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(54) **Method and device of synthesizing panorama image from ultrasonic images**

Verfahren und Gerät zur Panoramabildherstellung aus Ultaschallbildern

Méthode et appareil pour synthétiser une image panoramique à partir d'images ultrasonores

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(73) Proprietor: **Hitachi Ltd.**
Chiyoda-ku
Tokyo 100-8280 (JP)

(72) Inventors:
- **Miyatake, Takafumi**
  Chiyoda-ku
  Tokyo 100-8220 (JP)
- **Nagasaka, Akio**
  Chiyoda-ku
  Tokyo 100-8220 (JP)
- **Umemura, Shinichiro**
  Chiyoda-ku
  Tokyo 100-8220 (JP)

(74) Representative: **Beetz & Partner**
Patentanwälte
Steinsdorfstrasse 10
80538 München (DE)

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- **YONGMIN KIM: "Real-time medical imaging with multimedia technology" INFORMATION TECHNOLOGY APPLICATIONS IN BIOMEDICINE, 1997. ITAB '97., PROCEEDINGS OF THE IEEE ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY REGION 8 INTERNATIONL CONFERENCE PRAGUE, CZECH REPUBLIC 7-9 SEPT. 1997, NEW YORK, NY, USA,IEEE, US, 7 September 1997 (1997-09-07), pages 33-37, XP010265406 ISBN: 0-7803-4318-2**

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Description

Background of the Invention

[0001] The present invention relates to a method and device of synthesizing a panorama image from motion images obtained by ultrasound waves and, more particularly, to a method and device of obtaining an image (hereinbelow, called a panorama image) by synthesis of a sequence of consecutive frame images which are captured in a position by a manual ultrasound probe operation, which is especially suitable for an ultrasound diagnosis and a device used for the ultrasound diagnosis.

[0002] In recent years, a diagnosis using ultrasound waves is becoming widespread. According to the ultrasound diagnosing device, a probe is manipulated on the surface of a subject such as human body while generating ultrasound waves of 2 to 10 MHz that travel into the body, the ultrasound waves reflected by the surface of internal organs or the like are received, the received ultrasound waves are subjected to signal processing, and slice images of the organs or the like of the patient are real-time displayed. The diagnosis using ultrasound waves does not give pain or adverse influence on the patient and is safer as compared with a surgical operation or a diagnosis using X-ray. Consequently, it is important in diagnosing a pregnant woman and an infant. Representative measurement examples of the ultrasound diagnosing device are growth measurement of an unborn baby and circulatory organ measurement. Since their measurement regions are larger than the range in which a slice image can be displayed by using the probe at once, the function of obtaining a panorama image from the slice images and displaying the panorama image while scanning the subject with the probe is necessary. Although only a two-dimensional cross sectional image of an extremely narrow range can be obtained by one capturing operation, when the probe is attached to a mechanical scanner having a position sensor and slice images are stored while shifting the scanner across the human body, a panorama image of the whole can be produced from all of the stored slice images when the manipulation of the probe on the subject such as human body is finished.

The document US 5,782,766 A1 discloses a method and a corresponding apparatus for creating panoramic images, in which consecutive ultrasonic image frames are correlated in order to derive transducer motion information. The speed of motion of the transducer is also estimated and image frames may also be zoomed and displayed in an undistorted manner.

The document US 5,832,110 A1 teaches to perform image registration by reducing images to histograms, rotating histograms to register histograms, then using the registration the histograms to register the images, thereby registering images with less computation than image rotation.

Summary of the Invention

[0003] It is, however, difficult to accurately shift the probe attached to the mechanical scanner along a curved region of the human body such as the calf or the thyroid gland. Since the ultrasound waves are transmitted into the body through a layer of a jelly material applied on the skin, the probe has to be held so as to be in direct contact with the skin of the human body. A high-degree operating technique is therefore necessary to accurately scan a part having a curved surface. It is desirable to realize a device capable of synthesizing a panorama image by connecting cross sectional images over a wide range in a real time manner and displaying the panorama image while manually scanning the surface of the human body with the probe. In order to synthesize images without using a position sensor or rotation sensor, a shift amount and a rotation amount between frame images which are neighboring with respect to position have to be detected from image data. For the detection, a motion vector between images has to be calculated. For the real-time processing, a high-speed image processor is required.

[0004] Further, in order to improve the operability of the device of obtaining an ultrasound slice image, a function capable of producing a panorama image only by correcting an operation partly is necessary even when a wrong region is scanned by a manual probe operation of the user of the diagnosing device. For example, in the case of measuring the bloodstream, the user has to move the probe along the blood vessel on the surface of the human body. Since the blood vessel is narrow, however, there is a case such that the position of the probe is deviated from the position of the blood vessel to be measured. In such a case, when the operation of the probe is not restarted but can be corrected and the scanning can be restarted, the operability is certainly improved. When means by which the user can check the slice image while shifting (scanning with) the probe without turning his/her eyes from the probe position is provided, accurate scanning operation can be made possible.

[0005] Realization of a desired ultrasound diagnosing device has, however, a problem such that the cost of the device is very high since the mechanical scanner to which the position sensor is attached, a high-speed image processor, or the like is necessary.

[0006] U.S. Patent No. 5,575,286 discloses a panorama image generating technique for use in an ultrasound diagnosing device, for obtaining a panorama image by deriving a motion vector between ultrasound image frames which

are related to each other and connecting a plurality of frame images by using the motion vector. Since the technique disclosed in the above uses what is called advanced block matching to obtain the motion vector, however, a signal processing amount is still large. There is a problem such that a high speed signal processor is necessary to perform a real-time process.

[0007] Although the conventional ultrasound diagnosing device is safe to the human body, there are problems of the high cost of the device and the low operability in the case of displaying a panorama image of the whole. Specifically, there are problems such that a high-speed image processor is necessary to obtain the panorama image of the human body from partial cross-sectional images and the panorama image is discontinued when the probe is not moved accurately.

[0008] It is therefore an object of the invention to provide a panorama image synthesizing method capable of generating and real-time displaying a panorama image from ultrasound images of the subject and a cheap, easily operable ultrasound diagnosing device of carrying out the method.

[0009] In order to achieve the object, there is provided a method as disclosed in the claims

[0010] Other objects and features of the invention will appear more fully from the following description. Since the invention is especially effective on an ultrasound diagnosing device, the ultrasound diagnosing device will be described hereinbelow but the invention can be also carried out for other applications.

Brief Description of the Drawings

[0011]

Fig. 1 is a block diagram showing the configuration of an ultrasound diagnosing device as an embodiment of a device of synthesizing a panorama image from ultrasound images according to the invention.

Fig. 2 is a schematic diagram for explaining an embodiment of the ultrasound diagnosing device according to the invention.

Fig. 3 is a diagram showing an example of a screen displayed on a display of the ultrasound diagnosing device in the embodiment.

Figs. 4A to 4D are diagrams showing panorama images each displayed on a panorama image display window in the embodiment.

Fig. 5 is an external view of a probe used in another embodiment of the ultrasound diagnosing device according to the invention.

