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(54) **ULTRASONIC IMAGE DISPLAY METHOD AND ULTRASONIC DIAGNOSIS APPARATUS**

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(57) **ABSTRACT**

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An ultrasonic image display method for displaying a composite image made from a B mode image and a tissue velocity image of an object taken by means of ultrasound. The method includes decreasing the weight of the B mode image while increasing the weight of the tissue velocity image, in response to increase of brightness of the B mode image, adding thus weighted B mode image and tissue velocity image, and displaying an image obtained by the addition.

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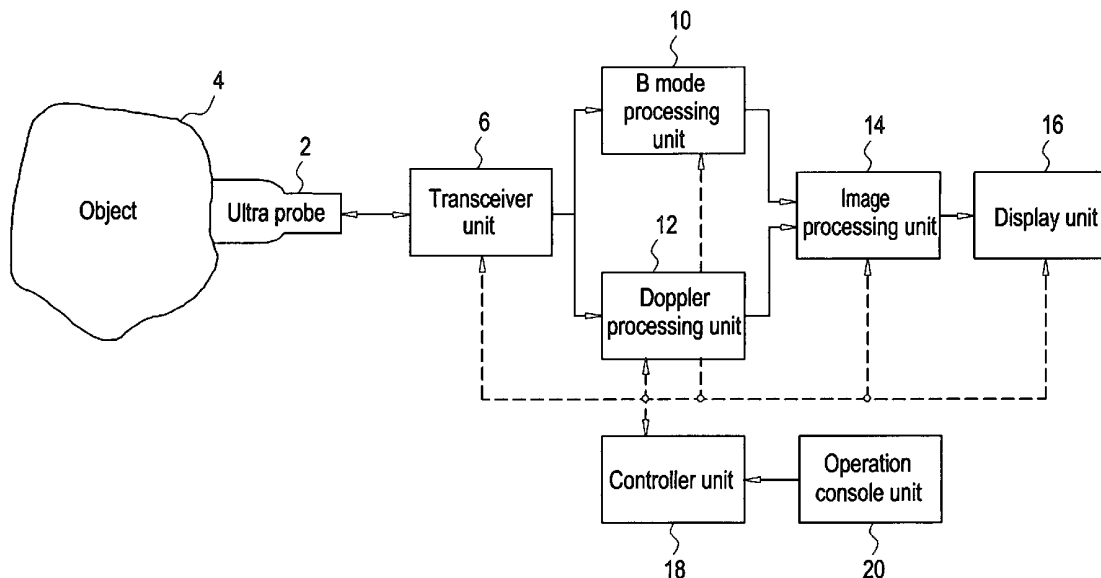


