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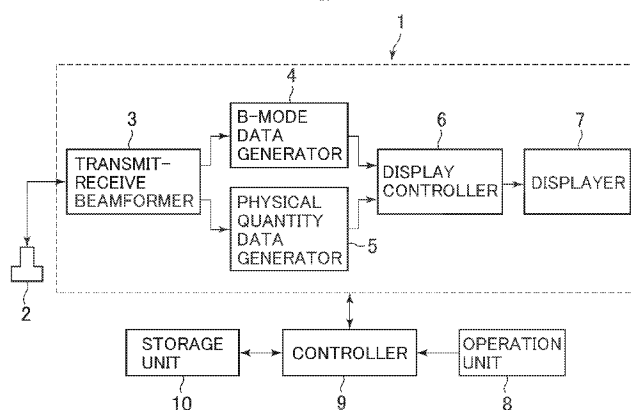
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(54) Title: ULTRASONIC DIAGNOSTIC APPARATUS AND CONTROL PROGRAM THEREOF

FIG. 1



(57) Abstract: The ultrasonic diagnostic apparatus is equipped with an elastic image data generating unit which generates elastic image data having color information corresponding to strain calculated by a physical quantity data generating unit, and a displayer which causes an elastic image having a color corresponding to the strain to be displayed on an ultrasound image of the biological tissue, based on the elastic image data. The elastic image data generating unit generates the elastic image data, based on a color conversion table TA which is indicative of information of association of strain and the color information with each other and in which the color information changes depending on strain in a predetermined range X of strain set in advance. The displayer displays an elasticity index image indicating an elasticity index In indicative of a relative relationship of an average value Stav of strain in a region set to the ultrasound image and the predetermined range X of strain.



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ULTRASONIC DIAGNOSTIC APPARATUS AND CONTROL PROGRAM THEREOF

BACKGROUND

[0001] The present invention relates to an ultrasonic diagnostic apparatus which displays an elastic image indicative of the hardness or softness of a biological tissue in a subject, and a control program thereof.

[0002] An ultrasonic diagnostic apparatus which combines a normal B-mode image and an elastic image indicative of the hardness or softness of a biological tissue in a subject together and displays the result of combination, has been disclosed in, for example, Japanese Patent Publication No. 2007-282932 or the like. The elastic image is generated in the following manner, for example. A physical quantity related to the elasticity of the subject is first calculated based on echo signals obtained by transmitting ultrasound to the subject. The physical quantity is strain, for example. An elastic image comprised of a color corresponding to the elasticity is generated based on the calculated physical quantity and displayed.

[0003] Meanwhile, there has recently been a demand for evaluation of a liver disease by an ultrasonic diagnostic apparatus capable of displaying an elastic image. Here, as for a diffuse liver disease, the elasticity of a liver may change in entirety without changing locally. Even in such a case, it has been desired that the elasticity of a biological tissue is recognized by the ultrasonic diagnostic apparatus to properly perform the evaluation of the disease.

BRIEF SUMMARY OF THE INVENTION

[0004] The invention made to solve the above problems is an ultrasonic diagnostic apparatus which is equipped with a physical quantity calculating unit which calculates a physical quantity related to elasticity of each part in a biological tissue, based on echo signals obtained by transmission/reception of ultrasound to and from the biological tissue, an elastic image data generating unit which generates elastic image data having information indicative of a display form corresponding to the physical quantity calculated by the physical quantity calculating unit, and a displayer which causes an elastic image having the display form corresponding to the physical quantity to be displayed on an ultrasound image of the biological tissue, based on the elastic

image data. In the ultrasonic diagnostic apparatus, the elastic image data generating unit generates the elastic image data, based on information, the information being information in which the physical quantity and the information indicative of the display form are associated with each other, and in which the information indicative of the display form changes depending on a physical quantity in a prescribed range of physical quantities set in advance. The displayer displays an elasticity index image indicating an elasticity index indicative of a relative relationship between a typical value representative of a physical quantity in a region set to the ultrasound image and the prescribed range of physical quantities.

[0005] According to the invention of the above aspect, since an elasticity index image indicating an elasticity index indicative of a relative relationship between a typical value representative of a physical quantity in a region set to the ultrasound image and the prescribed range of physical quantities is displayed, the elasticity of a biological tissue can be shown in a quantified form. It is thus possible to recognize the elasticity of the biological tissue and properly perform the evaluation of a disease.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a block diagram showing one example of a schematic configuration of an embodiment of an ultrasonic diagnostic apparatus according to the present invention.

[0007] FIG. 2 is a block diagram illustrating a configuration of a display controller in the ultrasonic diagnostic apparatus shown in FIG. 1.

[0008] FIG. 3 is a diagram depicting one example of a composite ultrasound image displayed on a displayer.

[0009] FIG. 4 is a diagram showing one example of a color conversion table.

[0010] FIG. 5 is a diagram illustrating one example of an elasticity index in a strain range to which a slope part of the color conversion table is set.

[0011] FIG. 6 is a diagram for describing a comparative example in which a color conversion table is set according to a distribution of strain.

[0012] FIG. 7 is a diagram for describing a comparative example in which a color conversion table is set according to a distribution of strain.

[0013] FIG. 8 is a diagram showing a color conversion table and elasticity indices in different strain distributions.

[0014] FIG. 9 is a diagram illustrating the displayer on which an elasticity index bar is displayed in a modification of the first embodiment.

[0015] FIG. 10 is a diagram showing the displayer in a second embodiment.

[0016] FIG. 11 is a diagram illustrating the displayer in a modification of the second embodiment.

[0017] FIG. 12 is a diagram showing another example of an elasticity index image.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Embodiments of the present invention will hereinafter be described based on the accompanying drawings.

[0019] A first embodiment will first be explained based on FIGS. 1 through 8. An ultrasonic diagnostic apparatus 1 shown in FIG. 1 is equipped with an ultrasonic probe 2, a transmit-receive beamformer 3, a B-mode data generator 4, a physical quantity data generator 5, a display controller 6, a displayer 7, an operation unit 8, a controller 9 and a storage unit 10.

[0020] The ultrasonic probe 2 transmits ultrasound to a subject and receives its echoes. The transmit-receive beamformer 3 drives the ultrasonic probe 2 under a predetermined scan condition to perform the scanning of the ultrasound every sound ray. Also, the transmit-receive beamformer 3 performs signal processing such as phasing-adding processing on each echo received by the ultrasonic probe 2. Echo data subjected to the signal processing by the transmit-receive beamformer 3 is outputted to the B-mode data generator 4 and the physical quantity data generator 5. The transmit-receive beamformer 3 is one example illustrative of an embodiment of transmit-receive beamformer in the present invention.

[0021] The B-mode data generator 4 performs B-mode processing such as logarithmic compression

processing, envelop detection processing or the like on the echo data outputted from the transmit-receive beamformer 3 to thereby generate B-mode data. The B-mode data may be stored in the storage unit 10.

[0022] The physical quantity data generator 5 calculates a physical quantity related to the elasticity of each portion in the subject, based on the echo data outputted from the transmit-receive beamformer 3 to generate physical quantity data (physical quantity calculating function). As described in, for example, Japanese Unexamined Patent Publication No. 2008-126079, the physical quantity data generator 5 sets correlation windows to echo data different in time on the same sound ray at one scanning surface. The physical quantity data generator 5 performs a correlation computation between the correlation windows to calculate a physical quantity related to the elasticity for each pixel, thereby generating physical quantity data corresponding to one frame. Accordingly, the physical quantity data corresponding to one frame is obtained from echo data corresponding to two frames, and an elastic image is generated as will be described later.