Fig. 6 is a diagram showing a geometric relation between time-sequential frame images obtained by the probe of the ultrasound diagnosing device according to the invention.

Fig. 7 is a diagram for explaining the principle of the shift amount detection in an embodiment of the panorama image synthesizing device according to the invention.

Fig. 8 is a diagram for explaining the principle of the rotation amount detection in the embodiment of the panorama image synthesizing device according to the invention.

Fig. 9 is a diagram showing an example of an ultrasound slice image.

Fig. 10 is a flowchart of an example of a control program of the ultrasound diagnosing device according to the invention.

Fig. 11 is a diagram for explaining the structure of control data referred to by the control program executed in the panorama image synthesizing method of the invention.

Fig. 12 is a diagram for explaining the structure of control data referred to by the control program executed in the panorama image synthesizing method of the invention.

Fig. 13 is a flowchart showing the details of a panorama image generation starting process 931 in Fig. 10.

Fig. 14 is a flowchart showing the details of a panorama image generating process 951 in Fig. 10.

Description of the Preferred Embodiments

[0012] Fig. 1 is a block diagram showing the configuration of an ultrasound diagnosing device as an embodiment of the device of synthesizing a panorama image from ultrasound images according to the invention.

[0013] In the embodiment, an ultrasound diagnosing device 100 comprises: a probe 200 for emitting an ultrasound beam 220 to the subject by a signal from an ultrasound transmitter 110 and receiving a beam reflected from the subject; an ultrasound imaging unit 120 for converting a signal from the probe 200 into a frame image; a central processing unit (hereinbelow, abbreviated as CPU) 130 for processing motion image data; a memory 140 for storing data 140-2 necessary to process a motion image and a panorama image and a control program 140-1; an image memory 155 for displaying a panorama image 151 or the like on a display 150; a D/A converter 156; and a bus line 132 for connecting the functioning units. The ultrasound diagnosing device 100 has input/output devices such as a keyboard 160 and a pointing device 170 connected via an interface (I/F), a printer 180, and an external storage 190. The hardware structure of the ultrasound

diagnosing device 100 is similar to that of a generally known digital computer.

[0014] In the configuration of the device, the oscillation frequency (2 - 10 MHz) of the ultrasound transmitter 110 follows an instruction from the CPU 130. Image data converted by the ultrasound imaging unit 120 is stored into the memory 140 and simultaneously into the image memory 155. The image data written in the image memory 155 is sequentially read by the D/A converter 156 called an RAMADC in accordance with a scanning speed of the display 150 and is displayed on the display 150.

[0015] When the data of the image memory 155 is updated, the updated data is therefore immediately reflected on the image displayed on the display 150. The display 150 is a device for displaying an image. For example, a small CRT or plasma display, a liquid crystal display, or the like is used. By repeating the capture of an image at the frequency of about 30 times per second, motion images as consecutive slice images of the subject are displayed on a part of the display.

[0016] The external storage 190 is a large-capacity recording device such as a hard disk for semipermanently storing digital data. This can be a recording device such as a PCMCIA type hard disk card which can be detached from the body 100 or a recording device of a type from which only a recording medium such as a magnetooptic disk can be detached.

[0017] The CPU 130 executes a control program for performing a control for ultrasound diagnosis, obtaining image data which will be described hereinlater, detecting a motion in images, converting image data into an image display signal, or controlling a display format of an image. The control program stays resident on the memory 140-1 and data necessary to execute the program is stored in the data memory 140-2 as necessary. The printer 180 prints a processed image or diagnostic result.

[0018] In the configuration of the ultrasound diagnosing device, the frame images in the captured sequence of frame images are connected to each other in accordance with a shifting operation (hereinbelow, also called scanning) of the probe 200. According to the control program stored in the memory 140-1, while storing the image data captured during diagnosis into the memory 140, designated frame images in the plurality of frame images are connected to thereby obtain panorama image data, the panorama image data is sequentially transferred to the image memory 155 and the panorama image 151 is displayed on the display 150. When the diagnosis is finished, the panorama image data is stored as an image data structure 190-1 in the external storage 190. The image data structure 190-1 includes an image header 190-1-1 such as the type and size of the image, date and time of diagnosis, and region of diagnosis, and panorama image data 190-1-2 compressed or not compressed.

[0019] Fig. 2 is a schematic diagram for explaining an embodiment of the ultrasound diagnosing device according to the invention. The probe 200 is manually shifted in the longitudinal direction (shown by a curve with an arrow) of the probe 200 along the surface 230 of the body (a part of the subject). Most pixels of time-sequential frame images obtained by shifting the probe 200 coincide with each other. As will be described in relation to Fig. 6, a positional deviation occurs between the images in correspondence with the shift distance in the moving direction of the probe. A rotational deviation occurs between the images in accordance with the curvature of the body surface 230. According to the ultrasound diagnosing device 100 of the embodiment, the shift amount and the rotation amount between the frame images are detected by a signal process of calculating means constructed by the CPU 130 and the program 140-1. By using the detected shift amount and rotation amount, the plurality of frame images are synthesized into panorama image data which is sequentially displayed as the panorama image 151 via the image memory 155 on the display 150. Consequently, a panorama image synthesizing device easy to operate is realized without using a position sensor.

[0020] Fig. 3 is a diagram showing an example of a screen displayed on the display of the ultrasound diagnosing device in the embodiment.

[0021] The display 150 comprises a trademark window 300, a motion image display window 310, a panorama image display window 320, and an operation instruction window 330. In the trademark window 300, the device name, the holder of the copyright, and the like are displayed. In the motion image display window 310, slice images obtained during medical examination are displayed in a real time manner. By displaying images at the frequency of 30 frames per second, the state of the internal of the body is displayed as motion images. An area 311 in the motion image display window 310 is an effective area of the slice image. When the shape of the probe 200 for transmitting and receiving the ultrasound beam 220 is a convex type, the effective area of the slice image (frame image) has a fan shape as shown in the diagram. In the diagram, the upper part corresponds to the body surface side and the lower part corresponds to the inside of the body. When the shape of the probe 200 is a linear type, the effective area 311 has a rectangle shape.

[0022] An area 312 is an image processing area which is set in the slice image 311 and used to form a panorama image. The area 312 is displayed as a rectangle figure. The image data signal process of detecting the motion amount and the rotation amount between close frame images is performed by using the data in the area 312. The process area 312 is usually fixed with respect to the effective area 311. Since there is a case such that the size and position of a captured image change when the probe 200 is replaced, the process area is changed accordingly.

[0023] An area 313 is a partial area of a slice image used to form a panorama image. The partial area 313 is an area of a motion image having high resolution. Frames are set in the same position. The user can freely set the image processing areas 312 and 313 via a user interface.

[0024] In the panorama image display window 320, the whole panorama image formed in a real time manner from

slice images captured during diagnosis is displayed. An area 321 denotes a panorama image. An area 322 denotes a cursor indicating the position and direction of the probe 200 presently being operated.

[0025] There is a case that the panorama image 321 is larger than the panorama display window 320 depending on the shift distance of the probe 200. In this case, it can be solved by scaling and displaying the panorama image 321 so as to be within the panorama image display window 320.

