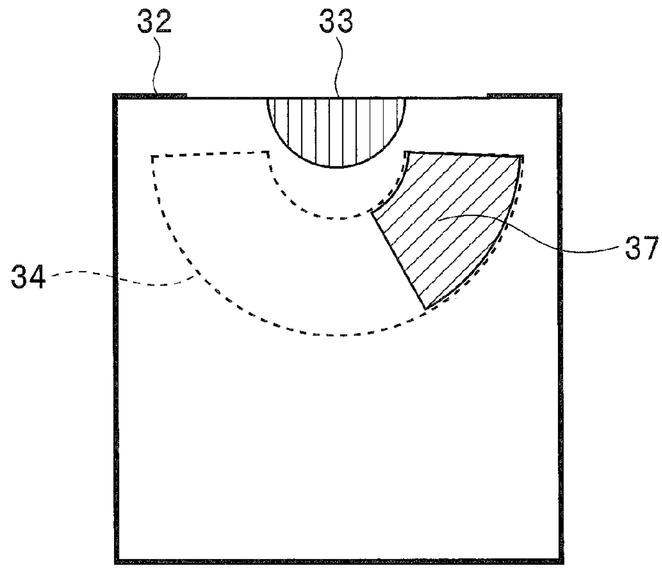


FIG. 7

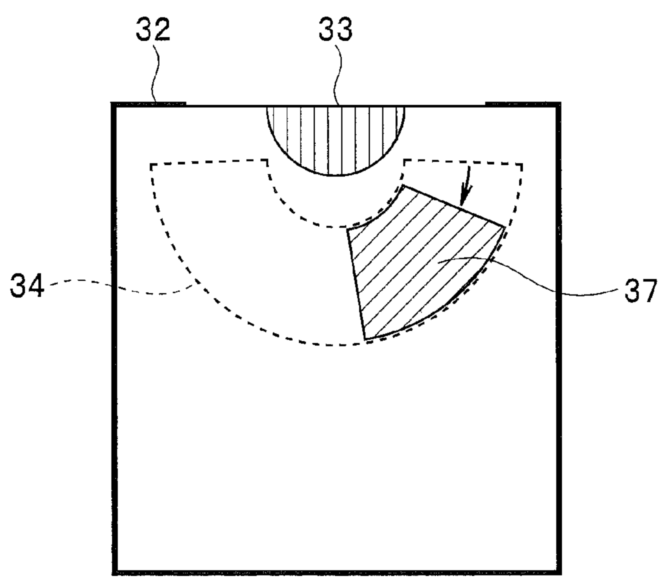


FIG. 8

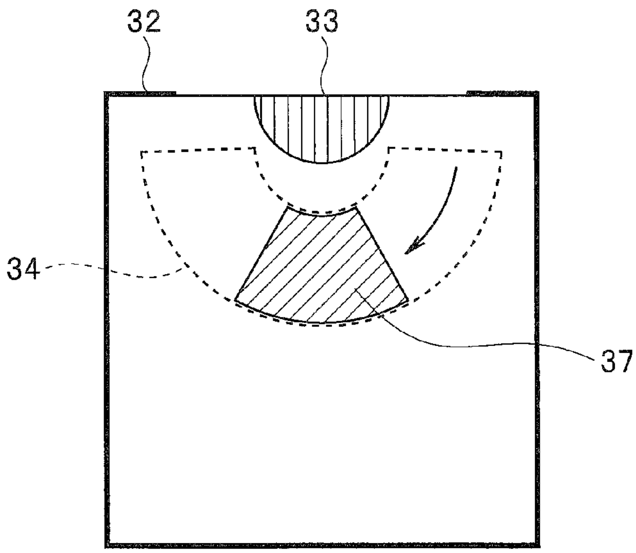


FIG. 9

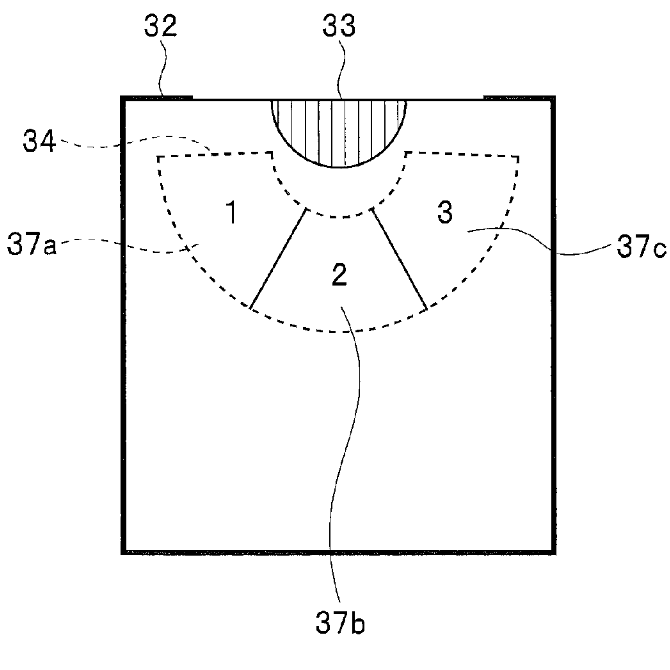


FIG. 10

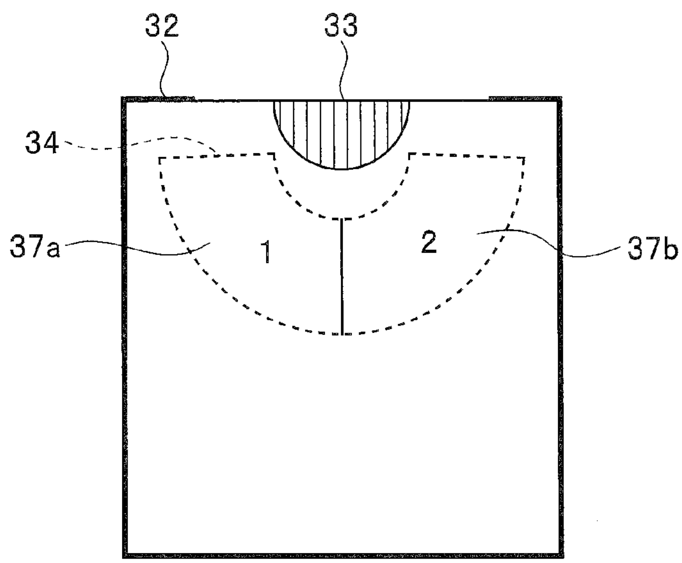


FIG. 11

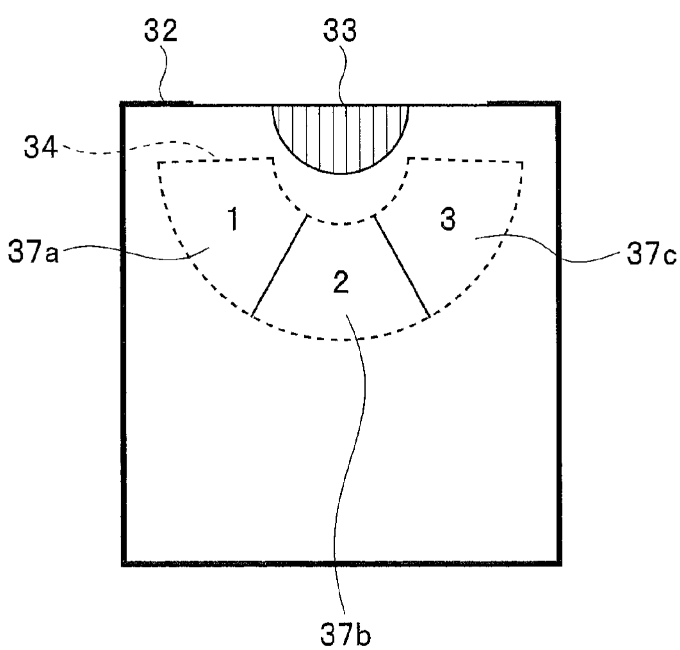


FIG. 12

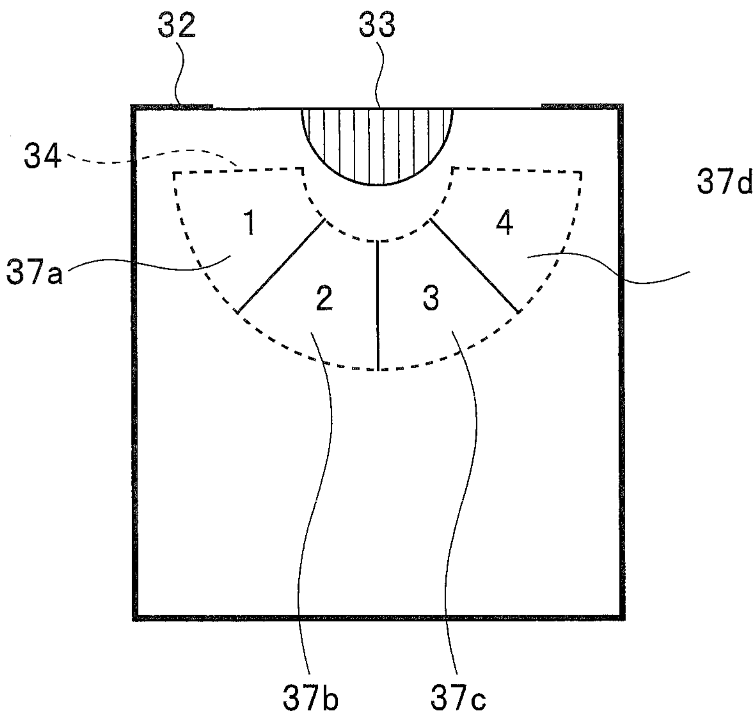


FIG. 13

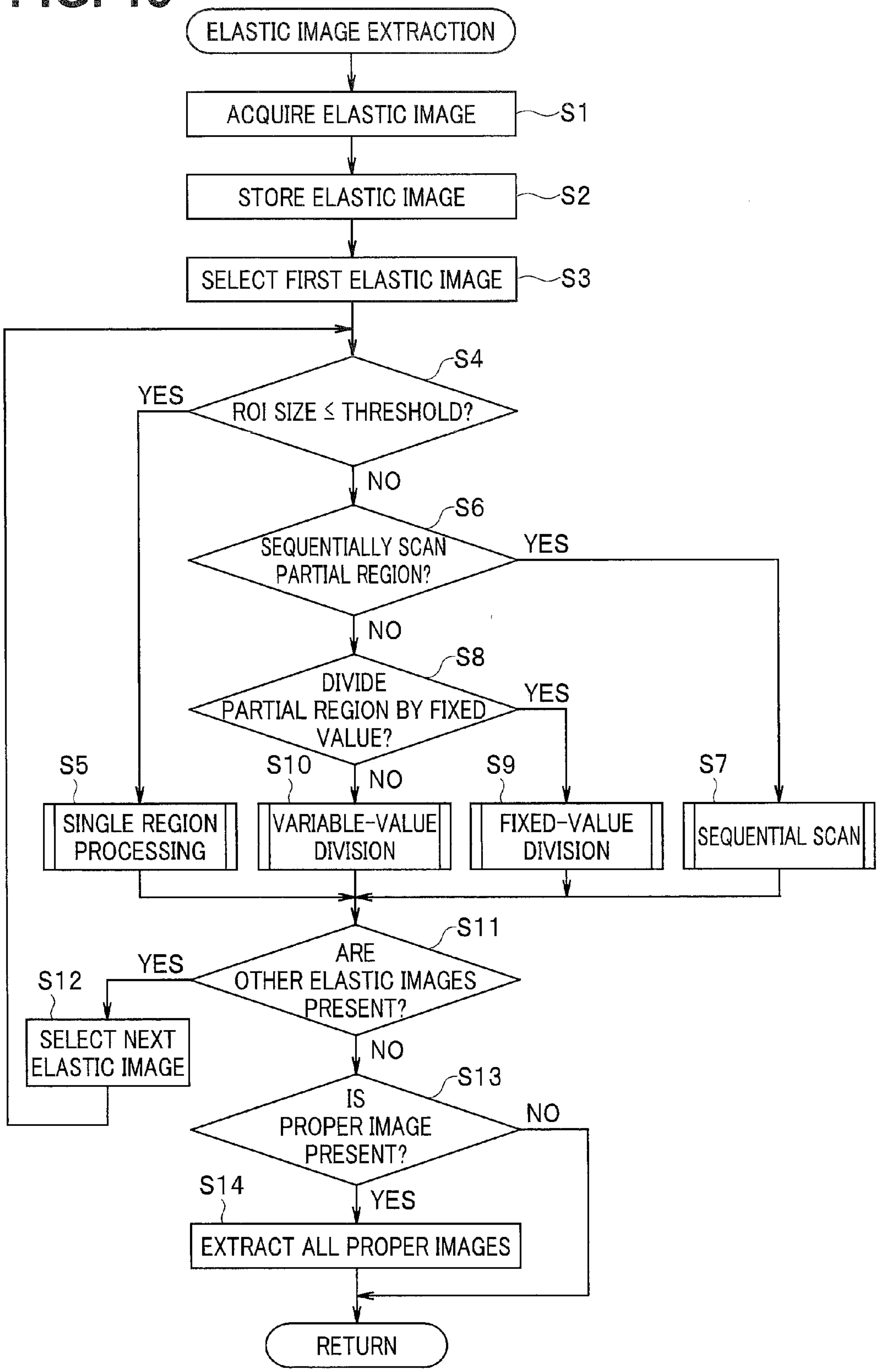

ELASTIC IMAGE EXTRACTION
ACQUIRE ELASTIC IMAGE
S1
STORE ELASTIC IMAGE
S2
SELECT FIRST ELASTIC IMAGE
S3
S4
ROI SIZE ≤ THRESHOLD?
YES
NO