[0023] The physical quantity data generator 5 calculates strain as the physical quantity related to the elasticity in the present embodiment. That is, the physical quantity data is data about the strain. In the present embodiment, as will be described later, strain is calculated by the deformation of the liver due to the pulsation of the heart or blood vessels. The physical quantity data generator 5 is one example illustrative of an embodiment of a physical quantity calculating unit in the present invention. The physical quantity calculating function is one example illustrative of an embodiment of a physical quantity calculating function in the present invention.

[0024] The physical quantity data may be stored in the storage unit 10.

[0025] The display controller 6 is inputted with the B-mode data from the B-mode data generator 4 and the physical quantity data from the physical quantity data generator 5. As shown in FIG. 2, the display controller 6 has a B-mode image data generating unit 61, an elastic image data generating unit 62, an average value calculating unit 63, an elasticity index calculating unit 64, an elasticity index image generating unit 65, and an image display control unit 66.

[0026] The B-mode image data generating unit 61 performs scan conversion based on a scan converter on the B-mode data to convert it to B-mode image data having information indicative of brightness corresponding to the signal intensity of each echo. The B-mode image data has information indicative of brightness of 256 levels of gray, for example.

[0027] The elastic image data generating unit 62 converts the physical quantity data to information indicative of colors and performs scan conversion based on the scan converter to generate color elastic image data having information indicative of colors corresponding to strain (color elastic image data generating function). The elastic image data generating unit 62 brings physical quantity data into gradation and generates color elastic image data comprised of information indicative of colors assigned to respective gradations. The details thereof will be described later. The elastic image data generating unit 62 is one example illustrative of an embodiment of an elastic image data generating unit in the present invention. The color elastic image data is one example illustrative of an embodiment of elastic image data having information indicative of a display form corresponding to a physical quantity in the present invention. The information indicative of the display form is information indicative of each color in the present embodiment. The color elastic image data generating function is one example illustrative of an embodiment of an elastic image data generating function in the present invention.

[0028] The average value calculating unit 63 calculates an average value $Stav$ of strain calculated by the physical quantity data generating unit 5 in a region R (refer to FIG. 3) set to a B-mode image BI as will be described later. This average value $Stav$ of strain is one example illustrative of an embodiment of a typical value representative of a physical quantity of a region in the present invention. The average value calculating unit 63 is one example illustrative of an embodiment of a typical value calculating unit in the present invention.

[0029] The elasticity index calculating unit 64 calculates an elasticity index. The elasticity index is an index of the elasticity of a biological tissue in the region R. The elasticity index image generating unit 65 generates an elasticity index image indicative of the elasticity index calculated by the elasticity index calculating

unit 64. The details thereof will be explained later. The elasticity index calculating unit 64 is one example illustrative of an embodiment of an elasticity index calculating unit in the present invention. The elasticity index image generating unit 65 is one example illustrative of an embodiment of an elasticity index image generating unit in the present invention.

[0030] The image display control unit 66 combines the B-mode image data and the color elastic image data together and generates image data of a composite ultrasound image displayed on the displayer 7. The image display control unit 66 causes the displayer 7 to display the image data as a composite ultrasound image UI obtained by combining a B-mode image BI and an elastic image EI (refer to FIG. 3). The elastic image EI is displayed in the region R set to the B-mode image BI.

[0031] The B-mode image data and the color elastic image data may be stored in the storage unit 10. The image data of the composite ultrasound image may be stored in the storage unit 10.

[0032] The image display control unit 66 causes the displayer 7 to display an elasticity index image InI indicative of the elasticity index generated by the elasticity index image generating unit 65 along with the composite ultrasound image UI (refer to FIG. 3). The image display control unit 66 is one example illustrative of an embodiment of an image display control unit in the present invention and performs an image display control function in the present invention.

[0033] The displayer 7 is comprised of, for example, an LCD (Liquid Crystal Display), a CRT (Cathode Ray Tube) or the like. The displayer 7 is one example illustrative of an embodiment of a displayer in the present invention.

[0034] The operation unit 8 includes a keyboard and a pointing device (not shown) or the like for inputting instructions and information by an operator.

[0035] The controller 9 is comprised of a CPU (Central Processing Unit). The controller 9 reads a control program stored in the storage unit 10 to execute functions at the respective parts of the ultrasonic diagnostic apparatus 1, starting with the physical quantity calculating function, the color elastic image data

generating function and the image display control function.

[0036] The storage unit 10 is, for example, an HDD (Hard Disk Drive), or a semiconductor memory such as a RAM (Random Access Memory), a ROM (Read Only Memory) or the like.

[0037] A description will now be made of the operation of the ultrasonic diagnostic apparatus 1 according to the present embodiment. The transmit-receive beamformer 3 causes the ultrasonic probe 2 to transmit ultrasound to a biological tissue of a subject. In the present embodiment, the ultrasound is transmitted to the liver of the subject by the ultrasonic probe 2.

[0038] The transmit-receive beamformer 3 may cause the ultrasonic probe 2 to alternately transmit ultrasound for generating a B-mode image and ultrasound for generating an elastic image. Echo signals of ultrasound transmitted from the ultrasonic probe 2 are received by the ultrasonic probe 2.

[0039] Here, the liver is repeatedly deformed depending on the pulsation of the heart or blood vessels. A composite ultrasound image that has taken deformation as strain is generated based on echo signals obtained from the liver in which such deformation has been repeated. Specifically, when the echo signals are captured, the B-mode data generator 4 generates B-mode data, and the physical quantity data generator 5 calculates strain to generate physical quantity data. Further, the B-mode image data generating unit 61 generates B-mode image data, based on the B-mode data, and the elastic image data generating unit 62 generates color elastic image data, based on the physical quantity data. Then, the image display control unit 66 causes the displayer 7 to display a composite ultrasound image UI in which a B-mode image BI based on the B-mode image data and an elastic image EI based on the color elastic image data are combined, as shown in FIG. 3. The composite ultrasound image UI is a real-time image. The elastic image EI is displayed within a region R (shown in dots).

[0040] The image display control unit 66 causes the displayer 7 to display the elasticity index image InI as shown in FIG. 3. The elasticity index image InI includes an elasticity index graph G indicative of changes in elasticity index with time. The details thereof will be described later.

[0041] A description will be made of the generation of the color elastic image data. The elastic

image data generating unit 62 converts the physical quantity data to information indicative of colors (hereinafter called “color information”), based on a color conversion table TA to thereby generate the color elastic image data comprised of color information corresponding to a physical quantity. The color information is one example illustrative of an embodiment of information indicative of a display form in the present invention.

[0042] The color conversion table TA will be explained. The color conversion table TA is information in which strain and color information are associated with each other. Color information converted by this color conversion table TA is a prescribed number of gradations (0 to N). For example, the number of gradations is 256 ($N = 255$).

[0043] The color conversion table TA can be shown in the graph shown in FIG. 4, for example. The color conversion table TA shown in FIG. 4 takes the form of a graph having a slope part S1 and a horizontal part Hr. In the present embodiment, a predetermined range X of strain extending from zero to strain St_{max} corresponds to the slope part S1.

[0044] In the slope part S1, the color information is set so as to change stepwise depending on the strain. For example, the gradation 0 is color information indicative of blue, and the gradation N is color information indicative of red. The gradation $N/2$ being gradation in the middle between the gradation 0 and the gradation N is color information indicative of green. In this case, the color changes from blue to green between the gradation 0 and the gradation $N/2$, and the color changes from green to red between the gradation $N/2$ and the gradation N. The predetermined strain range X is one example illustrative of a predetermined range of physical quantities in the present invention.