[0026] The operation instruction window 330 is used to instruct an operation necessary for diagnosis and has a button 331 for instructing panorama image display, a reset button 334, an operation correction button 335, a save button 336, a print button 337, and a setup button 338. The button selection is carried out by moving a pointer 339 by the pointing device 170 such as a mouse onto a desired button and clicking the pointing device 170. It is also possible to attach a touch panel on the display 150 and directly push a desired button with a finger. The panorama image 321 in Fig. 3 shows the final result of the diagnosis.

[0027] Figs. 4A to 4D show panorama images on the panorama image display window 320 in the embodiment. An operation in a diagnosing process of the ultrasound diagnosing device according to the invention and the panorama display image will be described with reference to Fig. 3 and Figs. 4A to 4D. An ultrasound diagnosis is started by pushing the panorama button 331 in Fig. 3. When the panorama button 331 is pushed, an image displayed on the panorama image display window 320 is cleared. From the state, as the probe 200 is manipulated along the body surface 230, panorama images are sequentially formed.

[0028] Fig. 4A shows a panorama image obtained when the probe 200 is scanning a blood vessel. Fig. 4B shows an example in which a blood vessel image 400 is cut since the position of the probe is deviated from the blood vessel. When the panorama button 331 is pushed in such a state, the panorama image formation is interrupted. In the state, the user corrects the position of the probe 200 by seeing the image on the motion image display window 310 so that the image 400 of the blood vessel is displayed. After that, when the panorama button 331 is pushed, the panorama image forming process is restarted. When the interruption in the image 400 of the blood vessel is large, it is necessary to return a panorama image to a previous state. In this case, the operation correction button 335 is used. The correction button 335-1 is a button to return the panorama image to a previous state. When the correction button 335-1 is continuously pushed, the cursor 322 sequentially goes back to previous states. A button 335-2 is a button to advance the cursor which has returned too much.

[0029] Fig. 4C shows an example in which the process is restarted and the blood vessel image 400 is continued. Fig. 4D is an example of a panorama image finally obtained. When the reset button 334 is pushed during the panorama image formation, the panorama image display window 320 enters the initial diagnostic state and the panorama image 321 is cleared.

[0030] According to the embodiment as mentioned above, the user can freely correct a panorama image during diagnosis or restart the panorama image forming process, so that an easily operable ultrasound diagnosing device is realized. Further, the result can be easily saved or printed. When the save button 336 is pushed, the panorama image is stored in the external storage 190. By pushing the print button 337, the panorama image can be printed by the printer 180. The setup button 338 is used to input various information necessary for setting up the image processing areas 312 and 313 or diagnosis.

[0031] Fig. 5 is an external view of a probe used in another embodiment of the ultrasound diagnosing device according to the invention. In the embodiment, in order to make diagnosis easier, the probe 200 and the liquid crystal display 150 are integrally formed. Specifically, the liquid crystal display 150 is rotatably attached to a part of the body of the probe 200. The probe 200 is provided with buttons 201 and 202 having the functions equivalent to those of the panorama button 331 and the reset button 332 shown in Fig. 4, respectively. In the embodiment, by the buttons 201 and 202 provided for the probe 200 on hand, restart and interruption of the diagnosis can be executed. Since the user does not have to turn his/her eyes off from the probe 200 during the diagnosis, the diagnosis can be easily and accurately performed.

[0032] Fig. 6 shows a geometric relation between time-sequential frame images obtained by the probe of the ultrasound diagnosing device according to the invention. In the diagram, the curvature 230 denotes the body surface, a slice image It obtained at time t is displayed in an image area 505 and a slice image It+1 obtained at time t+1 is displayed in an image area 506. Since the body surface 230 is a curve, the images It and It+1 have a geometric relation of shift and rotation as shown in the diagram. More specifically, in the case of a coordinate system in which the center (o) of the area 506 of the image It is used as an origin, the lateral axis 503 of the image It is set as Xt axis and the axis 504 which perpendicularly crosses the Xt axis is set as a Yt axis, the image It+1 moves by dx 508 along the X axis and is turned by dΘ 507 around the origin (o). From the shift amount dx and the rotation amount dΘ, the geometric relation between close frame images can be expressed by the following expression.

$$p' = Ap + B$$

where A denotes a rotation matrix, B denotes a shift amount, p indicates coordinates of the image It, and p' expresses coordinates of the image It+1.

[0033] Fig. 7 is a diagram for explaining the principle of the shift amount detection in the embodiment of the panorama image synthesizing device according to the invention. In the diagram, line segments, polygonal lines, and the like (blood vessel or the like) in the image It in the image area 505 and the image It+1 in the image area 506 show an image. The area 312 in each of the image areas 505 and 506 is the image processing area used to form the panorama image. The shift amount dx between the image It and the image It+1 is detected as follows. Vertical projective distributions 601 and 602 in the image area 312 of the images are obtained. After that, the projective distributions are correlated. While shifting the position in the horizontal direction, the position where the correlation value E(dx) shown hereinbelow becomes the minimum is obtained as a shift amount dx. The correlation value E(dx) is the sum of difference absolute values of the values of the elements between the projection distributions and is expressed by the following equation.

$$E(dx) = \sum_{i=s}^{e} \left| Pt(i - dx) - Pt + 1(i) \right| \qquad (1)$$

where, e and s denote x coordinates and Pt denotes an amplitude of the projective distribution.

[0034] Since a global characteristic amount called a projective distribution in one axis direction of a two-dimensional image is used for calculation of the image shift amount, a motion amount is obtained stably and the calculation amount is extremely small. Consequently, the shift amount can be real-time detected by the ability of an ordinary CPU 130.

[0035] Fig. 8 is a diagram for explaining the principle of detection of the rotation amount in an embodiment of the diagnosing device according to the invention. In the diagram, images in image areas 505 and 506 are the same as those in Fig. 7. Although one image process area 312 is sufficient to detect the shift amount, in the case of detecting the rotation amount, one area is insufficient and two or more areas have to be set. Fig. 8 shows an example where six designated partial areas 700i (i = 1 ... 6) are set in order in the vertical direction. The i numbers from 1 to 6 are allocated to the image process areas from the bottom. A projective distribution is obtained every partial area 700i and a shift amount dxi is calculated. When there is a rotation between images, as a principle, the shift vector of each area monotonously increases or decreases as shown in the lower part of Fig. 8 in accordance with the order of i numbers. The rotation amount dΘ is calculated by the equation of the rotation amount dΘ shown below from the difference between the shift amounts in the areas which are most apart from each other.

$$d\Theta = \tan^{-1} \frac{dx6 - dx1}{hx5/6} \qquad (2)$$

where, dx6 and dx1 denote shift amounts in the partial areas 7006 and 7001, respectively, and hx denotes the distance in the vertical direction between the areas 7006 and 7001. Since the partial area 700i used to detect the shift amount is set locally, the reliability of the shift amount detection is lower than that shown in Fig. 7. For example, when the probe 200 is moved and comes across a bone or the like, since ultrasound does not penetrate the bone, no echo is returned from the part behind the bone. In an obtained slice image, therefore, the part behind the bone is dark. When the dark part largely occupies each image process area, the shift amount cannot be accurately derived. In the embodiment, pixels are evaluated in each area 700i. When there are many dark pixels, the shift amount detection is not performed. In order to check the reliability of the detected shift amount, the monotonous increase or monotonous decrease in each shift amount is checked in the areas in accordance with the order of the i numbers. Only when the monotony is recognized, the rotation amount is calculated. At this time, the rotation amount is calculated by using a differential value of the shift amounts determined in the partial areas which are most apart from each other.