FIG. 1

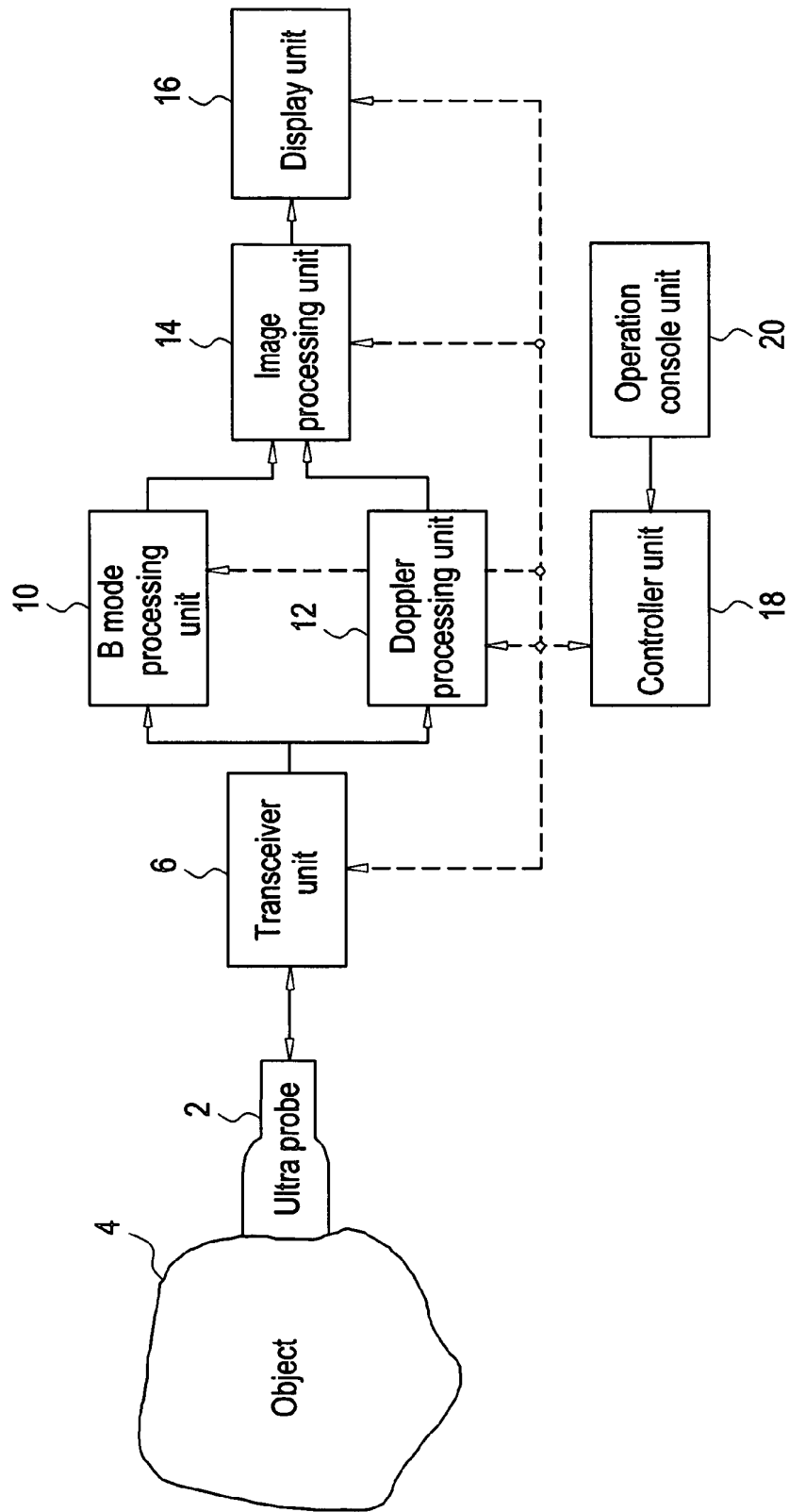


FIG. 2

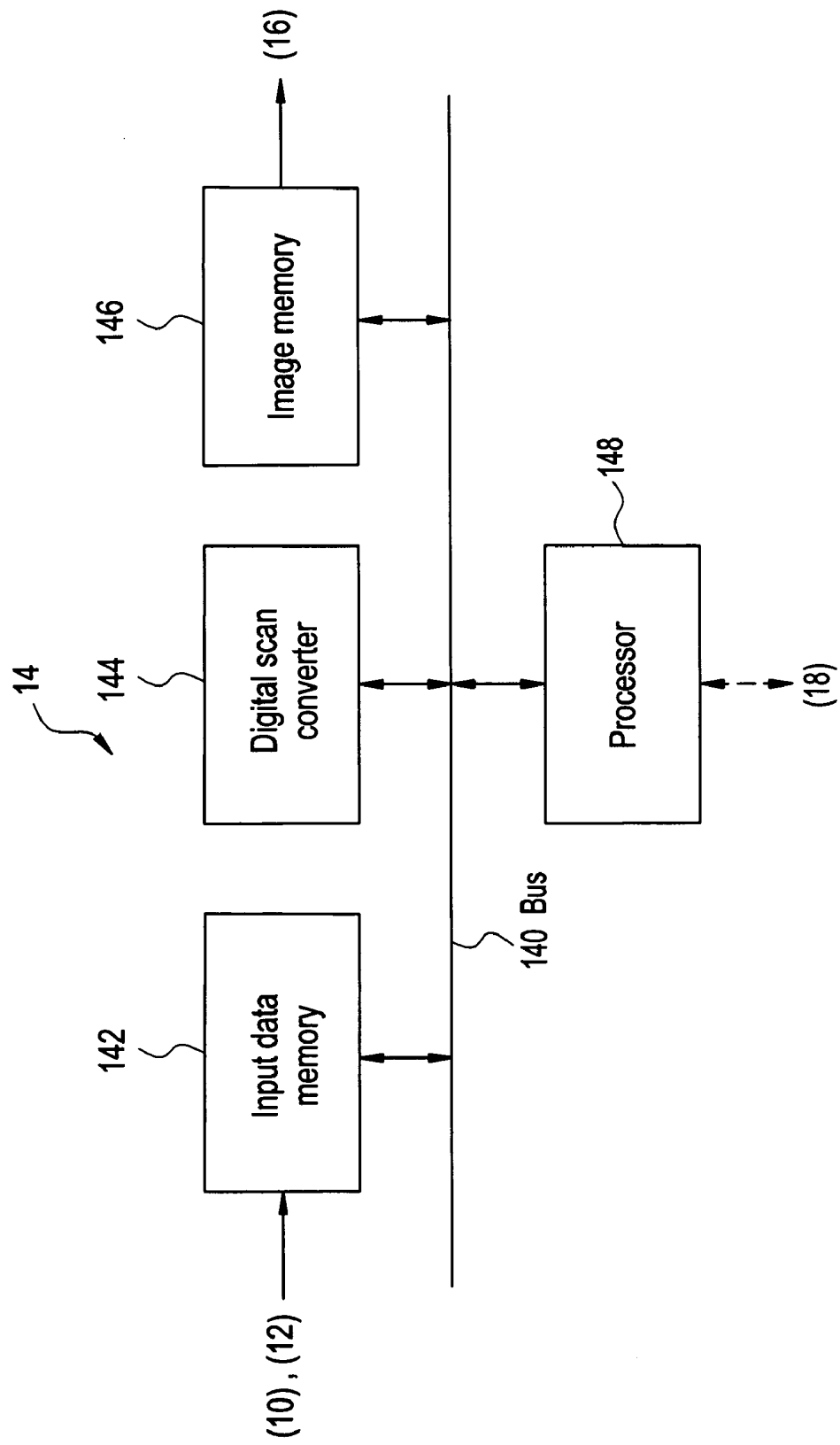


FIG. 3

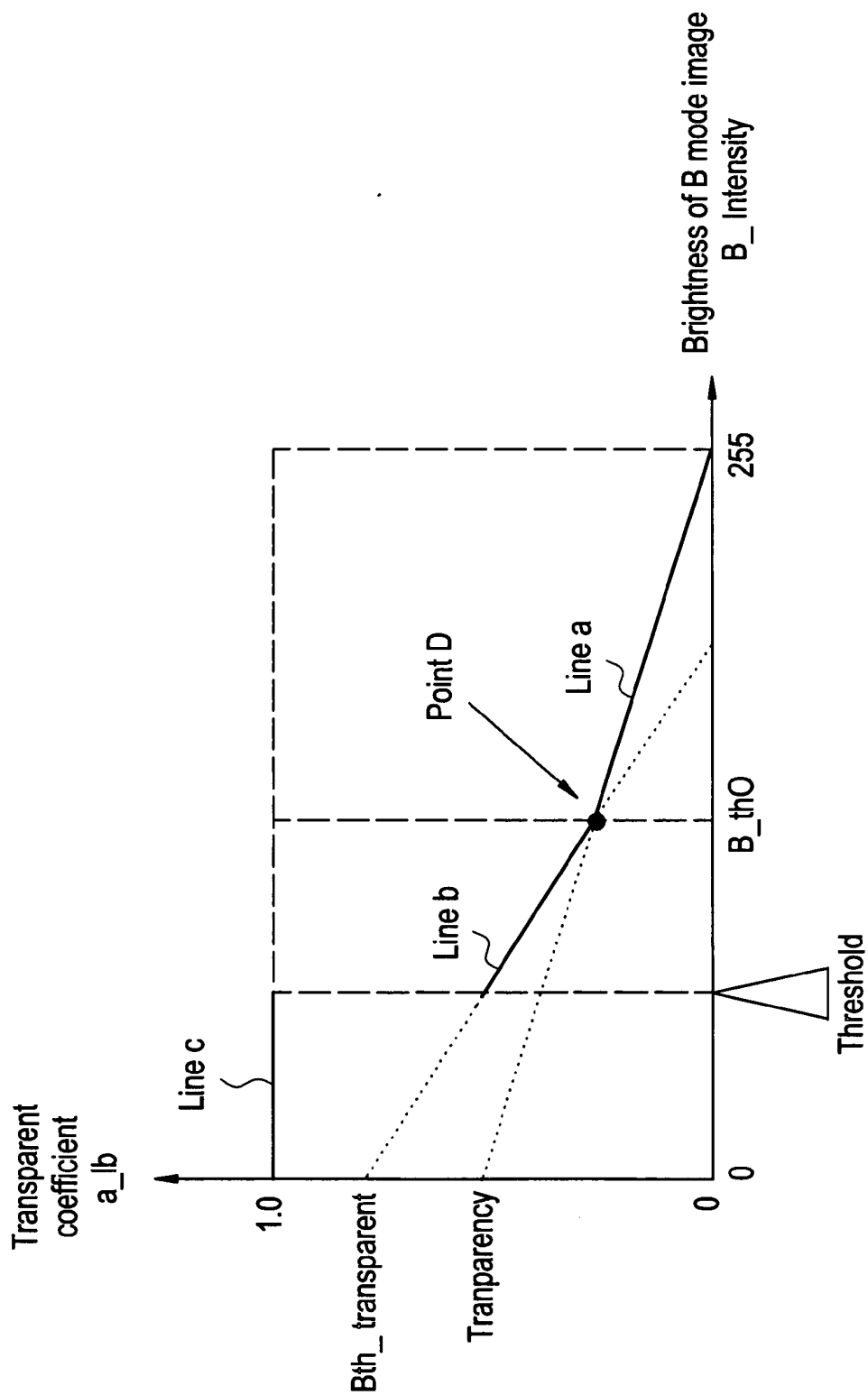
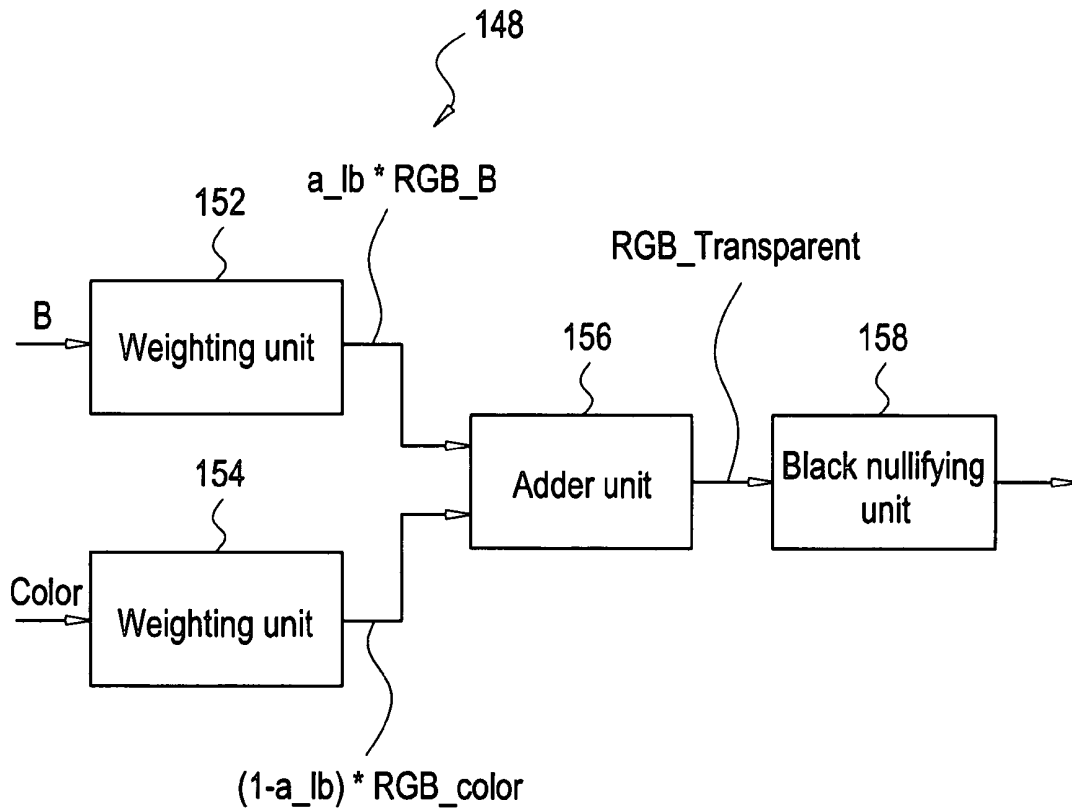


FIG. 4



ULTRASONIC IMAGE DISPLAY METHOD AND ULTRASONIC DIAGNOSIS APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Japanese Application No. 2004-237926 filed Aug. 18, 2004.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to an ultrasonic image display method and an ultrasonic diagnosis apparatus. More specifically the present invention relates to an ultrasonic image display method in which the composite image is displayed from a B mode image and a tissue velocity image of an object, taken by means of ultrasound, and to an ultrasonic diagnosis apparatus, which takes the B mode image and tissue velocity image of an object by means of ultrasound to display a composite image of those two images.