[0045] The maximum value St_{max} of strain in the predetermined strain range X is converted to the gradation N. Strain greater than or equal to the maximum value St_{max} is converted to the gradation N. That is, strain is converted to the gradation N at the horizontal part Hr. Thus, the strain greater than or equal to the maximum value St_{max} is represented in the same color (e.g., red) at an elastic image.

[0046] The predetermined strain range X is set in advance to a range of values of strain that the liver

being targeted for the display of an elastic image can take according to the deformation of the liver due to the pulsation of the heart or blood vessels. For example, the predetermined strain range X is set to such a range that it includes from the value of strain of the normal liver to the value of strain of a liver of cirrhosis.

[0047] The elasticity index graph G will next be explained. The elasticity index graph G is a graph indicative of time changes in elasticity index In. The elasticity index In indicates a relative relationship between the average value Stav of strain in the region R and the predetermined range X of strain. This relative relationship means a position relationship of the average value Stav to the predetermined strain range X. Thus, the elasticity index In indicates in which position the average value Stav exists with respect to the predetermined strain range X.

[0048] The elasticity index In is calculated by the elasticity index calculating unit 64. Specifically, the elasticity index In is calculated by the following equation (1):

$$In = (\text{Average value Stav} / \text{Maximum value Stmax}) \times 100 \dots (1)$$

[0049] The elasticity index In is a numeric value with a percent (%) as a unit. As shown in FIG. 5, for example, when the average value Stav of strain is of the central value of the strain range X, the elasticity index In is 50%. It is able to recognize from such an elasticity index In in which position the average value Stav of strain exists within the strain range X. It is able to grasp whether the elasticity of the region is hard or soft.

[0050] Incidentally, when the average value Stav of strain is larger than the maximum value Stmax ($\text{Stav} > \text{Stmax}$), the elasticity index In is taken as 100%.

[0051] Here, as an example compared with the present embodiment, a description will be made of a case where a color conversion table TA' is assumed to be set according to the distribution of strain in the region R to generate elastic image data. In FIG. 6, reference numeral D1 indicates the distribution of strain in the region R. The strain distribution D1 is a distribution of strain in the region R at a given frame.

[0052] In the color conversion table TA', a slope part S1' is set to a predetermined strain range X' on

the basis of an average value $Stav1$ of strain in the strain distribution $D1$. Here, when the strain distribution $D1$ of FIG. 6 is taken as the normal liver, for example, the average value $Stav1$ is represented in green in an elastic image EI . On the other hand, assuming that a strain distribution $D2$ shown in FIG. 7 is a strain distribution about a liver hardened over its entirety, a slope part Sl' is set to a predetermined strain range X' on the basis of an average value $Stav2$ of strain in the strain distribution $D2$. Even in the elastic image EI generated based on the color conversion table TA' to which such a slope part Sl' is set, the average value $Stav2$ is represented in green in the elastic image EI . Thus, when the color conversion table TA' is set according to the distribution of strain, there is no difference in elastic image between the liver hardened over its entirety like cirrhosis and the normal liver.

[0053] On the other hand, as in the present embodiment, the strain range to which the slope part Sl of the color conversion table TA is set, is fixed to a predetermined strain range X . The elastic index In indicative of the average value being located in any position is calculated in the range X . Therefore, the elastic index In becomes different values between the liver hardened over its entirety like cirrhosis and the normal liver. As shown in FIG. 8, for example, an elastic index $In1$ of an average value $Stav1$ of strain in the strain distribution $D1$ (the same strain distribution as in FIG. 6), and an elastic index $In2$ of an average value $Stav2$ of strain in the strain distribution $D2$ (the same strain distribution as in FIG. 7) become different values ($In1 > In2$).

[0054] The elasticity index In is calculated for each frame of the elastic image EI . The elasticity index image generating unit 65 generates an elasticity index graph G indicative of time changes in the elasticity index In . The elasticity index graph G is displayed on the displayer 7 by the image display control unit 66.

[0055] The elasticity index image InI including the elasticity index graph G will be explained. The elasticity index image InI has a left line $L1$ (line), a right line $R1$, a zero point mark M , and an indication line $F1$ in addition to the elasticity index graph G . The elasticity index graph G is represented between the left line $L1$ and the right line $R1$. Between the left line $L1$ and the right line $R1$, the vertical direction indicates the size of an elasticity index In , and the horizontal direction indicates time. The zero point mark M means that the

elasticity index In is 0%. The upper ends of the left line L1 and the right line R1 means that the elasticity index is 100%.

[0056] A point of intersection of the indication line F1 and the elasticity index graph G indicates an elasticity index In of an elastic image EI displayed on the displayer 7 at present. The indication line F1 moves in the right direction with the elapse of time. With the movement of the indication line F1, the elasticity index graph G is updated.

[0057] According to the present embodiment as described above, since the elasticity index graph G is displayed, the elasticity of a biological tissue can be shown in a quantified form. It is able to recognize by the elasticity index graph G, time changes in the strain of the biological tissue, repeated according to the heart rate or the pulsation of blood vessels, for example. It is thus possible to perform the evaluation of a disease in detail.

[0058] A modification of the first embodiment will next be explained. In this modification, an elasticity index bar Ba is displayed as the elasticity index image InI as shown in FIG. 9. The elasticity index bar Ba is displayed at a part of which the background is black, and has a colored part C1 and a white part Wh. The length of the colored part C1 indicates the value of the elasticity index In. If the elasticity index In is 50%, for example, the colored part C1 becomes half of the overall length of the elasticity index bar Ba, and the white part Wh also becomes half of the overall length of the elasticity index bar Ba.

[0059] In the colored part C1, the color thereof may be changed depending on the value of the elasticity index In. When the elasticity index In is greater than or equal to 0% and less than 30%, for example, the colored part C1 may be blue. When the elasticity index In is greater than or equal to 30% and less than 60%, the colored part C1 may be green. When the elasticity index In is greater than or equal to 60% and less than or equal to 100%, the colored part C1 may be red. The above numerical range and colors are however one example and not limited to the above.

[0060] As in this modification, the elasticity of a biological tissue can be shown in a quantified form

even by the display of the elasticity index bar Ba.

[0061] A second embodiment will next be described. Description of the same items as those in the first embodiment is however omitted.

[0062] In the present embodiment, as shown in FIG. 10, a first region R1 is set to a B-mode image BI displayed on the displayer 7. Further, a second region R2 is set to within the first region R1. The image EI is displayed in the first region R1 including the second region R2. For example, the second region R2 is set to a region that an operator takes interest in particularly within the first region R1.

[0063] In the present embodiment, the elasticity index calculating unit 64 calculates a first elasticity index In1 indicative of in which position an average value StavR1 of strain in the first region R1 exists within the predetermined strain range X, by the following (equation 2):

$$\text{In1} = (\text{Average value StavR1} / \text{Maximum value Stmax}) \times 100 \dots (2)$$

[0064] Also the elasticity index calculating unit 64 calculates a second elasticity index In2 indicative of in which position an average value StavR2 of strain in the second region R2 exists within the predetermined strain range X, by the following (equation 3):

$$\text{In2} = (\text{Average value StavR2} / \text{Maximum value Stmax}) \times 100 \dots (3)$$

[0065] The elasticity index image generating unit 65 generates a first elasticity index graph G1 indicative of time changes in the first elasticity index In1. Also the elasticity index image generating unit 65 generates a second elasticity index graph G2 indicative of time changes in the second elasticity index In2.