[0036] According to the embodiment, a plurality of partial areas are set for the calculation to detect the rotation amount of an image. Even when a situation such that the shift amount cannot be detected partly occurs, the rotation amount can be calculated from the shift amounts obtained from the other image process areas, so that the reliability is increased. In the embodiment, six partial areas are set. Even when the rotation amount cannot be detected from four out of six areas, it can be detected from the rest of two areas, so that the detection ratio is high. Since the calculation amount is extremely small, the rotation amount can be detected in a real time manner by the ordinary CPU processing ability.

[0037] Fig. 9 shows an example of an ultrasound slice image. The upper part of a slice image area 505 corresponds to the body surface 230 side, that is, the side in contact with the probe 200. A color portion 801 is a portion where the

bloodstream is measured in the blood vessel and is especially colored by a color Doppler method. A gray portion 802 is a portion where echoes of ultrasound pulses are returned. A dark portion 803 is a portion where echoes of ultrasound pulses are no returned. When the ultrasound beam 220 are generated and come across a bone or cavity, a dark part occurs. In the embodiment, in the case of detecting the shift amount or rotation amount, only the gray portion 802 is regarded as effective pixels by using a color filter and is subjected to a process, thereby preventing deterioration in the detection accuracy.

[0038] Fig. 10 is a flowchart of an embodiment of the control program of the ultrasound diagnosing device according to the invention, which mainly shows a panorama image forming process during diagnosis. Besides the panorama image forming process, there are processes such as a control of ultrasound oscillation, display of a diagnosed region in figure, and search of an image. Since the processes are similar to those performed by a conventionally known ultrasound diagnosing device for obtaining a motion image, the detailed description is omitted here. The control program 140-1 in Fig. 10 is executed with reference to the control data 140-2 shown in Figs. 11 and 12. All of an input image memory, a panorama pixel memory, X_Proj_Current, X_Proj_Last, Rotate_Proj_Current, Rotate_Count_Current, Rotate_Proj_Last, Rotate_Count_Last, Total_dx, Total_dΘ, and k denote memory areas provided in the data memory 140-2.

[0039] In Fig. 10, step 900 relates to an initializing process. An initial frame of the ultrasound diagnosing device is displayed on the display 150. In step 905, a variable "status" is reset to 0. When the power source of the ultrasound diagnosing device is on (step 910), the following panorama image forming process is performed.

[0040] First, in step 915, signals of an image frame of an ultrasound image, that is, a motion image are captured and stored in a plane input image memory 140-2-1. The input image memory 140-2-1 exists in the memory 140 in Fig. 1. As shown in the input image memory in Fig. 11, data having a height of 1 to H and a width of 1 to W is stored. The ultrasound image in this area is displayed on the motion image display window 310 of the display 150 (step 920). In step 925, whether the panorama button 331 is pushed or not is checked. The following determining process is performed in step 930.

[0041] When the panorama button 331 is pushed under the condition that "status" is 0, a panorama image formation starting process 931 is executed. In the process, a previous panorama image displayed on the panorama image display window 320 is cleared so as to prepare to display a new panorama image. The details of the process 931 will be described hereinlater with reference to Fig. 13. In step 932, the variable "status" is set to 1, thereby setting a panorama image forming mode.

[0042] When the panorama button 331 is pushed under the condition that the variable "status" is 1, the variable "status" is set to 2 in step 933 to interrupt the panorama image formation.

[0043] When the panorama button 331 is pushed under the condition that the variable "status" is 2, the variable "status" is set to 1 to restart the panorama image formation.

[0044] Whether the reset button 334 is pushed or not is checked in the determining process of step 940. When YES, the panorama image formation starting process which has been already described is performed in step 941 and 1 is set in the variable "status" in step 942, thereby setting the panorama image forming mode.

[0045] Whether the panorama image is being formed or not is checked in step 950. When the variable "status" is 1, the panorama image is being formed, the panorama image forming process is performed in step 951 and the result is stored in a panorama image memory 140-2-2. The panorama image memory 140-2-2 exists in the memory 140-2 in Fig. 1. As shown in Fig. 11, the panorama input image memory stores data of an image having a height of 1 to PH and a width of 1 to PW. The details of the process in step 951 will be described hereinlater with reference to Fig. 14. The panorama image data stored in the panorama image memory 140-2-2 is converted into an image display signal and the image display signal is displayed on the panorama image display window 320. At this time, the cursor 322 as information regarding the current position and direction of the probe 200 is also displayed on the panorama image display window 320.

[0046] In step 960, whether the save button 336 is pushed or not is checked. When YES, the routine advances to step 961. Step 961 relates to a panorama image storing process for storing the panorama image data generated and stored in the panorama image memory 140-2-2 into the external storage 190.

[0047] In step 970, whether the print button 337 is pushed or not is checked. When YES, the routine advances to step 971. Step 971 relates to a panorama image printing process for outputting the panorama image generated and stored in the panorama image memory 140-2-2 to the printer 180.

[0048] In step 980, whether the setup button 333 is pushed or not is checked. When YES, the routine advances to step 981. Step 981 relates to a parameter setting process used to set a specific area 312 and an image synthesizing area 313 or to enter various information such as the region to be diagnosed and the name of the patient.

[0049] Finally, in step 990, whether or not the operation correction button 335 is pushed in the state where the panorama image formation is interrupted, that is, the variable "status" is 2 is checked. When YES, in step 991, the position of the cursor 322 which is currently displayed is shifted and displayed in a designated position. That is, while the button 335-1 is continuously pushed, the cursor sequentially returns to the position of the panorama image. When the button 335-2 is continuously pushed, the cursor is moved in the opposite direction. In such a manner, during the panorama image formation, the panorama image is corrected. By repeating the processes from step 915 to step 991, the panorama image from ultrasound images is formed in a state desired by the operator.

[0050] Fig. 13 is a flowchart showing the details of the panorama image formation starting process 931 in Fig. 10. First, in step 1000, a variable (k) for counting the total number of motion image frames contributed to the panorama image formation is reset to 0. The variable (k) is stored in the memory 140-2-11 in Fig. 12. In step 1010, the element at the head 1 of each of the memory area Total_dx 140-2-9 and the memory area Total_dΘ 140-2-10 in which the shift and rotation parameters used to form the panorama image are stored is reset to 0 (Fig. 12). In step 1020, the panorama image 321 which is being displayed on the panorama image display window 320 is deleted.

[0051] In step 1030, the input image data in the partial area 313 is written into a plane panorama image memory 140-2-2 for storing the panorama image. The first frame image serves as a reference image when panorama images are formed. The shift parameter and the rotation parameter of each of subsequent frame images are expressed as a relative difference from the first frame image. In step 1040, the data in the panorama image memory 140-2-2 is displayed in the panorama image display window 320 and the cursor 322 is also displayed.