S6
SEQUENTIALLY SCAN PARTIAL REGION?
YES
NO
S8
DIVIDE PARTIAL REGION BY FIXED VALUE?
YES
NO
S5
SINGLE REGION PROCESSING
S10
VARIABLE-VALUE DIVISION
S9
FIXED-VALUE DIVISION
S7
SEQUENTIAL SCAN
S11
ARE OTHER ELASTIC IMAGES PRESENT?
YES
S12
SELECT NEXT ELASTIC IMAGE
NO
S13
IS PROPER IMAGE PRESENT?
NO
S14
YES
EXTRACT ALL PROPER IMAGES
RETURN

FIG. 14

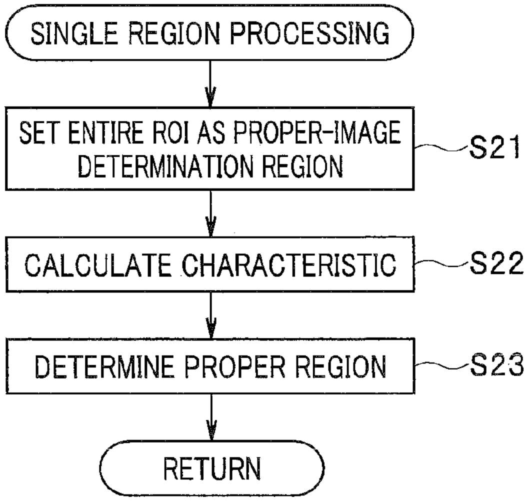

SINGLE REGION PROCESSING
SET ENTIRE ROI AS PROPER-IMAGE DETERMINATION REGION
S21
CALCULATE CHARACTERISTIC
S22
DETERMINE PROPER REGION
S23
RETURN