[0066] The image display control unit 66 causes the displayer 7 to display a first elasticity index image InI1 and a second elasticity index image InI2 as the elasticity index image InI as shown in FIG. 10. The first elasticity index image InI1 includes the first elasticity index graph G1 indicative of the time changes in the first elasticity index In1. The second elasticity index image InI2 includes the second elasticity index graph G2 indicative of the time changes in the second elasticity index In2. The first elasticity index image InI1 and the second elasticity index image InI2 are identical in configuration to the elasticity index image InI of the first

embodiment, and their detailed description is therefore omitted.

[0067] According to the present embodiment described above, since the first elasticity index graph G1 and the second elasticity index graph G2 are displayed with respect to the first region R1 and the second region R2, the elasticity of the biological tissue in the two regions can be displayed in the quantified form. Time changes in the strain of the biological tissue in the two regions can be recognized by the first elasticity index graph G1 and the second elasticity index graph G2. It is thus possible to perform the evaluation of a disease in detail.

[0068] A modification of the second embodiment will next be explained. In this modification, as with the modification of the first embodiment, as shown in FIG. 11, a first elasticity index bar Ba1 may be displayed as the first elasticity index image In1, and a second elasticity index bar Ba2 may be displayed as the second elasticity index image In2. The first elasticity index bar Ba1 is an image indicative of the value of the first elasticity index In1. The second elasticity index bar Ba2 is an image indicative of the value of the second elasticity index In2. The first elasticity index bar Ba1 and the second elasticity index bar Ba2 are identical in configuration to the elasticity index bar Ba in the modification of the first embodiment, and their detailed description is therefore omitted.

[0069] Although the present invention has been described above by the respective embodiments, it is needless to say that the present invention can be changed in various ways within the scope that does not change the gist of the invention. For example, although the elasticity index In is taken as 100% where the average value $Stav$ of strain becomes larger than the maximum value $Stmax$ in the above embodiment, the value obtained in each of the above equations (1), (2) and (3) may be defined as an elasticity index as it is. Accordingly, the value that exceeds 100% may be calculated as an elasticity index.

[0070] The elasticity index image InI may be a numeric value indicative of the value of an elasticity index In as shown in FIG. 12.

[0071] Further, in the second embodiment, the elasticity index image InI2 may be displayed only with

respect to the region R2.

[0072] In the above equations (1) through (3), their common denominators are numeric values each indicative of the size of the range X of strain. When the minimum value of the strain range X is not zero, the difference between the maximum value of the strain range X and its minimum value becomes a common denominator.

[0073] The composite ultrasound image UI is not limited to the real-time image, but may be an image based on the data stored in the storage unit 10.

[0074] This written description uses examples to disclose the present invention, including the best mode, and also to enable any person skilled in the art to practice the present invention, including making and using any computing system or systems and performing any incorporated methods. The patentable scope of the present invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

CLAIMS

What is Claimed Is:

1. An ultrasonic diagnostic apparatus comprising:
a physical quantity calculating unit which calculates a physical quantity related to elasticity of each part in a biological tissue, based on echo signals obtained by transmission/reception of ultrasound to and from the biological tissue;
an elastic image data generating unit which generates elastic image data, having information indicative of a display form corresponding to the physical quantity calculated by the physical quantity calculating unit; and
a displayer which causes an elastic image having the display form corresponding to the physical quantity to be displayed on an ultrasound image of the biological tissue, based on the elastic image data,
wherein the elastic image data generating unit generates the elastic image data, based on information, said information being information in which the physical quantity and the information indicative of the display form are associated with each other, and in which the information indicative of the display form changes depending on a physical quantity in a prescribed range of physical quantities set in advance, and
wherein the displayer displays an elasticity index image indicating an elasticity index indicative of a relative relationship between a typical value representative of a physical quantity in a region set to the ultrasound image and the prescribed range of physical quantities.
2. The ultrasonic diagnostic apparatus according to claim 1, including a typical value calculating unit which calculates the typical value.
3. The ultrasonic diagnostic apparatus according to claim 1 or 2, including an elasticity index calculating unit which calculates the elasticity index.

4. The ultrasonic diagnostic apparatus according to any one of claims 1 to 3, including an elasticity index image generating unit which generates the elasticity index image.
5. The ultrasonic diagnostic apparatus according to any one of claims 1 to 4, wherein the typical value representative of the physical quantity in the region is an average value of the physical quantity in the region.
6. The ultrasonic diagnostic apparatus according to claim 5, wherein the elasticity index is a value obtained from division of the average value by a maximum value in the prescribed range of physical quantities.
7. The ultrasonic diagnostic apparatus according to any one of claims 1 to 6, wherein the prescribed range of physical quantities is a range set as a range of physical quantities available at a biological tissue targeted for displaying the elastic image.
8. The ultrasonic diagnostic apparatus according to any one of claims 1 to 7, wherein the elastic image is an image having a color corresponding to the physical quantity.
9. The ultrasonic diagnostic apparatus according to any one of claims 1 to 8, wherein the elasticity index image includes a graph indicative changes in the elasticity index with time.
10. The ultrasonic diagnostic apparatus according to any one of claims 1 to 8, wherein the elasticity index image includes a bar in which the value of the elasticity index is shown in length.
11. The ultrasonic diagnostic apparatus according to any one of claims 1 to 8, wherein the

elasticity index image is a numeral indicative of the value of the elasticity index.

12. The ultrasonic diagnostic apparatus according to any one of claims 1 to 11, wherein the elastic image is displayed in the region.

13. The ultrasonic diagnostic apparatus according to any one of claims 1 to 11, wherein the region is set to within the elastic image.

14. The ultrasonic diagnostic apparatus according to any one of claims 1 to 11, wherein the region is a region in which an elastic image is displayed and a region set to within an elastic image, and wherein the elasticity index image is displayed with respect to each of said two regions.