[0052] Fig. 14 is a flowchart showing the details of the panorama image forming process 951 in Fig. 10. Steps 1100 to 1120 relate to processes for obtaining the shift amount dx between consecutive frame images.

[0053] First, in step 1100, the vertical projection distribution in the specified area 312 of the image stored in the input image memory 14-2-1 is calculated and the result is stored in the memory area X_Proj_Current 140-2-3. In step 1105, whether the total frame number k is larger than 0 or not is determined. When YES, the routine advances to steps 1110 and 1120. In step 1110, matching, that is, similarity calculation is performed between the projective distribution of the current input image in the memory area 140-2-3 and the immediately preceding image projective distribution in the memory area Proj_Last 140-2-4 while shifting the position dx. In step 1120, the position dx most coincided is determined as the motion amount between two time-sequential images. As the matching, specifically, the above-mentioned equation (1) is calculated.

[0054] Steps 1130 to 1165 relate to processes to obtain the rotation amount dΘ between consecutive frame images.

[0055] In step 1130, the number of effective pixels in the plurality of partial areas 700i of an image stored in the input image memory 140-2-1, that is, the pixels in the gray portion 802 in which the ultrasound echoes exist are counted every row in each of the areas 700i and written in the memory area Rotate_Proj_Current 140-2-6. In step 1140, the vertical projective distribution of the effective pixels in each of the plurality of partial areas 700i of the image stored in the input image memory 140-2-1 is calculated and written into the memory area Rotate_Proj_Current 140-2-5. Although the value of the projective distribution can be usually calculated by adding the values in each row, in this case, the value normalized by the number of effective pixels in each row is stored in a matrix.

[0056] In step 1160, whether the frame total number (k) is larger than 0 or not is checked. When YES, steps 1161 to 1167 are executed. In steps 1161 to 1164, a local shift amount between consecutive frame images is calculated with respect to the six areas 700i (i = 1 ... 6). First, in step 1162, whether the ratio of the effective pixels in the area (i) is equal to or higher than a predetermined value such as 0.5. When YES, steps 1163 and 1164 are executed. In step 1163, the matching is performed between the projective distribution of the currently input image in the memory area Rotate_Proj_Current 140-2-5 and the immediately preceding input image projective distribution in the memory area Rotate_Proj_Current 140-2-7 while shifting the position dxi. In step 1164, the position dxi which is the most coincided is determined as the shift amount in the area (i) between two time-sequential images.

[0057] In step 1165, the rotation amount dΘ is calculated by the equation shown in Fig. 8 from the shift amount between the areas which are most apart from each other among the areas in which the shift amounts can be calculated.

[0058] By the above processes, the shift amount dx and the rotation amount dΘ between neighboring frame images are obtained. In step 1166, the shift amount and the rotation amount between the reference image and the current image are calculated. They can be easily calculated by accumulating the shift amount and the rotation amount of the frame calculated this time to the calculation results of the preceding images. In step 1167, since the shift amount and the rotation amount of the current image are known with respect to the reference image, coordinate conversion based on the rotation amount and the shift amount is performed. The resultant image data is written to the panorama image memory 140-2-2. By the processes, the panorama image is formed from the sequence of frame images accompanying the shift and rotation.

[0059] Finally, in step 1170, preparation for the next panorama image formation is made. The data in the memory area X_Proj_Current 140-2-3 is transferred to the memory area X_Proj_Last 140-2-4, the data in the memory area Rotate_Proj_Current 140-2-5 is transferred to the memory area Rotate_Proj_Last 140-2-7, and the data in the memory area Rotate_Proj_Current 140-2-6 is transferred to the memory area Rotate_Count_Last 140-2-8. Only 1 is added to the variable (k) for counting the total frame images used for the panorama image formation.

[0060] As described above, according to the panorama image forming method of the invention, the shift amount and the rotation amount between images are detected with respect to only the effective pixels. Consequently, even when the part such as bone or cavity which dos not transmit the ultrasound pulses is included in an image obtained during the diagnosis, it can be prevented that the part exerts an influence on the detection result. Since the projective distribution over a wide area is used as an image characteristic amount, the shift amount and the rotation amount can be stably detected from an ultrasound image having much noise. Further, the calculation amount of the projective distribution

used to detect the shift amount and the rotation amount is extremely small. Consequently, an effect such that the calculation can be executed in a real time manner by a cheap CPU is produced.

[0061] Although the method and apparatus of the invention for synthesizing a panorama image from ultrasound images have been described by the embodiment of the ultrasound diagnosing device, the invention is not limited to the embodiment. When the position of the generation source of the motion image fluctuates, obviously, the invention can be applied to the case where a sequence of frame images is synthesized to obtain a synthetic image. Although the case where the probe, ultrasound transmitter, and ultrasound imaging unit and a computer unit such as CPU are integrally connected has been described as the embodiment, the case where a series of frame images are stored in an image accumulating memory, and the image data in the image accumulating memory is inputted to obtain the panorama image is also included.

[0062] According to the invention, when it is applied to the ultrasound diagnosing device or the like, motion images captured during diagnosis are automatically synthesized to thereby form the panorama image. The panorama image can be formed in a real time manner from the sequence of slice images obtained by the probe operation of the operator of the device. The forming state of the panorama image can be checked momentarily on the display and an erroneous probe operation during the diagnosis can be corrected. Since the probe and the display are integrated in the preferred embodiment, the operator can perform the diagnosing work without turning his/her eyes off from the diagnostic region. As described above, according to the invention, the ultrasound diagnosing device of high operability can be realized.

[0063] While the present invention has been described above in conjunction with the preferred embodiments, one of ordinary skill in the art would be enabled by this disclosure to make various modifications to this embodiment and still be within the scope of the invention as defined in the appended claims.

Claims

1. A method of synthesizing a panorama image from ultrasound images, comprising:

a step of obtaining data of a plurality of consecutive ultrasound frame images constructing an ultrasound motion image;
a step of obtaining a shift amount (dx) between the plurality of consecutive ultrasound frame images by use of correlation of first projective distributions derived from a specific area (312) in each of the plurality of consecutive ultrasound frame images;
a step of obtaining shift amounts (dx) between the plurality of consecutive ultrasound frame images by use of correlation of a plurality of second projective distributions derived from a plurality of partial areas (313) which are in each of the plurality of consecutive ultrasound frame images:

a step of obtaining a rotation amount (dθ) between the plurality of consecutive ultrasound frame images by use of the shift amounts (dx); and
a step of connecting the plurality of ultrasound frame images by using the shift amount (dx) and the rotation amount (dθ) to synthesize panorama image data.

2. The method of synthesizing the panorama image from ultrasound images according to claim 1, further comprising a step of displaying the panorama image data on a display of a display device (150).

3. The method of synthesizing the panorama image (151) from ultrasound images according to claim 1 or 2,
wherein the first projective distributions are first projective distributions (601, 602) in one axis direction of the specific area (312),
the second projective distributions are second projective distributions in one axis direction of the plurality of partial areas (313) obtained by dividing each of the consecutive ultrasound frame images in one axis direction, and
the rotation amount (dθ) is obtained by using differences between the shift amounts (dx).