FIG. 15

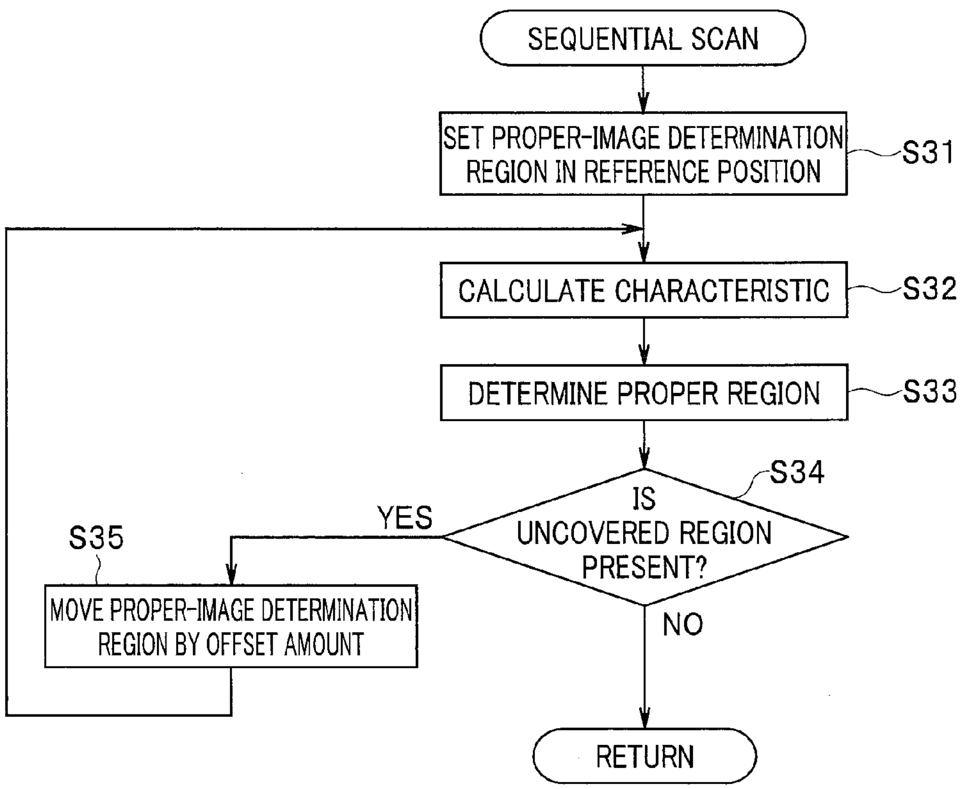

SEQUENTIAL SCAN
SET PROPER-IMAGE DETERMINATION REGION IN REFERENCE POSITION
S31
CALCULATE CHARACTERISTIC
S32
DETERMINE PROPER REGION
S33
S34
IS UNCOVERED REGION PRESENT?
YES
NO
S35
MOVE PROPER-IMAGE DETERMINATION REGION BY OFFSET AMOUNT
RETURN

FIG. 16

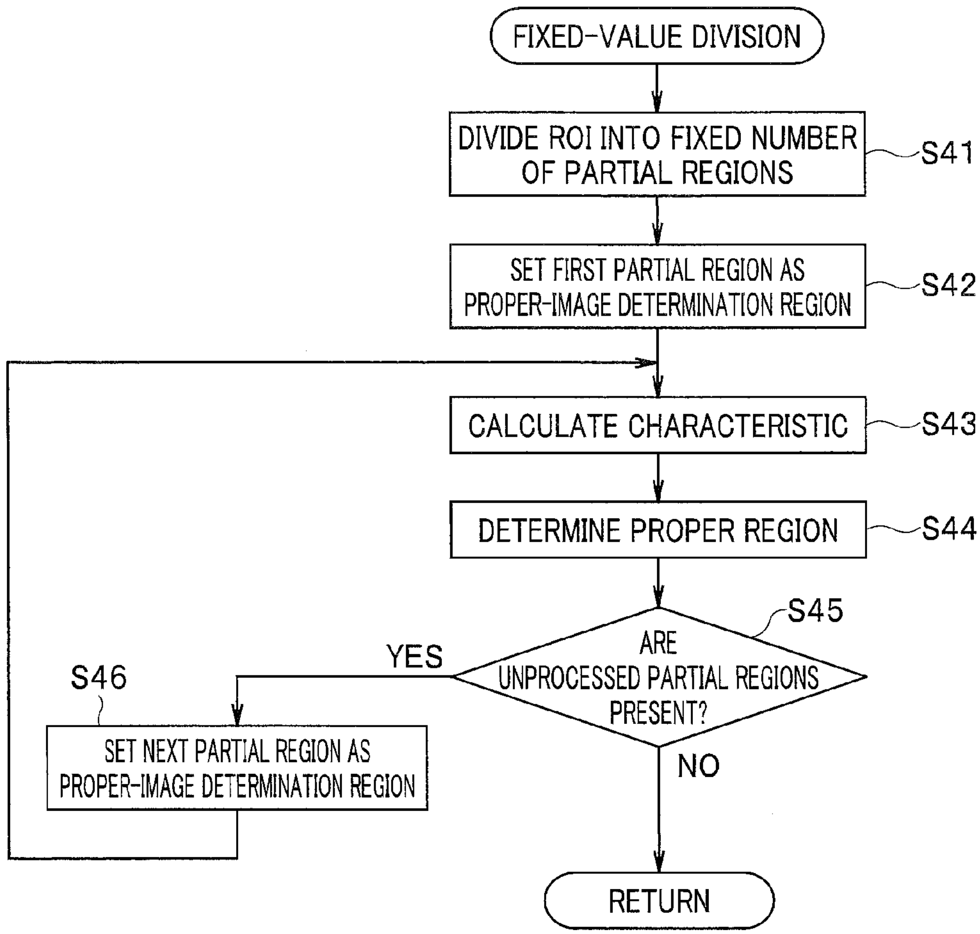
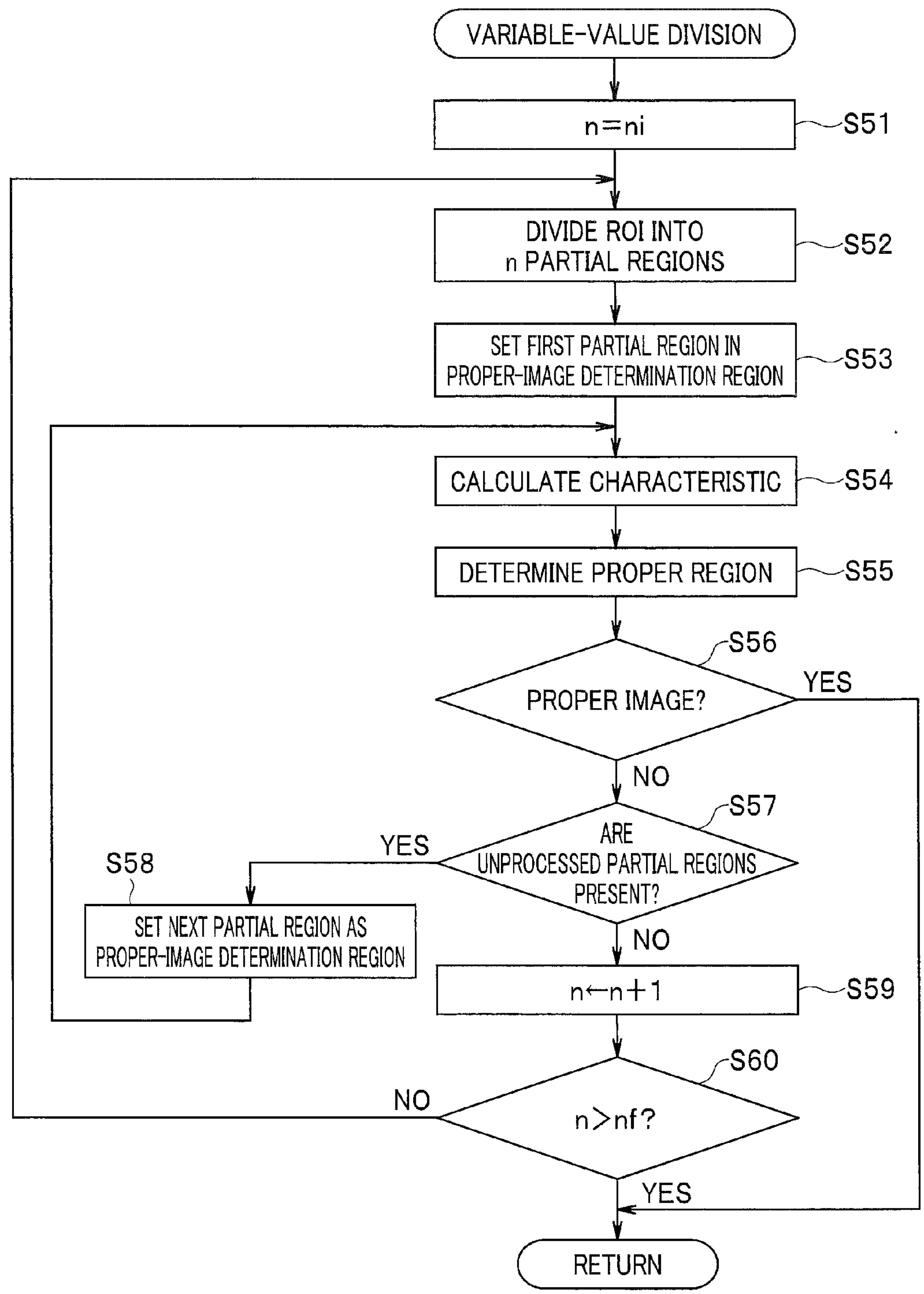