[0003] The ultrasonic diagnosis apparatus takes a B mode image and tissue velocity image of an object by means of ultrasound to display a composite image of those two images. Doppler signals of ultrasonic echo are used for the echogram of tissue velocity images (for example, see Patent document 1).

[0004] Patent document 1: specification of U.S. Pat. No. 6,517,485 (columns 7 to 13, and FIGS. 3 to 4)

[0005] The composite image is a superposition of a color tissue velocity image on a monochrome B mode image. As the impression of the color tissue velocity image is stronger and the monochrome B mode image is barely seen, the composite image of such kind is not always appropriate.

SUMMARY OF THE INVENTION

[0006] Therefore, an object of the present invention is to achieve an ultrasonic image display method and ultrasonic diagnosis apparatus for displaying a composite image of B mode image and a tissue velocity image in a fashion much suitable.

[0007] In an aspect for solving the problem, the present invention provides an ultrasonic image display method for displaying a composite image made from a B mode image and a tissue velocity image of an object taken by means of ultrasound, including decreasing the weight of the B mode image while increasing the weight of the tissue velocity image, in response to increase of brightness of the B mode image; adding thus weighted B mode image and tissue velocity image; and displaying an image obtained by the addition.

[0008] In another aspect for solving the problem, the present invention provides ultrasonic diagnosis apparatus, for taking a B mode image and a tissue velocity image of an object by means of ultrasound to display a composite image of these two images, including: a weight adjustor means for decreasing the weight of B mode image in response to the increase of brightness of B mode image, while increasing the weight of tissue velocity image; an adder means for adding thus weighted B mode image and tissue velocity image; and a display means for displaying an image obtained from the addition.

[0009] It is preferable that the variation cha of the weight is a linear function of the brightness, for the purpose of appropriate adjustment of weight. It is also preferable that the linear function is a polygonal linear function for the purpose of more appropriate adjustment of weight.

[0010] In addition, it is preferable that the linear function is a concatenation of a plurality of linear functions for the purpose of much easier setting of polygonal functions. It is further preferable that the joint of the plurality of linear functions is variable, for the purpose of facilitating the modification of polygonal linear function characteristics. It is also preferable that the slope of the plurality of linear functions is variable for the purpose of facilitating the modification of the polygonal linear function characteristics.

[0011] It is preferable that for the B mode image and the tissue velocity image, the black section where the brightness of B mode image is below a predetermined threshold is nullified, for the purpose of better display of a composite image. It is furthermore preferable that the threshold is variable such that the range of nullified black image is adjustable.

[0012] In accordance with the present invention, which allow displaying a composite image of B mode image and tissue velocity image by decreasing the weight of weighted addition of B mode image in the composite image while increasing the weight of weighted addition of tissue velocity image in response to the increase of brightness of the B mode image, the composite image of B mode image and tissue velocity image can be displayed appropriately.

[0013] Further objects and advantages of the present invention will be apparent from the following description of the preferred embodiments of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] **FIG. 1** shows a schematic block diagram of an ultrasonic diagnosis apparatus in accordance with one embodiment of the best mode for carrying out the invention;

[0015] **FIG. 2** shows a schematic block diagram of an image processing unit;

[0016] **FIG. 3** shows an exemplary graph used for the weight adjustment;

[0017] **FIG. 4** shows a schematic block diagram illustrating the processor capability.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Now the present invention will be described in greater details herein below with reference to the accompanying drawings. It should be noted that the description of embodiment is not to be considered to limit the present invention. **FIG. 1** shows a schematic block diagram of an ultrasonic diagnosis apparatus. The apparatus is an exemplary embodiment for carrying out the invention. The structure of the apparatus illustrates an example of the best mode for carrying out the invention of ultrasonic diagnosis apparatus. The operation of the apparatus illustrates an example of the best mode for carrying out the invention of ultrasonic diagnosis apparatus.

[0019] As shown in FIG. 1, the apparatus has an ultrasonic probe 2. The ultrasonic probe 2 has an array of a plurality of ultrasound transducers not shown in the figure. Each transducer is made of a piezoelectric material, such as for example PZT ceramics (Plumb Zirconate Titanate). An operator uses the ultrasonic probe 2 by contacting the object 4.

[0020] The ultrasonic probe 2 is connected to a transceiver unit 6. The transceiver unit 6 transmits driving signals to the ultrasonic probe 2 to generate ultrasound waves. The transceiver unit 6 also receives the echo signals received by the ultrasonic probe 2.

[0021] The transmission and reception of ultrasound waves is conducted by scanning an imaging range with the ultrasonic beam, i.e., sonic line. Types of sonic line scan include the sector scan, convex scan, and linear scan.