4. An apparatus for synthesizing a panorama image from ultrasound images, comprising:

an input unit (210) of image data of a plurality of frame images;
a calculating unit (130) including a first signal processing unit for obtaining a shift amount (dx) between the plurality of consecutive ultrasound frame images by use of correlation of first projective distributions derived from a specific area in each of the plurality of consecutive ultrasound frame images, and a second signal processing unit for obtaining a rotation amount (dθ) between the plurality of consecutive ultrasound frame images by use of shift amounts (dx), which are derived from correlation of second projective distributions of a plurality of partial areas which are in each of the plurality of consecutive ultrasound frame images; and

a synthesizing unit for synthesizing a panorama image (151) from the plurality of ultrasound frame images by using the shift amount and the rotation amount obtained by the calculating unit.

5. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 4, wherein the first projective distributions are first projective distributions (601, 602) in one axis direction of the specific area (312), and
the second projective distributions are second projective distributions in one axis direction of the plurality of partial areas (313).

6. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 4 or 5, wherein the partial areas (313) are obtained by dividing each of the consecutive ultrasound frame images in one axis direction, and
the rotation amount (dθ) is obtained by using differences between the shift amounts (dx).

7. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 5 or 6, wherein the first signal processing unit normalizes the first projective distributions (601, 602) in the specific area (312) and the second signal processing unit normalizes the second projective distributions in the plurality of partial areas (313) by using a number obtained by integrating the integrated pixels in one axis direction.

8. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 5 to 7, wherein the pixel used for obtaining the first and second projective distributions (601, 602) is a pixel of a specific color signal.

9. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 4 to 8, wherein the second signal processing unit uses the shift amounts (dx) obtained from the set of areas which are most apart from each other in the plurality of partial areas (313) divided in one axis direction.

10. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 4 to 9, further comprising image displaying unit for converting motion image data and panorama image data into image display signals and displaying the signals on the display (150).

11. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 10, wherein the image displaying unit displays an image process area which is for detecting at least one of the shift amount (dx) and the rotation amount (dθ) as a figure in a motion image display area (310) on the display (150).

12. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 10, wherein the image displaying unit has process area designating unit for displaying an image process area which is used to form the panorama image (151) as a figure in a motion image display area (310) on the display.

13. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 10 to 12, the image displaying unit has position designating unit (322) for displaying position information of a motion image which is currently being processed as a figure in the panorama image display area (320) on the display (150).

14. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 10 to 13, wherein the image displaying unit returns the panorama image (151) to a state arbitrary prior time by moving the position information.

15. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 13 or 14, wherein the input unit (210) of data of the plurality of frame image is connected to a probe (200) for obtaining ultrasound data, and the calculating unit (130), synthesizing unit, and image displaying unit are constructed to display at least one of the motion image or the panorama image (151) on the display (150) simultaneously with the probe operation.

16. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 15, wherein the display (150) is integrally formed with the probe (200).

17. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 15 or 16, wherein the probe (200) is provided with unit (202) for instructing setup or reset of the probe operation.

18. The apparatus for synthesizing a panorama image (151) from ultrasound images according to claim 4 to 17, further

comprising detachable image storing unit (190) for storing the panorama image data.

19. The apparatus for synthesizing a panorama image (151) from ultrasound images, according to claim 10 to 18, wherein the image displaying unit displays an image operation type symbol display arena (330) having areas of a panorama instruction button (331), a reset button (334), a forward/backward instruction button (335) is provided in the display (150), and start of display, interruption, restart, or reversion of the panorama image (151) is performed by the corresponding button in the instruction button area (330).

20. A recording medium which can be read by a computer and on which a program for obtaining panorama image data is recorded,
wherein the program comprises:

a first step of calculating a projective distribution (601, 602) of pixels in the vertical direction in a specified area (312) in each of present and previous two frame images and obtaining a shift amount (dx) in the horizontal direction between the present and previous two frame images by matching the present and previous projective distributions (601, 602);
a second step of providing a plurality of divided designated areas (313) in corresponding positions in each of the present and previous two image frames, calculating the projective distribution of pixels in each of the plurality of divided designated areas, and matching the projective distributions in the plurality of divided designated areas, thereby obtaining a shift amount (dx) in each of the plurality of divided designated areas between the present and previous two frame images;
a third step of calculating a rotational angle (dθ) between the present and previous two frame images by using the shift amount (dx) of each of the divided designated areas obtained in the second step; and
a fourth step of shifting and rotating the image area to be synthesized in the present image frame by the shift amount (dx) obtained in the first step and the rotational angle (dθ) obtained in the third step and writing the result into a panorama image memory (140),
the first to fourth steps being repeatedly executed on a newly input image frame as the present image frame.

21. The recording medium which can be read by a computer, according to claim 20,
wherein in the second step, the ratio of effective pixels to all of pixels in each of the plurality of divided partial areas (313) is checked and, when the ratio of effective pixels is equal to or larger than a predetermined value, the projective distribution of the divided designated area is calculated, and
the third step has a step of selecting the shift amounts (dx) between two divided designated areas which are most apart from each other among the shift amounts (dx) of the plurality of divided partial areas (313) and performing a calculation of the rotational angle (dθ) by use of a difference between the two selected shifts amounts (dx).

Patentansprüche

1. Verfahren zum Synthetisieren eines Panoramabildes aus Ultraschallbildern, das umfasst:

einen Schritt zum Erhalten von Daten mehrerer aufeinander folgender Ultraschall-Einzelbilder, die ein Ultraschall-Bewegungsbild ergeben;
einen Schritt zum Erhalten eines Verschiebungsbetrags (dx) zwischen den mehreren aufeinander folgenden Ultraschall-Einzelbildern unter Verwendung einer Korrelation erster projektiver Verteilungen, die aus einem bestimmten Bereich (312) in jedem der mehreren aufeinander folgenden Ultraschall-Einzelbilder abgeleitet werden;
einen Schritt zum Erhalten von Verschiebungsbeträgen (dx) zwischen den mehreren aufeinander folgenden Ultraschall-Einzelbildern unter Verwendung einer Korrelation mehrerer zweiter projektiver Verteilungen, die aus mehreren Teilbereichen (313) abgeleitet werden, die sich in jedem der mehreren aufeinander folgenden Ultraschall-Einzelbilder befinden;
einen Schritt zum Erhalten eines Drehbetrags (dθ) zwischen den mehreren aufeinander folgenden Ultraschall-Einzelbildern unter Verwendung der Verschiebungsbeträge (dx); und
einen Schritt zum Verbinden der mehreren Ultraschall-Einzelbilder unter Verwendung des Verschiebungsbetrags (dx) und des Drehbetrags (dθ), um Panoramabilddaten zu synthetisieren.

2. Verfahren zum Synthetisieren des Panoramabildes aus Ultraschallbildern nach Anspruch 1, das ferner einen Schritt zum Anzeigen der Panoramabilddaten auf einer Anzeige einer Anzeigevorrichtung (150) umfasst.