FIXED-VALUE DIVISION
DIVIDE ROI INTO FIXED NUMBER OF PARTIAL REGIONS
S41
SET FIRST PARTIAL REGION AS PROPER-IMAGE DETERMINATION REGION
S42
CALCULATE CHARACTERISTIC
S43
DETERMINE PROPER REGION
S44
S45
ARE UNPROCESSED PARTIAL REGIONS PRESENT?
YES
NO
S46
SET NEXT PARTIAL REGION AS PROPER-IMAGE DETERMINATION REGION
RETURN

FIG. 17



VARIABLE-VALUE DIVISION
n=ni
S51
DIVIDE ROI INTO n PARTIAL REGIONS
S52
SET FIRST PARTIAL REGION IN PROPER-IMAGE DETERMINATION REGION
S53
CALCULATE CHARACTERISTIC
S54
DETERMINE PROPER REGION
S55
S56
PROPER IMAGE?
YES
NO
S57
ARE UNPROCESSED PARTIAL REGIONS PRESENT?
YES
S58
SET NEXT PARTIAL REGION AS PROPER-IMAGE DETERMINATION REGION
NO
n←n+1
S59
S60
NO
n>nf?
YES
RETURN

ULTRASOUND OBSERVATION APPARATUS, ULTRASOUND OBSERVATION SYSTEM, AND ACTUATION METHOD FOR ULTRASOUND OBSERVATION APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation application of PCT/JP2015/057196 filed on Mar. 11, 2015 and claims benefit of Japanese Application No. 2014-170752 filed in Japan on Aug. 25, 2014, the entire contents of which are incorporated herein by this reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an ultrasound observation apparatus, an ultrasound observation system, and an actuation method for the ultrasound observation apparatus for generating an image including an elastic image based on an ultrasound signal obtained by transmitting and receiving ultrasound.

[0004] 2. Description of the Related Art

[0005] An ultrasound observation apparatus that generates, from a distortion amount of a biological tissue caused by an oppression force, an elastic image representing hardness or softness of the biological tissue has been put to practical use.

[0006] A series of images acquired in such an ultrasound observation apparatus are once stored in an image memory or the like. A user selects, out of the series of images stored in the image memory, a proper image as an image for calculating elasticity information and an image for medical record storage.

[0007] Incidentally, when the ultrasound observation apparatus is set in an elastic image observation mode, a region having a distortion amount is larger than a predetermined threshold in an image is sometimes colored and displayed. However, not all frame images are always colored. Therefore, when the user selects the proper image, the user has to search for the proper image not only in colored frame images but also uncolored frame images.

[0008] In order to cope with such a point, for example, International Publication No. 2011/010626 discloses a technique for automatically extracting a proper image based on an oppression state to an organism. References used for extraction in the publication are an average of displacement, an average of elasticity information, displacement of pressure, fluctuation in pressure in a beam line direction, and the like.

[0009] Japanese Patent Application Laid-Open Publication No. 2012-213545 discloses an ultrasound diagnostic apparatus that, in order to provide a high-quality three-dimensional elastic image, determines elastic volume data formed by a plurality of two-dimensional elastic image including a noise image as a noise volume and hides a three-dimensional elastic image by the elastic volume data determined as the noise volume.

[0010] Further, Japanese Patent Application Laid-Open Publication No. 2005-118152 describes a technique for, in order to provide a high-quality elastic image, evaluating, based on various data (pressure data, displacement frame data, and elastic frame data) used in a generation process of a distortion elastic image (elastic frame data), a value of performing image display concerning respective measurement points in a region of interest (ROI), distinguishing useless information and useful information, and finally not leaving (masking to hide) the useless information as an image.

SUMMARY OF THE INVENTION

[0011] An ultrasound observation apparatus according to an aspect of the present invention is an ultrasound observation apparatus that generates an ultrasound image based on an ultrasound signal generated from ultrasound transmitted to a subject and reflected, the ultrasound observation apparatus including: a transmitting section that transmits a driving signal for generating the ultrasound transmitted to the subject; a receiving section that receives the ultrasound signal generated from the ultrasound reflected by the subject; a displacement calculating section that measures displacement of the subject based on the ultrasound signal received by the receiving section; an elastic-image generating section that generates an elastic image based on the displacement measured by the displacement calculating section; a storing section that stores one or more of the elastic images generated by the elastic-image generating section; a determination-region setting section that sets, according to a size of an ROI, which is a region of interest, a proper-image determination region for determining a proper image out of the one or more elastic images stored in the storing section; a characteristic calculating section that calculates a region characteristic of the proper-image determination region; and a proper-image determining section that determines based on the region characteristic whether the elastic image in which the proper-image determination region is set is the proper image.

[0012] An ultrasound observation system according to an aspect of the present invention includes: the ultrasound observation apparatus; and an ultrasound probe that receives the driving signal transmitted from the transmitting section, transmits the ultrasound to the subject, receives the ultrasound reflected by the subject, generates the ultrasound signal, and transmits the ultrasound signal to the receiving section.

[0013] An actuation method for an ultrasound observation apparatus according to an aspect of the present invention is an actuation method for an ultrasound observation apparatus that generates an ultrasound image based on an ultrasound signal generated from ultrasound transmitted to a subject and reflected, the actuation method for the ultrasound observation apparatus including: a step in which a transmitting section transmits a driving signal for generating the ultrasound transmitted to the subject; a step in which a receiving section receives the ultrasound signal generated from the ultrasound reflected by the subject; a step in which a displacement calculating section measures displacement of the subject based on the ultrasound signal received by the receiving section; a step in which an elastic-image generating section generates an elastic image based on the displacement measured by the displacement calculating section; a step in which a storing section stores one or more of the elastic images generated by the elastic-image generating section; a step in which a determination-region setting section sets, according to a size of an ROI, which is a region of interest, a proper-image determination region for determining a proper image out of the one or more elastic images stored in the storing section; a step in which a characteristic calculating section calculates a region characteristic of the proper-image determination region; and a step in which a proper-image determining section determines based on the region characteristic whether the elastic image in which the proper-image determination region is set is the proper image.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is a block diagram showing a configuration of an ultrasound observation system in a first embodiment of the present invention;

[0015] FIG. **2** is a diagram showing a state in which a region where a distortion amount in an ROI is equal to or larger than a predetermined value is displayed in the first embodiment;

[0016] FIG. **3** is a diagram showing an example of a position of a displacement source with respect to the ROI in the first embodiment;

[0017] FIG. **4** is a diagram showing an example of a proper-image determination region set when a center angle of the ROI is larger than a predetermined threshold in the first embodiment;

[0018] FIG. **5** is a diagram showing an example of a proper-image determination region set when the center angle of the ROI is equal to or smaller than the predetermined threshold;

[0019] FIG. **6** is a diagram showing an example of a first position in sequentially scanning the proper-image determination region in the ROI of the first embodiment;

[0020] FIG. **7** is a diagram showing an example of a second position in sequentially scanning the proper-image determination region in the ROI of the first embodiment;

[0021] FIG. **8** is a diagram showing an example of a third position in sequentially scanning the proper-image determination region in the ROI of the first embodiment;

[0022] FIG. **9** is a diagram showing an example in which the proper-image determination region is divided by a fixed value in the ROI of the first embodiment;

[0023] FIG. **10** is a diagram showing a first division example in dividing the proper-image determination region by a variable value in the ROI of the first embodiment;

[0024] FIG. **11** is a diagram showing a second division example in dividing the proper-image determination region by a variable value in the ROI of the first embodiment;

[0025] FIG. **12** is a diagram showing a third division example in dividing the proper-image determination region by a variable value in the ROI of the first embodiment;

[0026] FIG. **13** is a flowchart showing elastic-image extraction processing in an ultrasound observation system of the first embodiment;

[0027] FIG. **14** is a flowchart showing single region processing in the first embodiment;

[0028] FIG. **15** is a flowchart showing sequential scan processing in the first embodiment;

[0029] FIG. **16** is a flowchart showing fixed-value division processing in the first embodiment; and

[0030] FIG. **17** is a flowchart showing variable-value division processing in the first embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] An embodiment of the present invention is explained below with reference to the drawings.