[0022] The transceiver unit 6 is connected to a B mode processing unit 10 and to the Doppler processing unit 12. The echo receiver signals for every sonic scan line output from the transceiver unit 6 is input into the B mode processing unit 10 and the Doppler processing unit 12.

[0023] The B mode processing unit 10 generates a B mode image. The B mode processing unit 10 retrieves signals indicative of the intensity of echo at each reflection point on the sonic scan line, namely A scope signals to use the transient amplitude of A scope signals as brightness value to generate a B mode image.

[0024] The Doppler processing unit 12 generates a tissue velocity image. The Doppler processing unit 12 performs an orthogonal detection of echo receiver signals to obtain I, Q signals to process in MTI (Moving Target Indication) to obtain echo complex Doppler signals, and based on which it determines the tissue velocity image for respective sonic scan line by a predetermined operation.

[0025] Although Doppler signals includes the component of blood velocity in addition to the component of tissue velocity, only the tissue velocity component is extracted by using the difference of velocity domain of both components to thereby determine the tissue velocity image.

[0026] The B mode processing unit 10 and the Doppler processing unit 12 are connected to an image processing unit 14. The image processing unit 14 uses image data input from the B mode processing unit 10 and the Doppler processing unit 12 to generate an image for display. The B mode image is generated as monochrome image. The tissue velocity image is generated as color image. The color image represents the velocity direction as color hue.

[0027] The image processing unit 14 includes, as shown in FIG. 2, a input data memory 142, a digital scan converter 144, an image memory 146, and a processor 148, all of which are connected through a bus 140.

[0028] The B mode image and tissue velocity image input from the B mode processing unit 10 and the Doppler processing unit 12 as sonic scan lines are stored in the input data memory 142. The data in the input data memory 142 is scan-converted by the digital scan converter 144 to store in the image memory 146. The processor 148 performs data processing for display on the data in the input data memory 142 and in the image memory 146. The data processing for display will be described later.

[0029] The image processing unit 14 is connected to a display unit 16. The display unit 16 is fed with image signals from the image processing unit 14 and based on which it displays an image. The display unit 16 is an exemplary embodiment of the display means in accordance with the present invention. The display unit 16 is constituted of for example a graphic display that can display color images.

[0030] A controller unit 18 is connected to the above-cited transceiver unit 6, B mode processing unit 10, Doppler processing unit 12, image processing unit 14 and display unit 16. The controller unit 18 supplies control signals to other units to control the operation thereof. It receives various information signals from those units under the control.

[0031] Under the control of the controller unit 18, B mode photographic operation and tissue velocity photographic operation are performed. The controller unit 18 is connected to an operation console unit 20. The operation console unit 20 is operated by an operator to input appropriate instructions and information to the controller unit 18. The operation console unit 20 may be constituted of for example an operation panel having a keyboard, a pointing device, and other operating devices.

[0032] Now the data processing for display will be described. The data processing for display is a process for generating a composite image made from a B mode image and a tissue velocity image. The composite image can be generated by weighted addition of a B mode image to a tissue velocity image.

[0033] FIG. 3 shows an example of graph used for weight control. The graph shown in the figure uses the brightness value of B mode image ($B_Intensity$) as its transverse axis and the transparency coefficient a_Ib as its vertical axis. The range of brightness values $B_Intensity$ may be for example 0 to 255. $B_Intensity=0$ indicates the lowest brightness, while $B_Intensity=255$ indicates the highest brightness. The range of transparency coefficient a_Ib is from 0 to 1. $a_Ib=0$ indicates complete opaque, while $a_Ib=1$ indicates complete transparency.

[0034] The transparency coefficient a_Ib indicates the degree of transparency of the tissue velocity image when the composite image is made by superposing the tissue velocity image on the B mode image. This means that the tissue velocity image is completely opaque when $a_Ib=0$. In this case, the underlying B mode image is not visible, hidden by the tissue velocity image, so that the composite image may become the image made of solely the tissue velocity image. On the other hand, when $a_Ib=1$, the tissue velocity image is completely transparent. In this case, the tissue velocity image is invisible, therefore the composite image is made of solely B mode image. When $0 < a_Ib < 1$, the tissue velocity image is translucent, corresponding to the value of a_Ib . In this case, the B mode image can be seen through the tissue velocity image.