3. Verfahren zum Synthetisieren des Panoramabildes (151) aus Ultraschallbildern nach Anspruch 1 oder 2, wobei die ersten projektiven Verteilungen erste projektive Verteilungen (601, 602) in einer Achsenrichtung des bestimmten Bereichs (312) sind,
die zweiten projektiven Verteilungen zweite projektive Verteilungen in einer Achsenrichtung der mehreren Teilbereiche (313) sind, die durch Unterteilen jedes der aufeinander folgenden Ultraschall-Einzelbilder in einer Achsenrichtung erhalten werden, und
der Drehbetrag (dθ) unter Verwendung von Differenzen zwischen den Verschiebungsbeträgen (dx) erhalten wird.

4. Vorrichtung zum Synthetisieren eines Panoramabildes für Ultraschallbilder, die umfasst:

eine Eingabeeinheit (201) für Bilddaten mehrerer Einzelbilder;
eine Berechnungseinheit (130), die eine erste Signalverarbeitungseinheit, um einen Verschiebungsbetrag (dx) zwischen den mehreren aufeinander folgenden Ultraschall-Einzelbildern unter Verwendung einer Korrelation erster projektiver Verteilungen, die aus einem bestimmten Bereich in jedem der mehreren aufeinander folgenden Ultraschall-Einzelbilder abgeleitet werden, zu erhalten, und eine zweite Signalverarbeitungseinheit, um einen Drehbetrag (dθ) zwischen den mehreren aufeinander folgenden Ultraschall-Einzelbildern unter Verwendung von Verschiebungsbeträgen (dx) zu erhalten, die aus einer Korrelation zweiter projektiver Verteilungen mehrerer Teilbereiche, die in jedem der mehreren aufeinander folgenden Ultraschall-Einzelbilder enthalten sind, abgeleitet werden, umfasst; und
eine Synthetisierungseinheit, um ein Panoramabild (151) aus den mehreren Ultraschall-Einzelbildern unter Verwendung des Verschiebungsbetrags und des Drehbetrags, die durch die Berechnungseinheit erhalten werden, zu synthetisieren.

5. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 4, wobei die ersten projektiven Verteilungen erste projektive Verteilungen (601, 602) in einer Achsenrichtung des bestimmten Bereichs (312) sind und
die zweiten projektiven Verteilungen zweite projektive Verteilungen in einer Achsenrichtung der mehreren Teilbereiche (313) sind.

6. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 4 oder 5, wobei die Teilbereiche (313) durch Unterteilen jedes der aufeinander folgenden Ultraschall-Einzelbilder in einer Achsenrichtung erhalten werden, und
der Drehbetrag (dθ) unter Verwendung von Differenzen zwischen den Verschiebungsbeträgen (dx) erhalten wird.

7. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 5 oder 6, wobei die erste Signalverarbeitungseinheit die ersten projektiven Verteilungen (601, 602) in dem bestimmten Bereich (312) normiert und die zweite Signalverarbeitungseinheit die zweiten projektiven Verteilungen in den mehreren Teilbereichen (313) unter Verwendung einer Zahl, die durch Integrieren der integrierten Pixel in einer Achsenrichtung erhalten wird, normiert.

8. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 5 bis 7, wobei das Pixel, das verwendet wird, um die ersten und zweiten projektiven Verteilungen (601, 602) zu erhalten, ein Pixel eines bestimmten Farbsignals ist.

9. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 4 bis 8, wobei die zweite Signalverarbeitungseinheit die Verschiebungsbeträge (dx) verwendet, die aus der Menge von Bereichen erhalten werden, die unter den mehreren Teilbereichen (313), die in einer Achsenrichtung unterteilt sind, am weitesten voneinander beabstandet sind.

10. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 4 bis 9, die ferner eine Bildanzeigeeinheit umfasst, um Bewegungsbilddaten und Panoramabilddaten in Bildanzeigesignale umzusetzen und um die Signale auf der Anzeige (150) anzuzeigen.

11. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 10, wobei die Bildanzeigeeinheit einen Bildverarbeitungsbereich, der der Erfassung des Verschiebungsbetrags (dx) und/oder des Drehbetrags (dθ) dient, als eine Figur in einem Bewegungsbild-Anzeigebereich (310) auf der Anzeige (150) anzeigt.

12. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 10, wobei die Bildanzeigeeinheit eine Verarbeitungsbereich-Bezeichnungseinheit besitzt, um einen Bildverarbeitungsbereich, der verwendet wird, um das Panoramabild (151) zu erzeugen, als eine Figur in einem Bewegungsbild-Anzeigebereich (310) auf der Anzeige anzuzeigen.

13. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 10 bis 12, wobei die Bildanzeigeeinheit eine Positionsbezeichnungseinheit (322) besitzt, um Positionsinformationen eines Bewegungsbildes, das momentan verarbeitet wird, als eine Figur in dem Panoramabild-Anzeigebereich (320) auf der Anzeige (150) anzuzeigen.

14. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 10 bis 13, wobei die Bildanzeigeeinheit das Panoramabild (151) in einen beliebigen Zustand zu einem früheren Zeitpunkt zurückstellt, indem sie die Positionsinformationen bewegt.

15. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 13 oder 14, wobei die Eingabeeinheit (210) für Daten der mehreren Einzelbilder mit einer Sonde (200) zum Erhalten von Ultraschalldaten verbunden ist und die Berechnungseinheit (130), die Synthetisierungseinheit und die Bildanzeigeeinheit so konstruiert sind, dass sie das Bewegungsbild und/oder das Panoramabild (151) gleichzeitig mit dem Sondenbetrieb auf der Anzeige (150) anzeigen.

16. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 15, wobei die Anzeige (150) einteilig mit der Sonde (200) ausgebildet ist.

17. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 15 oder 16, wobei die Sonde (200) mit einer Einheit (202) versehen ist, um ein Einrichten oder Zurücksetzen des Sondenbetriebs anzuweisen.

18. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 4 bis 17, die ferner eine abnehmbare Bildspeichereinheit (190) umfasst, um die Panoramabilddaten zu speichern.

19. Vorrichtung zum Synthetisieren eines Panoramabildes (151) aus Ultraschallbildern nach Anspruch 10 bis 18, wobei die Bildanzeigeeinheit einen Bildoperationstypsymbol-Anzeigebereich (330) anzeigt, der Bereiche eines Panoramabefehlschalters (331), eines Rücksetzschalters (334) und eines Vorwärts/Rückwärts-Befehlsschalters (335) besitzt und in der Anzeige (150) vorgesehen ist, und der Beginn der Anzeige, die Unterbrechung, der Neustart oder die Umkehrung des Panoramabildes (151) durch den entsprechenden Schalter in dem Befehlsschalterbereich (330) ausgeführt wird.