First Embodiment

[0032] FIG. **1** to FIG. **17** show a first embodiment of the present invention. FIG. **1** is a block diagram showing a configuration of an ultrasound observation system.

[0033] The ultrasound observation system includes an intra-body cavity probe **2** that transmits ultrasound to a subject and receives the ultrasound reflected by the subject and an ultrasound observation apparatus **1** that generates an ultrasound image based on an ultrasound signal obtained from the received ultrasound.

[0034] The intra-body cavity probe **2** is an ultrasound probe inserted into a body cavity and used. The intra-body cavity probe **2** includes an ultrasound transducer configured by arraying a large number of vibration elements, transmits ultrasound from an ultrasound transmission/reception surface of the ultrasound transducer to the subject, receives, on the ultrasound transmission/reception surface of the ultrasound transducer, the ultrasound reflected by the subject, and generates an ultrasound signal from the received ultrasound. Specifically, the intra-body cavity probe **2** is configured as an ultrasound probe of a convex type, an ultrasound probe of a radial type, or the like.

[0035] The ultrasound observation apparatus **1** includes a transmitting section **11**, a transmission/reception switching section **14**, a receiving section **15**, a phasing addition section **16**, a signal processing section **17**, a displacement calculating section **21**, an elastic-image generating section **22**, a memory section **24**, a determination-region setting section **25**, a characteristic calculating section **26**, a proper-image determining section **27**, and an image display section **31**.

[0036] The transmitting section **11** transmits a driving signal for generating ultrasound transmitted to a subject. The transmitting section **11** includes a transmission-waveform generating section **12** and a transmission delay section **13**.

[0037] The transmission-waveform generating section **12** generates a signal waveform for driving the respective vibration elements configuring the ultrasound transducer and outputs the signal waveform as a driving signal.

[0038] The transmission delay section **13** delays the driving signal generated by the transmission-waveform generating section **12** to thereby adjust driving timing of the respective vibration elements configuring the ultrasound transducer. Consequently, a focus and a direction of an ultrasound beam transmitted from the ultrasound transducer are controlled. The ultrasound can be converged in a desired position (depth).

[0039] The transmission/reception switching section **14** includes, for example, a multiplexer that sequentially selects a plurality of vibration elements for performing transmission and reception of the ultrasound. The transmission/reception switching section **14** transmits the driving signal, which is transmitted from the transmitting section **11**, to the ultrasound transducer and transmits an ultrasound signal (an echo signal), which is transmitted from the ultrasound transducer, to the receiving section **15**.

[0040] The receiving section **15** receives the ultrasound signal, which is transmitted from the transmission/reception switching section **14**, and performs processing such as amplification and conversion into a digital signal.

[0041] The phasing addition section **16** delays the ultrasound signal and adjusts a phase and then adds the ultrasound.

[0042] The signal processing section **17** performs coordinate conversion and interpolation processing on the ultrasound signal transmitted from the phasing addition section **16** and creates an ultrasound image as an image for display.

[0043] The displacement calculating section **21** measures displacement of the subject based on the ultrasound signal transmitted from the phasing addition section **16**.

[0044] The elastic-image generating section **22** includes a distortion calculating section **23**. The distortion calculating section **23** calculates, based on the displacement measured by the displacement calculating section **21**, a distortion amount of a region of interest (ROI) (see an ROI **34** in FIG. **2** to FIG. **12**) for elastic image display. The elastic-image generating section **22** calculates a modulus of elasticity of the subject based on the distortion amount calculated by the distortion calculating section **23**. The elastic-image generating section **22** calculates a modulus of elasticity for each of coordinates of the subject. Therefore, a calculation result is an elastic image in which moduli of elasticity are distributed on a two-dimensional coordinate. The generation of the elastic image by the elastic-image generating section **22** is performed, for example, every frame. One or more elastic images are generated. The elastic-image generating section **22** further calculates a distortion amount of the ROI **34** based on the displacement measured by the displacement calculating section **21** and performs coloring on pixels of the elastic images in which the distortion amount is equal to or larger than a predetermined value.

[0045] The memory section **24** is a storing section that temporarily stores the one or more elastic images generated by the elastic-image generating section **22**.

[0046] The determination-region setting section **25** sets, according to a size of the ROI **34**, a proper-image determination region **37** (see FIG. **4** to FIG. **12**, etc.) for determining a proper image out of the one or more elastic images stored in the memory section **24**.

[0047] The characteristic calculating section **26** calculates a region characteristic of the proper-image determination region **37** set by the determination-region setting section **25**. Specifically, the characteristic calculating section **26** calculates, as the region characteristic, for example, at least one of an average of the displacement of the proper-image determination region **37** measured by the displacement calculating section **21**, dispersion of the displacement, a deviation of the displacement and an average of elasticity information of the proper-image determination region **37** calculated by the elastic-image generating section **22**, dispersion of the elasticity information, and a deviation of the elasticity information. The characteristic calculating section **26** may calculate, as the region characteristic, at least one of the number of colored pixels and a total area of the colored pixels of the proper-image determination region **37**, a ratio of the number of colored pixels to the number of pixels of the entire proper-image determination region **37**, and a ratio of a total area of the colored pixels to an area of the entire proper-image determination region **37**.

[0048] Note that a pressure detecting section for detecting pressure on an ultrasound transmission/reception surface for transmitting and receiving ultrasound may be further provided in the intra-body cavity probe **2**, which is an ultrasound probe. The characteristic calculating section **26** may calculate, as the region characteristic, at least one of an average of pressure, a rate of change of the pressure, dispersion of the pressure, and a deviation of the pressure of the proper-image determination region **37** obtained based on a detection result of the pressure detecting section.

[0049] The proper-image determining section **27** determines based on the region characteristic calculated by the characteristic calculating section **26** whether the proper-image determination region **37** is a proper region. Further, when the proper-image determination region **37** is not the proper region, the proper-image determining section **27** causes the determination-region setting section **25** to set the proper-image determination region **37** again according to necessity. In this way, when at least one of the proper-image determination regions **37** set in the ROI **34** of the elastic image is the proper region, the proper-image determining section **27** determines that the elastic image in which the proper-image determination region **37** is set is a proper image.

[0050] The image display section **31** includes a display device such as a monitor and displays an image for display transmitted from the signal processing section **17**. That is, in an ultrasound diagnosis mode, the image display section **31** displays an ultrasound image. In an elastic image observation mode, the image display section **31** displays an elastic image transmitted from the elastic-image generating section **22** or superimposes and displays the elastic image on the ultrasound image. When displaying the elastic image, the image display section **31** further superimposes and displays the proper-image determination region **37** transmitted from the proper-image determining section **27** on the elastic image according to necessity.

[0051] FIG. **2** is a diagram showing a state in which a region where a distortion amount is equal to or larger than a predetermined value in the ROI **34** is displayed. FIG. **3** is a diagram showing an example of a position of a displacement source with respect to the ROI **34**.

[0052] As shown in the figure, on a screen **32** of the image display section **31**, a probe image **33** showing a position of the intra-body cavity probe **2** itself as an image and the ROI **34** for elastic image display are displayed. A probe curvature radius R of the intra-body cavity probe **2** shown as the probe image **33** in FIG. **2** is, for example, 10 mm or less. The curvature radius R is relatively small. Further, a center angle of the ROI **34** is, for example, approximately 180°.

[0053] In this case, in the ROI **34**, a region **35** formed by pixels having a distortion amount equal to or larger than the predetermined value is displayed, for example, as shown in FIG. **2**. The region **35** is generated as, for example, an image colored in a specific color by the elastic-image generating section **22**, is displayed on the image display section **31**, and can be easily distinguished from other portions. Therefore, in the example shown in FIG. **2**, a colored region and an uncolored region are present in the ROI **34** of the elastic image.

[0054] When the user determines, viewing such an image, whether the image is an image suitable for a diagnosis and storage of the image, since the image is only partially colored with respect to the entire ROI **34**, it is assumed that the user sometimes determines that the image is not the proper image.