FIG. 1

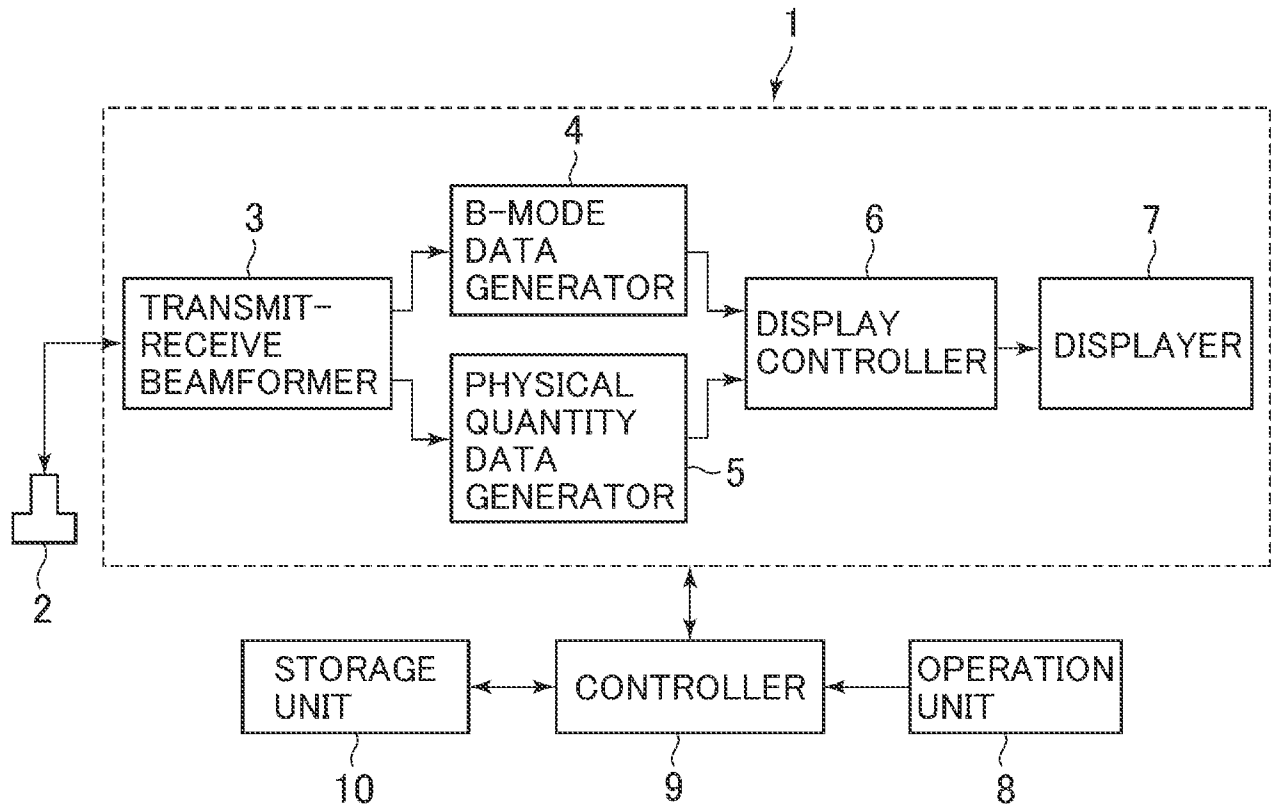


FIG. 2

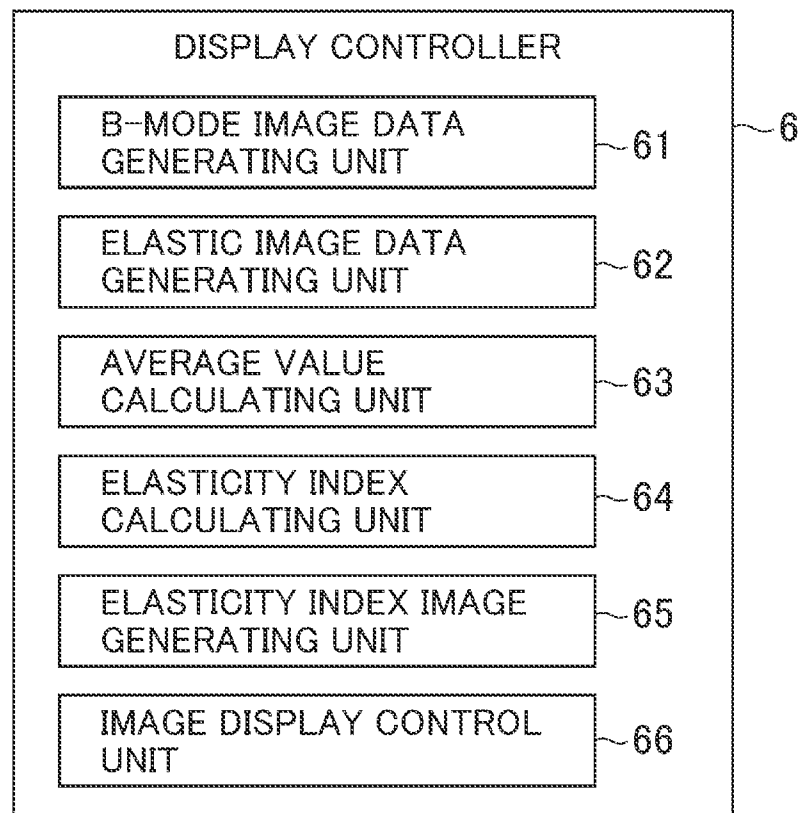


FIG. 3

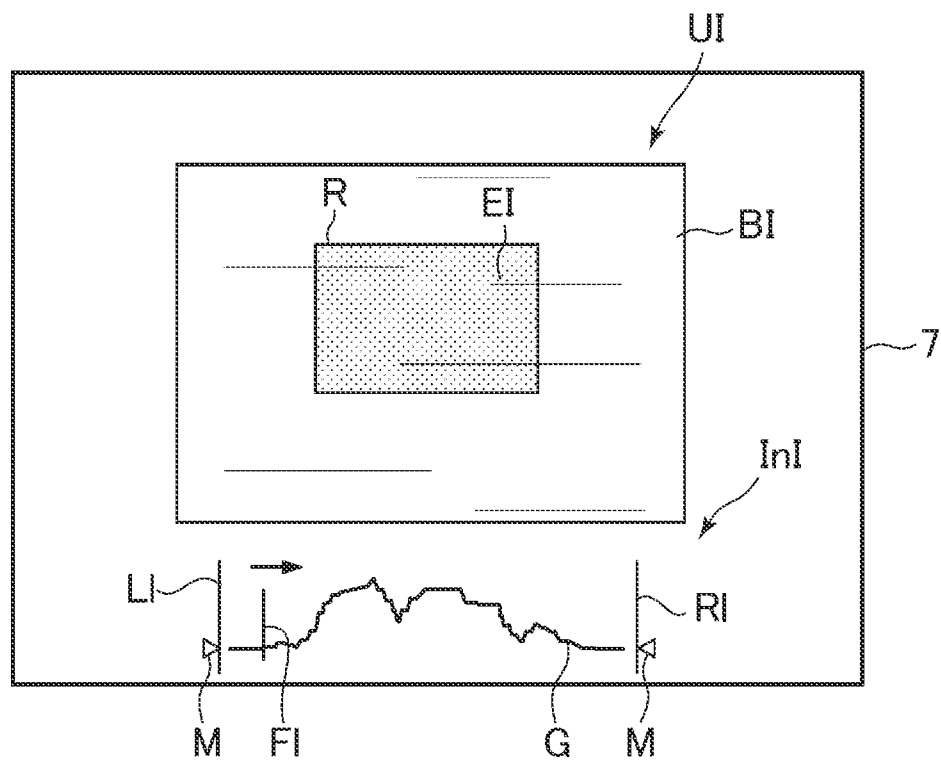


FIG. 4

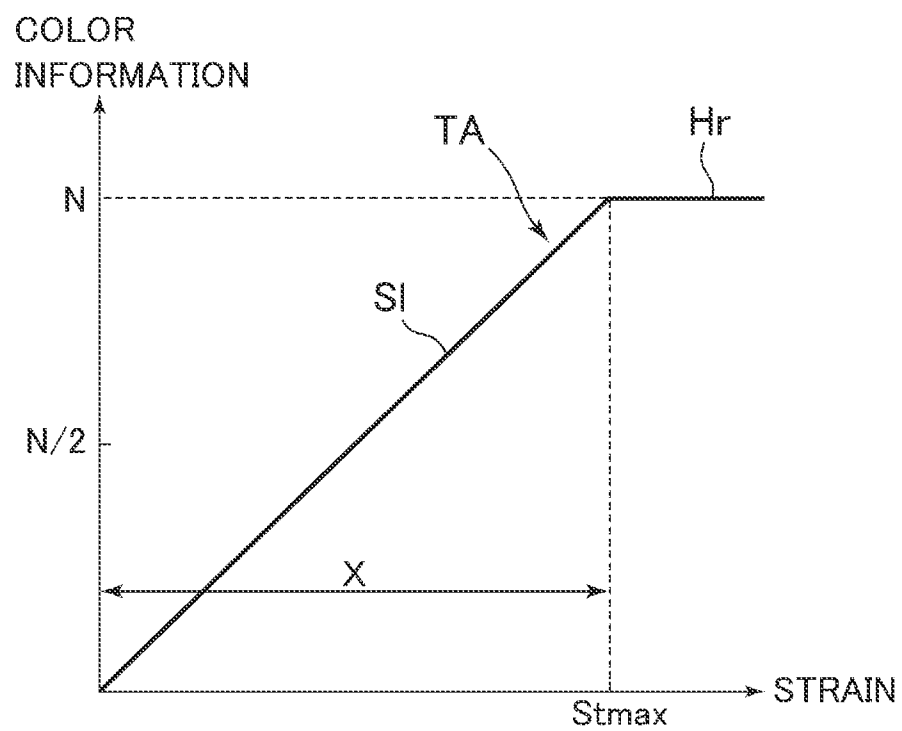


FIG. 5

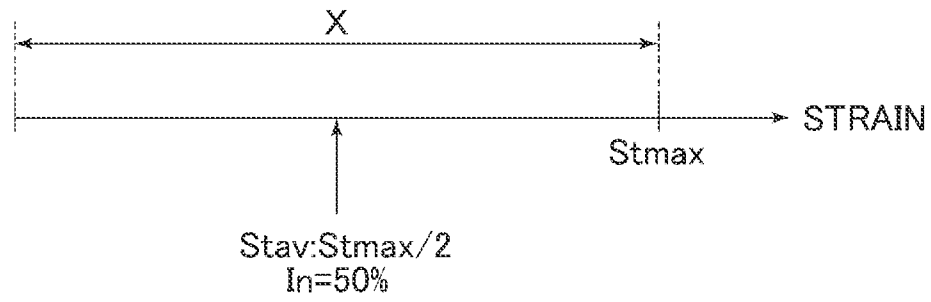


FIG. 6

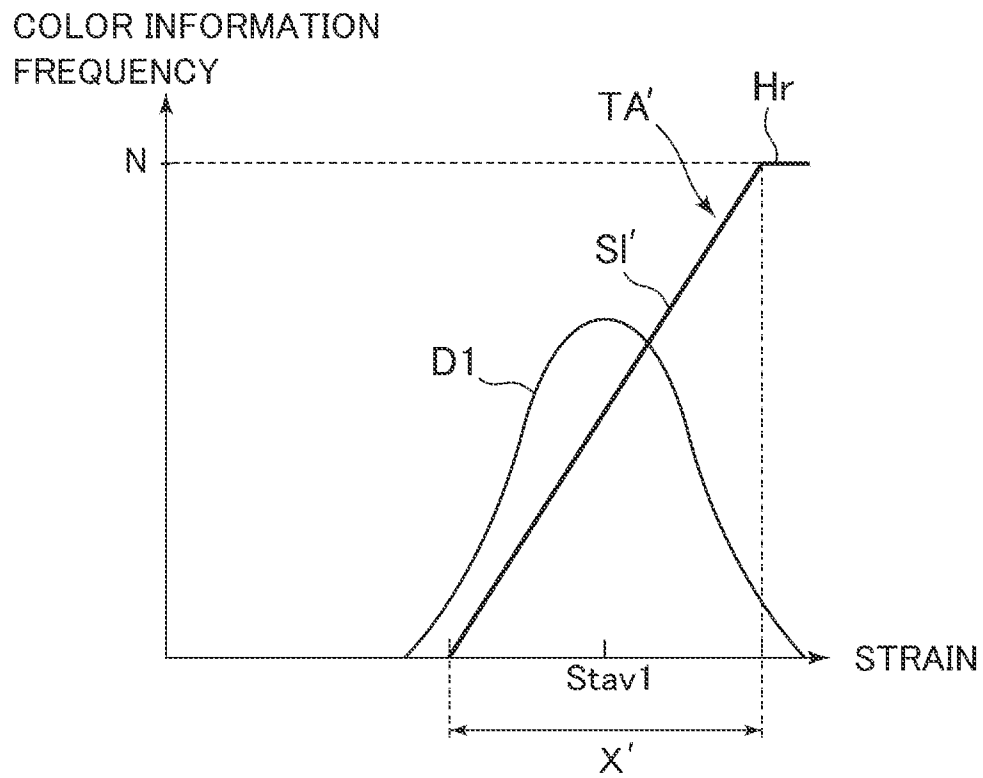


FIG. 7

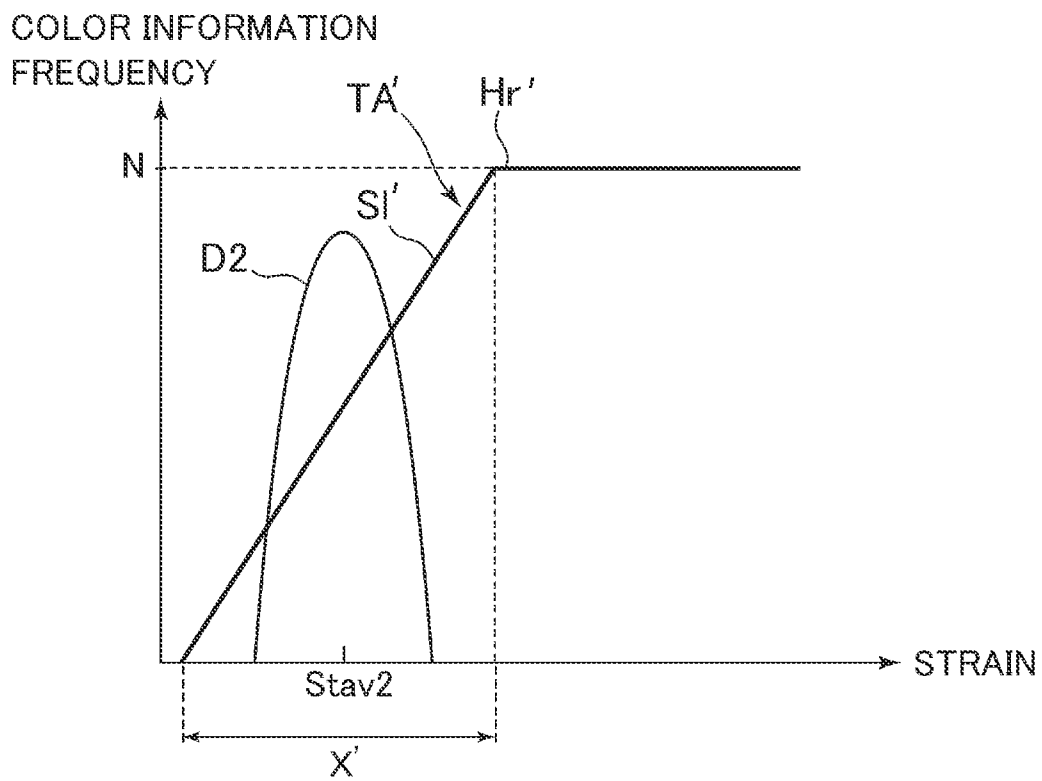


FIG. 8

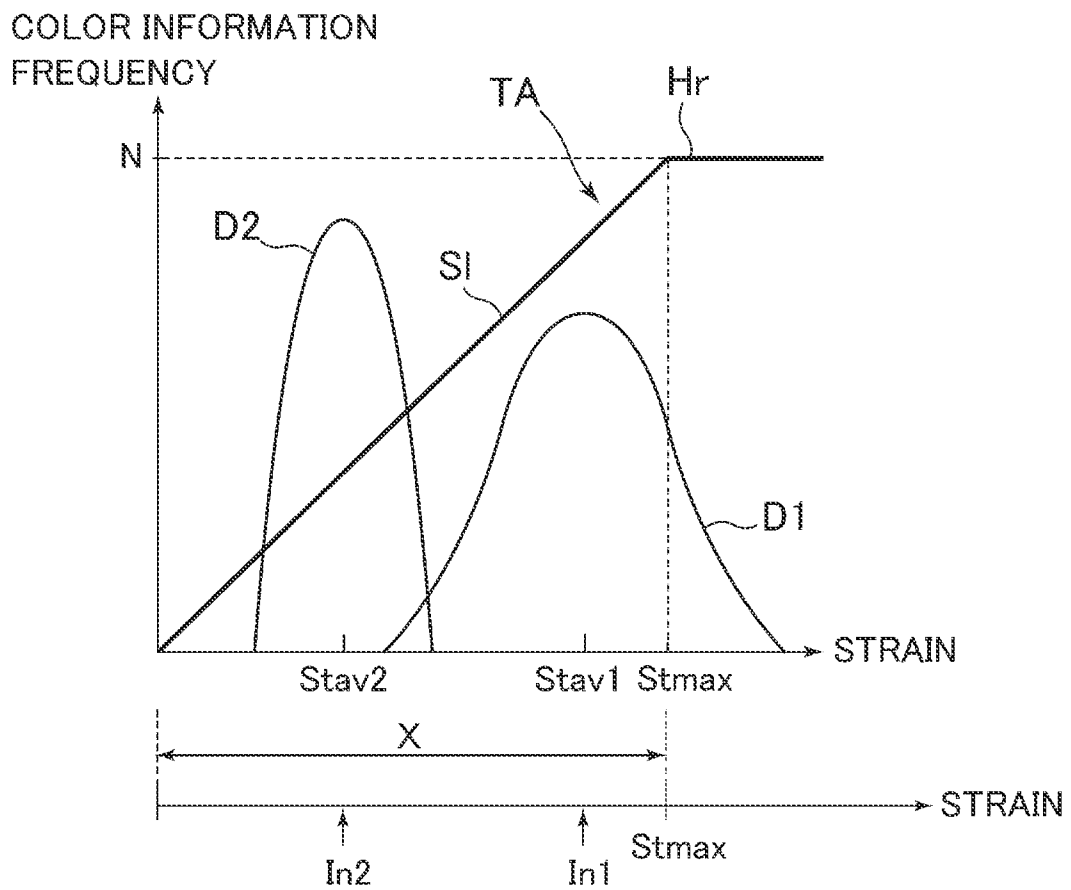


FIG. 9

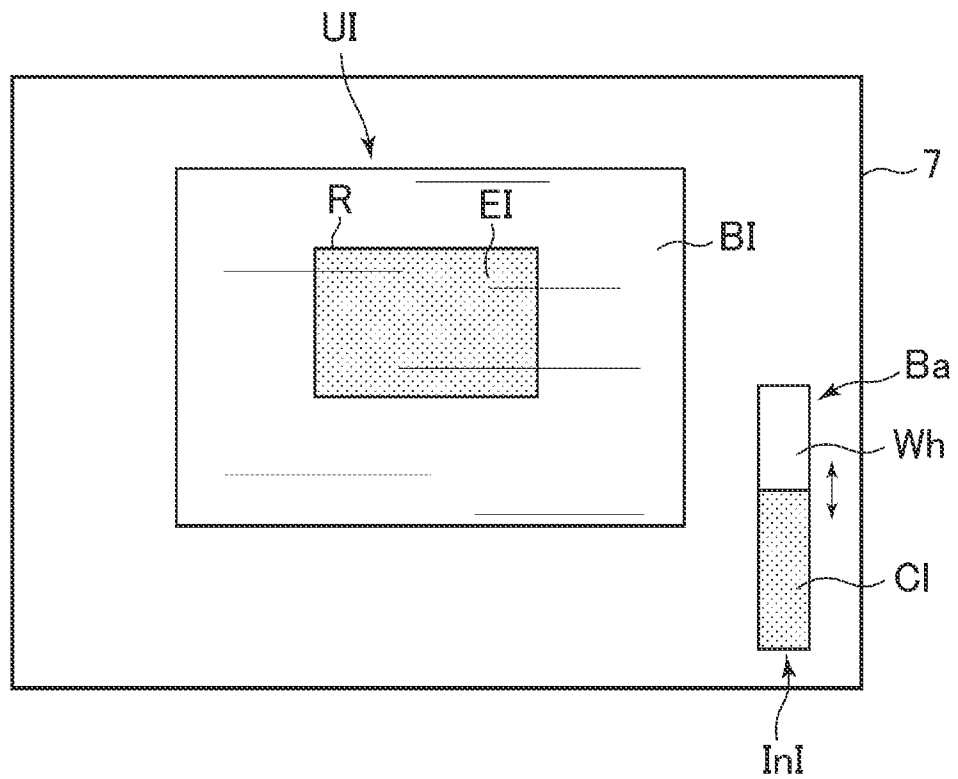


FIG. 10

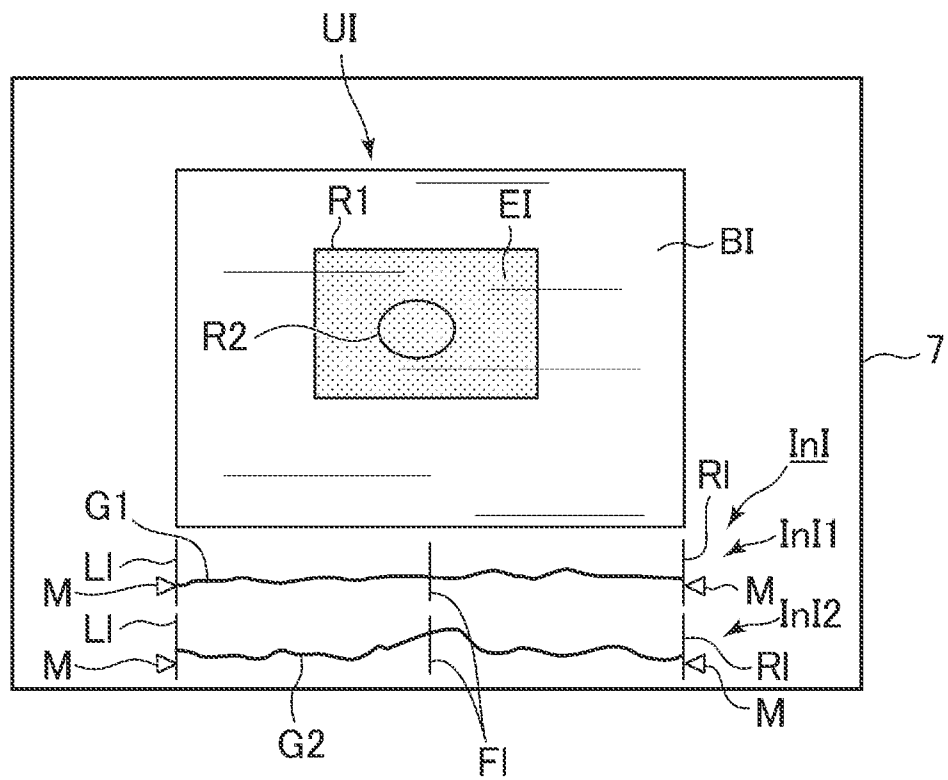


FIG. 11

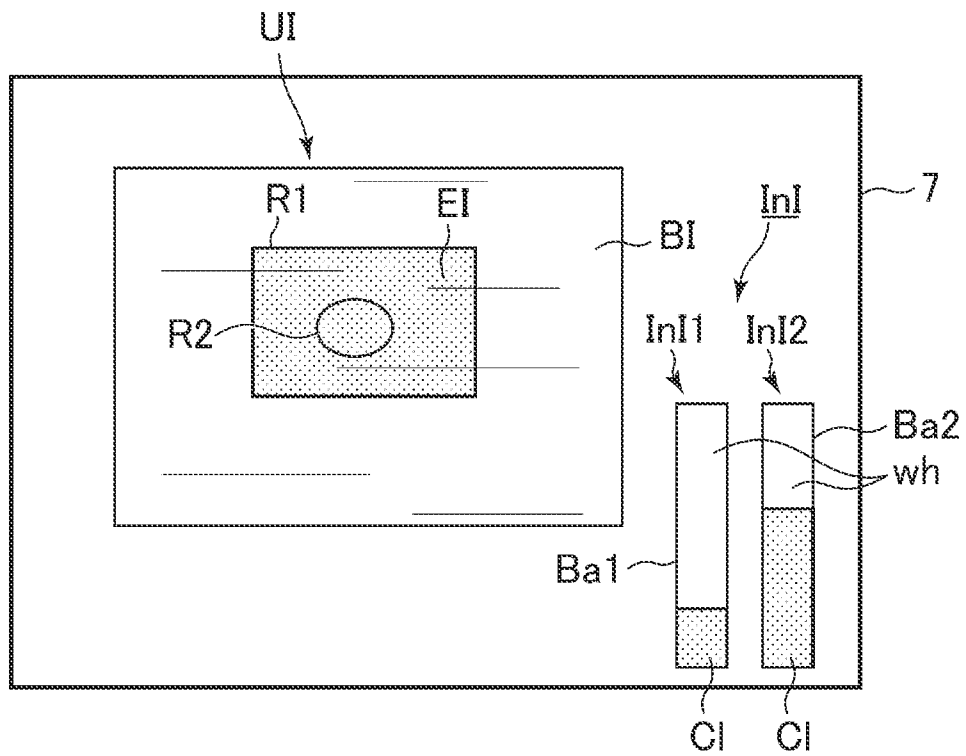
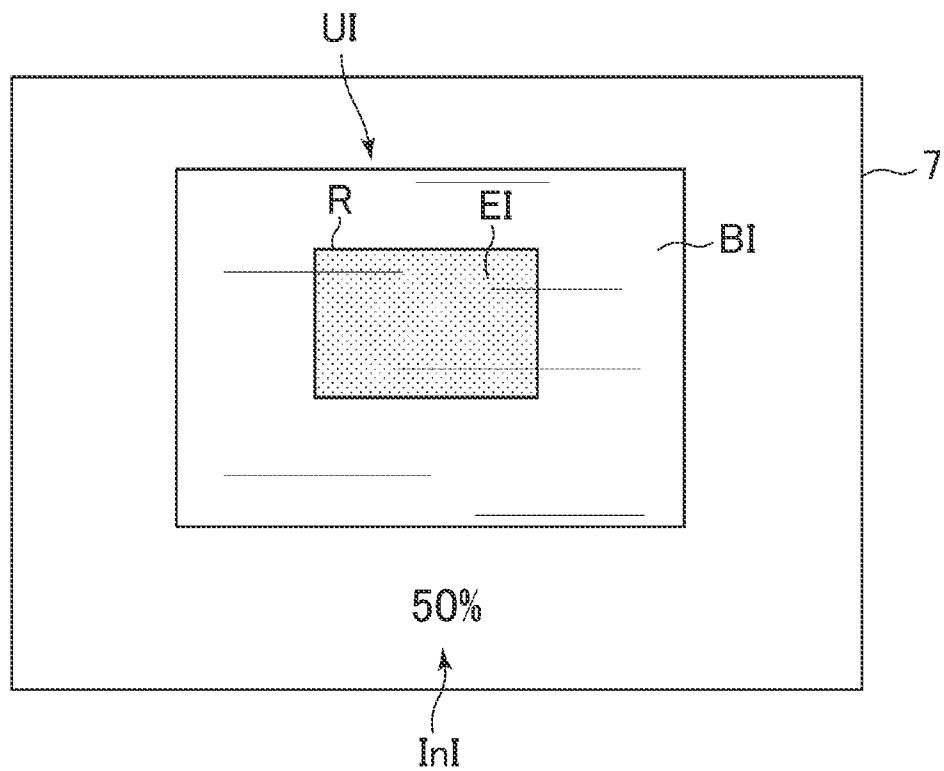