[0035] The composite image may be thought to be formed by superposing a tissue velocity image on a B mode image. In this context when $a_Ib=0$ the B mode image is totally transparent, and when $a_Ib=1$ the B mode image is totally opaque, and when $0 < a_Ib < 1$ the B mode image is translucent. In this situation, the composite image thus obtained is identical. In the description which follows, the composite

image is considered to be formed by superposing a tissue velocity image on a B mode image, as a matter of convenience.

[0036] The line a, which constitutes part of the graph, is a linear function that crosses the transversal axis at $B_Intensity=255$, and vertical axis at $a_Ib-Transparency$, and may be given by the following equation:

$$a_Ib = transparency \times \frac{(256 - B_Intensity)}{256}$$

[0037] The line b, which constitutes another part of the graph, is another linear function that crosses the line a at the point D, and the vertical line at $a_Ib - Bth_Transparent$, and may be given by the following equation:

$$a_Ib = \frac{transparency \times (256 - Bth_0) / 256 - Bth_transparent}{B_Intensity + Bth_transparent} \times$$

[0038] The line c, which constitutes the rest of the graph, is a zero-order function that crosses the vertical line at $a_Ib=1$.

[0039] For the brightness value $B_Intensity$, the setting point of crossing B_th0 and the threshold value $Threshold$ are configurable. The setting point of crossing B_th0 is a setting value for specifying the position of point D, namely the position of crossing of line a with line b. This specifies the joint between the line a and the line b. The threshold value $Threshold$ is a setting value that specifies the end point of line c. These setting values B_th0 and $Threshold$ can be arbitrarily set and adjusted by the operator through the operation console unit 20.

[0040] The crossing points of vertical axis with lines a and b, namely $Transparency$ and $Bth_transparent$ can be arbitrarily set and adjusted through the operation console unit 20. The adjustment of $Transparency$ and $Bth_transparent$ changes the slope of lines a and b, respectively.

[0041] Using these three lines a, b, and c, the transparency of the tissue velocity image in the composite image can be adjusted. The transparency adjustment can be performed based on the brightness value $B_Intensity$ of each of the pixels that constitute the B mode image.

[0042] When $B_Intensity < Threshold$, the transparency coefficient of the tissue velocity image is determined by line c. This makes $a_Ib=1$, resulting in the composite image derived from solely B mode image, with the tissue velocity image being completely transparent. Along with this processing, another operation that makes B mode image with nullified black. Since the tissue velocity image that is completely transparent is nullified in black section, both images are nullified in black section, accordingly.

[0043] As noted above, in the range where $B_Intensity < Threshold$, the B mode image and tissue velocity image are nullified in black section to prevent noises and artifacts from becoming evident, allowing better image quality of composite image.

[0044] In the range where $Threshold \leq B_Intensity < B_th0$, the transparent coefficient of the tissue velocity image is determined by line b. More specifically, the transparent coefficient a_Ib is determined by equation (2). This makes the tissue velocity image translucent, and B mode image can be seen therethrough. The composite image that gives such impression may be generated by weighted addition of the tissue velocity image on the B mode image. The weighted addition uses the following equation:

$$RGB_Transparent = a_Ib * RGB_B + (1 - a_Ib) * RGB_Color$$

[0045] Where $RGB_Transparent$ is data of three fundamental colors (R, G, B) indicative of the composite image. RGB_B is the data of three fundamental color indicative of monochrome B mode image. RGB_Color is the data of three fundamental colors indicative of the color tissue velocity image. Each data of three fundamental color is composed of 8 bits.

[0046] As shown in equation (3), the composite image is generated by adding the weight of B mode image as a_Ib , with the weight of tissue velocity image as $1-a_Ib$. In the equation (3) above, the transparency coefficient a_Ib is used merely as the value indicative of the weight. Thus, the graph of transparent coefficient can be used as the graph of weights for weighted addition. The transparent coefficient a_Ib is called as weight hereinbelow.

[0047] It should be noted here that a_Ib taken as the weight of B mode image is reasonable, since when the transparency coefficient a_Ib is larger the transparency of tissue velocity image is increased so that the B mode image thereafter can be seen better. In addition, when the transparency of tissue velocity image increases the tissue velocity image may become less visible, so that $1-a_Ib$ taken as the weight of tissue velocity image is reasonable.

[0048] When $B_th0 \leq B_Intensity$, the weight is determined by line a. More specifically, the weight a_Ib can be given by equation (1). Then by substituting the weight of B mode image with a_Ib , and the weight of tissue velocity image with $1-a_Ib$, the pixel values of the composite image can be given by equation (3).