[0055] However, when an ultrasound probe is the intra-body cavity probe **2** inserted into a body cavity and used, in order to generate an elastic image, displacement of an organism due to a beat or a pulsation is used. For example, when a displacement source **36** such as a pulsation source or a beat source is present in the position shown in FIG. **3**, only the region **35** shown in FIG. **2** receives proper pressure and has a distortion amount equal to or larger than the predetermined value in the ROI **34**. A distortion amount equal to or larger than the predetermined value does not occur in other regions. In this way, when the curvature radius R of the intra-body cavity probe **2** is small or when the center angle of the ROI **34** is wide, it cannot be expected that the entire ROI **34** is colored.

[0056] Therefore, in this case, it should be determined that the image shown in FIG. **2** is a proper image. Therefore, in the present embodiment, as explained below, a region for determining that an image is a proper image is set according to the size of the ROI **34** for elastic image display, a region characteristic in the set region is calculated, and it is determined according to the calculated characteristic whether the image is the proper image.

[0057] Action of generating an elastic image in such an ultrasound observation system is explained with reference to FIG. **13**. FIG. **13** is a flowchart showing elastic image extraction processing in the ultrasound observation system.

[0058] When the ultrasound observation system is set in the elastic image observation mode while executing not-shown main processing, this elastic image extraction processing is started.

[0059] Then, first, the transmitting section **11** transmits an ultrasound signal to the intra-body cavity probe **2**. Consequently, ultrasound is transmitted from the intra-body cavity probe **2** to the subject. The intra-body cavity probe **2** receives the ultrasound reflected by the subject, generates an ultrasound signal (an echo signal), and transmits the ultrasound signal to the ultrasound observation apparatus.

[0060] In the ultrasound observation apparatus, the receiving section **15** receives the ultrasound signal (the echo signal) via the transmission/reception switching section **14**, the phasing addition section **16** and the displacement calculating section **21** perform processing, thereafter, the distortion calculating section **23** calculates a distortion amount of the ROI **34** for each of coordinate positions, and the elastic-image generating section **22** generates an elastic image based on the calculated distortion amount. Such acquisition of the elastic image is performed, for example, in frame units. Consequently, the ultrasound observation apparatus acquires one or more elastic images (step S**1**).

[0061] The ultrasound observation apparatus stores the one or more elastic images acquired in this way in the memory section **24** (step S**2**).

[0062] Thereafter, the ultrasound observation apparatus selects a first elastic image out of the elastic images stored in the memory section **24** (step S**3**).

[0063] Then, the determination-region setting section **25** determines whether a size of the ROI **34** of the selected elastic image (the size of the ROI **34** can be set by, for example, the user and, when the user setting is not performed, is set to a predetermined size) is equal to or smaller than a predetermined threshold (step S**4**). For example, a center angle of the ROI **34** is determined as the size of the ROI **34**. The determination-region setting section **25** determines whether the center angle of the ROI **34** is equal to or smaller than a threshold. Note that the threshold used for the determination is desirably appropriately decided according to, for example, a size of the displacement source **36**.

[0064] FIG. **4** is a diagram showing an example of the proper-image determination region **37** set when the center angle of the ROI **34** is larger than the predetermined threshold. FIG. **5** is a diagram showing an example of the proper-image determination region **37** set when the center angle of the ROI **34** is equal to or smaller than the predetermined threshold.

[0065] As explained above, when the center angle of the ROI **34** is large, pressure from the displacement source **36** is not easily appropriately applied to the entire ROI **34**. However, when the center angle is small, appropriate pressure is considered to be applied to the entire ROI **34**.

[0066] Therefore, in a first case in which it is determined in step S**4** that the center angle of the ROI **34** for elastic image display is equal to or smaller than the predetermined threshold, the ultrasound observation apparatus performs single region processing (step S**5**). As explained with reference to FIG. **14**, the single region processing is processing for setting the entire ROI **34** as the proper-image determination region **37**.

[0067] On the other hand, in a second case in which it is determined in step S**4** that the center angle of the ROI **34** is larger than the predetermined threshold, as explained in step S**7**, step S**9**, or step S**10**, a partial region, which is a part in the ROI **34**, is set as the proper-image determination region **37**.

[0068] As a specific example, when the threshold is set to 60°, when the center angle of the ROI **34** is approximately 180° (i.e., larger than 60°) as shown in FIG. **4**, only the partial region in the ROI **34** is set as the proper-image determination region **37** and, when the center angle of the ROI **34** is approximately 30° (i.e., 60° or less) as shown in FIG. **5**, the entire ROI **34** is set as the proper-image determination region **37**.

[0069] When it is determined in step S**4** that the center angle of the ROI **34** is larger than the predetermined threshold, further, the ultrasound observation apparatus determines whether the partial region is set to be sequentially scanned (step S**6**).

[0070] When it is determined that the sequential scan is set, the ultrasound observation apparatus performs sequential scan processing (step S**7**). As explained below with reference to FIG. **15**, the sequential scan processing is processing in which the determination-region setting section **25** sequentially moves the partial region from a reference position by an offset amount at a time such that the entire ROI **34** is covered with the partial regions in all moving positions and sets each of the partial regions in the respective moving positions as the proper-image determination region **37**.

[0071] When it is determined in step S**6** that the sequential scan is not set, the ultrasound observation apparatus determines whether fixed-value division of the partial region is set (step S**8**).

[0072] When it is determined that the fixed-value division is set, the ultrasound observation apparatus performs fixed-value division processing (step S**9**). As explained below with reference to FIG. **16**, the fixed-value division processing is processing in which the determination-region setting section **25** divides the entire ROI **34** into a plurality of partial regions and sets each of the partial regions as the proper-image determination region **37** and is processing for setting the number of divisions into partial regions of the entire ROI **34** based on a fixed value.

[0073] On the other hand, when it is determined in step S**8** that the fixed-value division is not set, the ultrasound observation apparatus performs variable-value division processing (step S**10**). As explained below with reference to FIG. **17**, the variable-value division processing is processing in which the determination-region setting section **25** divides the entire ROI **34** into a plurality of partial regions and sets each of the partial regions as the proper-image determination region **37** and is processing for changing the number of divisions into the partial regions of the entire ROI **34** between a lower limit value and an upper limit value until the proper-image determination region **37** determined as the proper region by the proper-image determining section **27** is found.

[0074] When the processing in any one of step S**5**, step S**7**, step S**9**, or step S**10** is performed in this way, the ultrasound observation apparatus determines whether unprocessed other elastic images are present in the memory section **24** (step S**11**).

[0075] When it is determined that other elastic images are present, the ultrasound observation apparatus selects a next elastic image out of the unprocessed elastic images (step S**12**). Then, the ultrasound observation apparatus shifts to step S**4** and repeatedly performs the processing explained above.

[0076] When it is determined in step S**11** that unprocessed elastic images are absent, the ultrasound observation apparatus determines based on a processing result in step S**5**, step S**7**, step S**9**, or step S**10** whether proper images are present among elastic images stored in the memory section **24** (step S**13**).

[0077] When it is determined in step S**13** that proper images are present, the ultrasound observation apparatus extracts and displays all of the proper images on, for example, the image display section **31** (step S**14**). When it is determined that proper images are absent, the ultrasound observation apparatus directly returns from the elastic image extraction processing to not-shown main processing.

[0078] FIG. **14** is a flowchart showing single region processing.

[0079] When entering this processing in step S**5** of FIG. **13**, as explained above with reference to FIG. **5**, the ultrasound observation apparatus sets the entire ROI **34** for elastic image display as the proper-image determination region **37** (step S**21**).

[0080] Subsequently, the ultrasound observation apparatus calculates a region characteristic of the proper-image determination region **37** (step S**22**). The ultrasound observation apparatus determines based on the calculated region characteristic whether the set proper-image determination region **37** is a proper region (step S**23**). The ultrasound observation apparatus returns from this processing to the processing shown in FIG. **13**.

[0081] FIG. **15** is a flowchart showing the sequential scan processing.

[0082] When entering this processing in step S**7** of FIG. **13**, first, the ultrasound observation apparatus sets the proper-image determination region **37** at a predetermined angle (e.g., 60° same as the angle set as the threshold in step S**4**) as a reference position in the ROI **34** for elastic image display (step S**31**).

[0083] Subsequently, the ultrasound observation apparatus calculates a region characteristic of the proper-image determination region **37** (step S**32**) and determines based on the calculated region characteristic whether the set proper-image determination region **37** is a proper region (step S**33**).