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No

PCT/US2013/055052

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61B8/08 A61B8/00

ADD.

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)

A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/054314 A1 (TANIGAWA SHUNICHIRO [JP] ET AL) 3 March 2011 (2011-03-03) figures 3, 4 paragraphs [0056], [0060] - [0064] -----	1-14
X	EP 1 880 679 A1 (HITACHI MEDICAL CORP [JP]) 23 January 2008 (2008-01-23) figure 13 paragraph [0048] -----	1-14
X	EP 1 800 603 A1 (HITACHI MEDICAL CORP [JP]; MAEDA MASARU [JP] HITACHI MEDICAL CORP [JP]) 27 June 2007 (2007-06-27) paragraphs [0009], [0011], [0043], [0044] -----	1-14



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

27 January 2014

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2013/055052

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
US 2011054314	A1	03-03-2011	CN	101999907 A		06-04-2011
			JP	2011045457 A		10-03-2011
			US	2011054314 A1		03-03-2011

EP 1880679	A1	23-01-2008	CN	101160099 A		09-04-2008
			EP	1880679 A1		23-01-2008
			JP	5160227 B2		13-03-2013
			US	2009216123 A1		27-08-2009
			WO	2006121031 A1		16-11-2006

EP 1800603	A1	27-06-2007	CN	101065067 A		31-10-2007
			EP	1800603 A1		27-06-2007
			JP	3991282 B2		17-10-2007
			US	2008071174 A1		20-03-2008
			WO	2006013916 A1		09-02-2006

专利名称(译)	超声波诊断装置及其控制程序		
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申请(专利权)人(译)	通用电气医疗系统全球性技术公司，有限责任公司		
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优先权	2012182133 2012-08-21 JP		
外部链接	Espacenet		

摘要(译)

超声诊断设备配备有弹性图像数据产生单元，该弹性图像数据产生单元产生具有与由物理量数据产生单元计算的应变相对应的颜色信息的弹性图像数据，以及使得具有与应变相对应的颜色的弹性图像的显示器。基于弹性图像数据显示在生物组织的超声图像上。弹性图像数据生成单元基于颜色转换表TA生成弹性图像数据，该颜色转换表TA表示应变和颜色信息的关联信息，并且颜色信息根据预定范围内的应变而变化。预先设定的应变。显示器显示弹性指数图像，该弹性指数图像指示弹性指数In，其表示在设定为超声图像的区域中的应变的平均值Stav与应变的预定范围X的相对关系。