[0049] As can be seen from the foregoing, in the range of $Threshold \leq B_Intensity$, a composite image of the B mode image well matched with the tissue velocity image can be given, by adding the weights of both B mode image and tissue velocity image in a complementary manner in relation to $B_Intensity$.

[0050] By appropriately using the equation of weight in response to the range to which the $B_Intensity$ belongs so as to give the weight in relation to the polygonal linear function, the transparency adjustment optimal to each section to which $B_Intensity$ belongs can be performed.

[0051] It can be conceivable that a multi-step polygonal linear function provides the weight by creating two or more setting point of crossing B_th0 . This makes a finer transparency adjustment. Alternatively, the calculation of weight may be operated with a function of quadric or higher dimension, which yields a continuous curve.

[0052] In FIG. 4, there is shown a functional block diagram of the processor 148 for performing the formation of composite image as noted above. As can be seen in the

figure, the processor **148** weights a_{1b} and $1-a_{1b}$ for the B mode image (B) and tissue velocity image (color) respectively, in the weighting units **152** and **154**; forms a composite image (RGB_Transparent) by adding both images in the adder unit **156**, then outputs through the black nullifying unit **158**.

[0053] The weighting units **152** and **154** are an exemplary embodiment of the weight adjustment means in accordance with the present invention. The adder unit **156** is an exemplary embodiment of the adder means in accordance with the present invention. The black nullifying unit **158** is an exemplary embodiment of the black nullifying means in accordance with the present invention.

[0054] Many widely different embodiments of the invention may be configured without departing from the spirit and the scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in the specification, except as defined in the appended claims.

1. An ultrasonic image display method for displaying a composite image made from a B mode image and a tissue velocity image of an object taken by means of ultrasound, comprising:

decreasing the weight of the B mode image while increasing the weight of the tissue velocity image, in response to increase of brightness of the B mode image;

adding thus weighted B mode image and tissue velocity image; and

displaying an image obtained by the addition.

2. An ultrasonic image display method according to claim 1, in which the variation characteristics of said weight is a linear function of the brightness of B mode image.

3. An ultrasonic image display method according to claim 2, in which said linear function is a polygonal line function.

4. An ultrasonic image display method according to claim 3, in which said polygonal line function is made of a concatenation of a plurality of linear functions.

5. An ultrasonic image display method according to claim 4, in which the joint of said plurality of linear functions is variable.

6. An ultrasonic image display method according to claim 4, in which the slope of said plurality of linear functions is variable.

7. An ultrasonic image display method according to claim 1, in which for the black section where the brightness of B mode image is below a predetermined threshold, said B mode image and said tissue velocity image are nullified.

8. An ultrasonic image display method according to claim 7, in which said threshold is variable.

9. An ultrasonic diagnosis apparatus, for taking a B mode image and a tissue velocity image of an object by means of ultrasound to display a composite image of these two images, comprising:

a weight adjustor device for decreasing the weight of B mode image in response to the increase of brightness of B mode image, while increasing the weight of tissue velocity image;

an adder device for adding thus weighted B mode image and tissue velocity image; and

a display device for displaying an image obtained from the addition.

10. An ultrasonic diagnosis apparatus according to claim 9, in which the variation characteristics of said weight is a liner function of the brightness of B mode image.

11. An ultrasonic diagnosis apparatus according to claim 10, in which said linear function is a polygonal linear function.

12. An ultrasonic diagnosis apparatus according to claim 11, in which said polygonal linear function is made of a concatenation of a plurality of linear functions.

13. An ultrasonic diagnosis apparatus according to claim 12, in which the joint of said plurality of liner functions is variable.

14. An ultrasonic diagnosis apparatus according to claim 12, in which the slope of said plurality of linear functions is variable.

15. An ultrasonic diagnosis apparatus according to claim 9, further comprising:

a black nullifying device for nullifying on said B mode image and said tissue velocity image for the black section where the brightness of B mode image is below a predetermined threshold.

16. An ultrasonic diagnosis apparatus according to claim 15, in which said threshold is variable.

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专利名称(译)	超声波图像显示方法和超声波诊断装置		
公开(公告)号	US20060058666A1	公开(公告)日	2006-03-16
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当前申请(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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摘要(译)

一种超声波图像显示方法，用于显示由B模式图像和通过超声波拍摄的物体的组织速度图像制成的合成图像。该方法包括：响应于B模式图像的亮度的增加，减小B模式图像的重量同时增加组织速度图像的权重，添加因此加权的B模式图像和组织速度图像，并且显示由另外。