[0084] The ultrasound observation apparatus determines whether regions not determined as to whether the regions are the proper region are present in the ROI **34** (step S**34**). When it is determined that undetermined regions are present, the ultrasound observation apparatus moves the proper-image determination region **37** by a predetermined offset amount (e.g., an offset angle 30°) in the ROI **34** and sets a new proper-image determination region **37** (step S**35**). The ultrasound observation apparatus returns to step S**32** and performs the processing explained above.

[0085] Consequently, as shown in FIGS. **6** to **8**, the sequential scan in which the proper-image determination region **37** moves by, for example, 30° at a time in order in the ROI **34** is performed. FIG. **6** is a diagram showing an example of a first position in sequentially scanning the proper-image determination region **37** in the ROI **34**. FIG. **7** is a diagram showing an example of a second position in sequentially scanning the proper-image determination region **37** in the ROI **34**. FIG. **8** is a diagram showing an example of a third position in sequentially scanning the proper-image determination region **37** in the ROI **34**.

[0086] When the scan from one end to the other end of the ROI **34** is carried out in this way and it is determined in step S**34** that undetermined regions are absent, the ultrasound observation apparatus returns from this processing to the processing shown in FIG. **13**.

[0087] FIG. **16** is a flowchart showing the fixed-value division processing.

[0088] When entering this processing in step S**9** in FIG. **13**, first, the ultrasound observation apparatus divides the ROI **34** for elastic image display into partial regions based on a fixed value (step S**41**). The fixed value is, for example, a size of a partial region (an angle of the partial region) or the number of divisions.

[0089] For example, assuming that a center angle θ of the ROI **34** is larger than 60° (because, in the case of θ≤60°, the single region processing in step S**5** is performed), the fixed value is set to an angle 60° of the partial region. In this case, when the center angle θ of the ROI **34** is, for example, 180°, as shown in FIG. **9**, the entire ROI **34** is divided into three partial regions. The respective partial regions are set as first to third proper-image determination regions **37***a* to **37***c* in order. FIG. **9** is a diagram showing an example in which the proper-image determination region is divided by a fixed value in the ROI **34**. In such a case in which the angle of the partial region is set to the fixed value, the number of divisions is different according to the center angle θ of the ROI **34** (e.g., when the center angle θ is 120°, the number of divisions is two).

[0090] When the fixed value is set to the number of divisions of three, as explained above, the ROI **34** is divided into three partial regions shown in FIG. **9** (as a desired division example, equally divided). In this case, the number of divisions is desirably given as a fixed value corresponding to a size of the center angle θ of the ROI **34**. For example, when the center angle θ is 60°<θ≤120°, the fixed value is set to two. When the center angle θ is 120°<θ≤180°, the fixed value is set to three.

[0091] Subsequently, the ultrasound observation apparatus sets a first partial region among the divided partial regions as the proper-image determination region **37** (e.g., a first proper-image determination region **37***a*) (step S**42**), calculates a region characteristic of the proper-image determination region **37** (step S**43**), and determines based on the calculated region characteristic whether the set proper-image determination region **37** is a proper region (step S**44**).

[0092] The ultrasound observation apparatus determines whether unprocessed partial regions (partial regions not determined as to whether the partial regions are the proper region) are present (step S**45**). When it is determined that unprocessed partial regions are present, the ultrasound observation apparatus sets a next partial region as a new proper-image determination region **37** (step S**46**). The ultrasound observation apparatus returns to S**43** and performs the processing explained above.

[0093] When it is determined in step S**45** that unprocessed partial regions are absent in this way, the ultrasound observation apparatus returns from this processing to the processing shown in FIG. **13**.

[0094] FIG. 17 is a flowchart showing the variable-value division processing.

[0095] When entering this processing in step S10 in FIG. 13, first, the ultrasound observation apparatus sets, as an initial value, a lower limit value ni of the number of divisions in a variable n indicating the number of divisions (step S51). The lower limit value ni is, for example, 2 (when the number of divisions is one, the single region processing in step S5 is performed. Therefore, a suitable example of the lower limit value is 2 here).

[0096] Subsequently, the ultrasound observation apparatus divides (as a desirable division example, equally divides) the ROI 34 for elastic image display into n partial regions (step S52) and sets a first partial region among the divided partial regions in the proper-image determination region 37 (step S53).

[0097] Subsequently, the ultrasound observation apparatus calculates a region characteristic of the proper-image determination region 37 (step S54) and determines based on the calculated region characteristic whether the set proper-image determination region 37 is a proper region (step S55).

[0098] The ultrasound observation apparatus determines, according to whether it is determined in step S55 that the proper-image determination region 37 is the proper region, whether a processing target elastic image is a proper image (step S56).

[0099] When it is determined that the processing target elastic image is not a proper image, the ultrasound observation apparatus determines whether unprocessed partial regions (partial regions not determined as to whether the partial regions are a proper region) are present in the ROI 34 (step S57). When it is determined that unprocessed partial regions are present, the ultrasound observation apparatus sets the next partial region as a new proper-image determination region 37 (step S58). The ultrasound observation apparatus returns to step S54 and performs the processing explained above.

[0100] On the other hand, when it is determined in step S57 that unprocessed partial regions are absent, the ultrasound observation apparatus increases the variable n indicating the number of divisions by 1 (step S59) and then determines whether n is larger than an upper limit value nf of the number of divisions (step S60).

[0101] When it is determined that n is equal to or smaller than the upper limit value nf of the number of divisions, the ultrasound observation apparatus returns to step S52 and performs, as explained above, processing based on the number of divisions n set anew.

[0102] Consequently, as shown in FIG. 10 to FIG. 12, variable-value division is performed in which the number of the proper-image determination regions 37 sequentially increases to two (37*a* and 37*b*) shown in FIG. 10, three (37*a* to 37*c*) shown in FIG. 11, and four (37*a* to 37*d*) shown in FIG. 12. FIG. 10 is a diagram showing a first division example in dividing the proper-image determination region 37 by a variable value in the ROI 34. FIG. 11 is a diagram showing a second division example in dividing the proper-image determination region 37 by a variable value in the ROI 34. FIG. 12 is a diagram showing a third division example in dividing the proper-image determination region 37 by a variable value in the ROI 34.

[0103] When it is determined in step S60 that n is larger than the upper limit value nf or it is determined in step S56 that the processing target elastic image is a proper image, the ultrasound observation apparatus returns from this processing to the processing shown in FIG. 13.

[0104] Note that the number of divisions n is changed from the lower limit value ni to the upper limit value nf. However, the number of divisions n may be changed from the upper limit value nf to the lower limit value ni. The change of the number of divisions n is not limited to these examples. The number of divisions n may be changed in appropriate order between a value equal to or larger than the lower limit value ni and a value equal to or smaller than the upper limit value nf.

[0105] Note that (1) the threshold compared with the size of the ROI 34 in step S4 of FIG. 13, (2) the angle of the proper-image determination region 37 in step S31 and the offset amount in step S35 of FIG. 15, (3) the fixed value in step S41 of FIG. 16, and (4) the lower limit value ni in step S51 and the upper limit value nf in step S60 of FIG. 17 may be automatically set based on design values or a user may manually set the values. In this case, concerning (2), (3), and (4), the determination-region setting section 25, the proper-image determining section 27, or the like may store, in advance, a table for giving predetermined values corresponding to the size of the center angle of the ROI 34. The ultrasound observation apparatus may determine the respective values referring to the table based on the size of the center angle of the ROI 34 set by the user or the like.

[0106] In the above explanation, which processing of the single region processing in step S5, the sequential scan of step S7, the fixed-value division of step S9, and the variable-value division of step S10 is performed is automatically set. However, the user may manually select the processing.

[0107] Further, in the respective kinds of processing explained above, when it is determined that the proper-image determination region 37 is a proper region, the proper-image determining section 27 may further superimposes a region determined as a proper region on the elastic image, cause the image display section 31 to display the region, and clearly indicate the region to the user. In this case, the proper-image determining section 27 generates a signal for superimposing and displaying the proper-image determination region 37 determined as proper on the elastic image and transmits the signal to the image display section 31.

[0108] In the above explanation, the intra-body cavity probe 2 is explained as an example. However, the present invention is not limited to this. The ultrasound probe may be an external ultrasound probe. When the ultrasound probe is the external ultrasound probe, specifically, a linear ultrasound probe, the threshold compared with the size of the ROI 34 in step S4 of FIG. 13 only has to be, for example, length in a linear scan direction.

[0109] According to such a first embodiment, the proper-image determination region 37 is set according to the size of the ROI 34. It is determined based on the region characteristic of the proper-image determination region 37 whether the elastic image is a proper image. Therefore, it is possible to automatically extract a proper image without depending on the size of the ROI 34.

[0110] When the size of the ROI 34 is equal to or smaller than the threshold, the entire ROI 34 is set as the proper-image determination region 37. When the size of the ROI 34 is larger than the threshold, the partial region is set as the proper-image determination region 37. Therefore, it is possible to perform appropriate determination according to the size of the displacement source 36.

[0111] Further, when the sequential scan is performed, it is possible to perform appropriate determination without depending on the position of the displacement source **36** with respect to the ROI **34**.

[0112] When the fixed-value division is performed, it is possible to perform appropriate determination not depending on the position of the displacement source **36** without requiring the processing for moving the proper-image determination region **37**.

[0113] On the other hand, when the variable-value division is performed, it is possible to cope with a change in a size of a region that receives pressure from the displacement source **36**.

[0114] When at least one of the average, the dispersion, and the deviation of the displacement and the average, the dispersion, and the deviation of the elasticity information of the proper-image determination region **37** is calculated as the region characteristic, it is possible to perform appropriate determination corresponding to the displacement or the elasticity information.

[0115] Further, when at least one of the number of colored pixels and the total area of the colored pixels of the proper-image determination region **37**, the ratio of the number of colored pixels to the number of pixels of the entire proper-image determination region **37**, and the ratio of the total area of the colored pixels to the area of the entire proper-image determination region **37** is calculated as the region characteristic, it is possible to perform appropriate determination using the colored pixels.

[0116] When at least one of the average of the pressure, the rate of change of the pressure, the dispersion of the pressure, and the deviation of the pressure of the proper-image determination region **37** is calculated as the region characteristic, it is possible to perform appropriate determination corresponding to the pressure.

[0117] In addition, the proper-image determination region **37** determined as proper is superimposed and displayed on the elastic image. Therefore, the user can easily check the proper-image determination region **37**, based on which the elastic image is determined as the proper image.

[0118] Note that, in the above explanation, the ultrasound observation system including the ultrasound observation apparatus is mainly explained. However, the present invention may be an actuation method for actuating the ultrasound observation apparatus or the ultrasound observation system as explained above, a processing program for causing a computer to actuate the ultrasound observation apparatus or the ultrasound observation system as explained above, a nontransitory recording medium that records the processing program and is readable by the computer, and the like.

[0119] The present invention is not limited to the embodiment per se. In an implementation stage, the constituent elements can be modified and embodied in a range not departing from the spirit of the present invention. Forms of various inventions can be formed by appropriate combinations of the plurality of constituent elements disclosed in the embodiment. For example, several constituent elements can be deleted from all the constituent elements described in the embodiments. Further, the constituent elements described in different embodiments may be combined as appropriate. In this way, it goes without saying that various modifications and applications are possible in a range not departing from the spirit of the invention.

What is claimed is:

1. An ultrasound observation apparatus that generates an ultrasound image based on an ultrasound signal generated from ultrasound transmitted to a subject and reflected, the ultrasound observation apparatus comprising:

a transmitting section that transmits a driving signal for generating the ultrasound transmitted to the subject;

a receiving section that receives the ultrasound signal generated from the ultrasound reflected by the subject;

a displacement calculating section that measures displacement of the subject based on the ultrasound signal received by the receiving section;

an elastic-image generating section that generates an elastic image based on the displacement measured by the displacement calculating section;

a storing section that stores one or more of the elastic images generated by the elastic-image generating section;

a determination-region setting section that sets, according to a size of an ROI, which is a region of interest, a proper-image determination region for determining a proper image out of the one or more elastic images stored in the storing section;

a characteristic calculating section that calculates a region characteristic of the proper-image determination region; and

a proper-image determining section that determines based on the region characteristic whether the elastic image in which the proper-image determination region is set is the proper image.

2. The ultrasound observation apparatus according to claim **1**, wherein the determination-region setting section sets the entire ROI as the proper-image determination region in a first case in which the size of the ROI is equal to or smaller than a threshold and sets a partial region, which is a part of the ROI, as the proper-image determination region in a second case in which the size of the ROI is larger than the threshold.

3. The ultrasound observation apparatus according to claim **2**, wherein, in the second case, the determination-region setting section sequentially moves the partial region from a reference position by an offset amount at a time such that the entire ROI is covered with the partial regions in all moving positions and sets each of the partial regions in the respective moving positions as the proper-image determination region.

4. The ultrasound observation apparatus according to claim **2**, wherein, in the second case, the determination-region setting section divides the entire ROI into the partial region in plurality and sets each of the partial regions as the proper-image determination region.

5. The ultrasound observation apparatus according to claim **4**, wherein a number of divisions into the partial regions of the entire ROI is set based on a fixed value.

6. The ultrasound observation apparatus according to claim **4**, wherein the determination-region setting section changes a number of divisions into the partial regions of the entire ROI between a value equal to or larger than a lower limit value and a value equal to or smaller than an upper limit value until the proper-image determination region determined as proper by the proper-image determining section is found.

7. The ultrasound observation apparatus according to claim **1**, wherein the proper-image determining section determines based on the region characteristic whether the proper-image determination region is proper and, when it is determined that one or more of the proper-image determination region is proper, determines that the elastic image in which the proper-image determination region is set is a proper image.

8. The ultrasound observation apparatus according to claim **1**, wherein the characteristic calculating section calculates, as the region characteristic, at least one of an average of displacement of the proper-image determination region measured by the displacement calculating section, dispersion of the displacement, and a deviation of the displacement and an average of elasticity information of the proper-image determination region calculated by the elastic-image generating section, dispersion of the elasticity information, and a deviation of the elasticity information.

9. The ultrasound observation apparatus according to claim **1**, wherein

the elastic-image generating section further calculates a distortion amount of the ROI based on displacement measured by the displacement calculating section and performs coloring on pixels of the elastic image, the distortion amount of which is equal to or larger than a predetermined value, and

the characteristic calculating section calculates, as the region characteristic, at least one of a number of the colored pixels and a total area of the colored pixels of the proper-image determination region, a ratio of the number of colored pixels to a number of pixels of the entire proper-image determination region, and a ratio of a total area of the colored pixels to an entire area of the proper-image determination region.

10. The ultrasound observation apparatus according to claim **1**, wherein the proper-image determining section further generates a signal for superimposing and displaying the proper-image determination region determined as proper on the elastic image.

11. An ultrasound observation system comprising:

the ultrasound observation apparatus according to claim **1**; and

an ultrasound probe that receives the driving signal transmitted from the transmitting section, transmits the ultrasound to the subject, receives the ultrasound reflected by the subject, generates the ultrasound signal, and transmits the ultrasound signal to the receiving section.

12. The ultrasound observation system according to claim **11**, wherein the ultrasound probe further comprises a pressure detecting section for detecting pressure on an ultrasound transmission/reception surface for transmitting and receiving the ultrasound, and

the characteristic calculating section calculates, as the region characteristic, at least one of an average of pressure, a rate of change of the pressure, dispersion of the pressure, and a deviation of the pressure of the proper-image determination region obtained based on a detection result of the pressure detecting section.

13. An actuation method for an ultrasound observation apparatus that generates an ultrasound image based on an ultrasound signal generated from ultrasound transmitted to a subject and reflected, the actuation method for the ultrasound observation apparatus comprising:

a step in which a transmitting section transmits a driving signal for generating the ultrasound transmitted to the subject;

a step in which a receiving section receives the ultrasound signal generated from the ultrasound reflected by the subject;

a step in which a displacement calculating section measures displacement of the subject based on the ultrasound signal received by the receiving section;

a step in which an elastic-image generating section generates an elastic image based on the displacement measured by the displacement calculating section;

a step in which a storing section stores one or more of the elastic images generated by the elastic-image generating section;

a step in which a determination-region setting section sets, according to a size of an ROI, which is a region of interest, a proper-image determination region for determining a proper image out of the one or more elastic images stored in the storing section;

a step in which a characteristic calculating section calculates a region characteristic of the proper-image determination region; and

a step in which a proper-image determining section determines based on the region characteristic whether the elastic image in which the proper-image determination region is set is the proper image.

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