20. Aufzeichnungsmedium, das durch einen Computer gelesen werden kann und in dem ein Programm zum Erhalten von Panoramabilddaten aufgezeichnet ist,
wobei das Programm umfasst:

einen ersten Schritt zum Berechnen einer projektiven Verteilung (601, 602) von Pixeln in der vertikalen Richtung in einem bestimmten Bereich (312) sowohl in dem momentanen Einzelbild als auch in dem vorhergehenden Einzelbild und zum Erhalten eines Verschiebungsbetrags (dx) in der horizontalen Richtung zwischen dem momentanen und dem vorhergehenden Einzelbild durch Anpassen der momentanen und der vorhergehenden projektiven Verteilungen (601, 602);
einen zweiten Schritt zum Vorsehen mehrerer unterteilter bezeichneter Bereiche (313) an entsprechenden Positionen sowohl in dem momentanen als auch in dem vorhergehenden Einzelbild, zum Berechnen der projektiven Verteilung von Pixeln in jedem der mehreren unterteilten bezeichneten Bereiche und zum Anpassen der projektiven Verteilungen in den mehreren unterteilten bezeichneten Bereichen, um **dadurch** einen Verschiebungsbetrag (dx) in jedem der mehreren unterteilten bezeichneten Bereiche zwischen dem momentanen und dem vorhergehenden Einzelbild zu erhalten;
einen dritten Schritt zum Berechnen eines Drehwinkels ($d\theta$) zwischen dem momentanen und dem vorhergehenden Einzelbild unter Verwendung des Verschiebungsbetrags (dx) jedes der unterteilten bezeichneten Bereiche, der im zweiten Schritt erhalten wird; und
einen vierten Schritt zum Verschieben und Drehen des zu synthetisierenden Bildbereichs in dem momentanen Einzelbild um den Verschiebungsbetrag (dx), der im ersten Schritt erhalten wird, bzw. um den Drehwinkel ($d\theta$), der im dritten Schritt erhalten wird, und zum Schreiben des Ergebnisses in einen Panoramabild-Speicher (140),

wobei die ersten bis vierten Schritte an einem neu eingegebenen Einzelbild, das als momentanes Einzelbild dient, wiederholt ausgeführt werden.

21. Aufzeichnungsmedium, das durch einen Computer gelesen werden kann, nach Anspruch 20,
wobei im zweiten Schritt das Verhältnis effektiver Pixel zu allen Pixeln in jedem der mehreren unterteilten Teilbereiche (313) geprüft wird und dann, wenn das Verhältnis effektiver Pixel gleich oder größer als ein vorgegebener Wert ist, die projektive Verteilung des unterteilten bezeichneten Bereichs berechnet wird und
der dritte Schritt einen Schritt umfasst, um Verschiebungsbeträge (dx) zwischen zwei unterteilten bezeichneten Bereichen auszuwählen, die unter den Verschiebungsbeträgen (dx) der mehreren unterteilten Teilbereiche (313) am weitesten voneinander beabstandet sind, und um eine Berechnung des Drehwinkels (dθ) unter Verwendung einer Differenz zwischen den zwei ausgewählten Verschiebungsbeträgen (dx) auszuführen.

Revendications

1. Procédé pour synthétiser une image panoramique à partir d'images ultrasonores, comprenant :

une étape consistant à obtenir des données d'une pluralité d'images planes ultrasonores consécutives construisant une image ultrasonore en mouvement ;
une étape consistant à obtenir un taux de décalage (dx) entre la pluralité d'images planes ultrasonores consécutives en utilisant une corrélation des premières distributions projectives dérivées à partir d'une aire spécifique (312) dans chacune de la pluralité d'images planes ultrasonores consécutives ;
une étape consistant à obtenir des taux de décalage (dx) entre la pluralité d'images planes ultrasonores consécutives en utilisant une corrélation des deuxièmes distributions projectives dérivées d'une pluralité d'aires partielles (313) qui sont dans chacune de la pluralité d'images planes ultrasonores consécutives ;
une étape consistant à obtenir un taux de rotation (dθ) entre la pluralité d'images planes ultrasonores consécutives en utilisant les taux de décalage (dx) ;
et
une étape consistant à relier la pluralité d'images planes ultrasonores en utilisant le taux de décalage (dx) et le taux de rotation (dθ) pour synthétiser des données d'image panoramique.

2. Le procédé pour synthétiser l'image panoramique à partir d'images ultrasonores selon la revendication 1, comprenant en outre une étape consistant à afficher les données d'image panoramique sur un écran d'un dispositif d'affichage (150).

3. Le procédé pour synthétiser l'image panoramique (151) à partir d'images ultrasonores selon la revendication 1 ou 2, dans lequel les premières distributions projectives sont des premières distributions projectives (601, 602) dans la direction d'un axe de l'aire spécifique (312),
les deuxièmes distributions projectives sont des deuxièmes distributions projectives dans la direction d'un axe de la pluralité d'aires partielles (313) obtenues en divisant chacune des images planes ultrasonores consécutives dans la direction d'un axe, et
le taux de rotation (dθ) est obtenu en utilisant les différences entre les taux de décalage (dx).

4. Appareil pour synthétiser une image panoramique à partir d'images ultrasonores, comprenant :

une unité d'entrée (210) de données d'images d'une pluralité d'images planes ;
une unité de calcul (130) comprenant une première unité de traitement des signaux pour obtenir un taux de décalage (dx) entre la pluralité d'images planes ultrasonores consécutives en utilisant la corrélation des premières distributions projectives dérivées à partir d'une aire spécifique dans chacune de la pluralité d'images planes ultrasonores consécutives, et une deuxième unité de traitement des signaux pour obtenir un taux de rotation (dθ) entre la pluralité d'images planes ultrasonores consécutives en utilisant des taux de décalage (dx), qui sont dérivés à partir de la corrélation des deuxièmes distributions projectives d'une pluralité d'aires partielles qui sont dans chacune de la pluralité d'images planes ultrasonores consécutives ; et
une unité de synthèse pour synthétiser une image panoramique (151) à partir de la pluralité d'images planes ultrasonores en utilisant le taux de décalage et le taux de rotation obtenus par l'unité de calcul.

5. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 4, dans lequel les premières distributions projectives sont des premières distributions projectives (601, 602) dans la

direction d'un axe de l'aire spécifique (312) et
les deuxièmes distributions projectives sont des deuxièmes distributions projectives dans la direction d'un axe de la pluralité des aires partielles (313).

6. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 4 ou 5, dans lequel les aires partielles (313) sont obtenues en divisant chacune des images planes ultrasonores consécutives dans la direction d'un axe, et
le taux de rotation (dθ) est obtenu en utilisant des différences entre les taux de décalage (dx).

7. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 5 ou 6, dans lequel la première unité de traitement des signaux normalise les premières distributions projectives (601, 602) dans l'aire spécifique (312) et la deuxième unité de traitement des signaux normalise les deuxièmes distributions projectives dans la pluralité d'aires partielles (313) en utilisant un nombre obtenu en intégrant les pixels intégrés dans la direction d'un axe.

8. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 5 à 7, dans lequel le pixel utilisé pour obtenir les premières et deuxièmes distributions projectives (601, 602) est un pixel d'un signal de couleur spécifique.

9. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 4 à 8, dans lequel la deuxième unité de traitement des signaux utilise les taux de décalage (dx) obtenus à partir de l'ensemble des aires qui sont les plus éloignées l'une de l'autre dans la pluralité des aires partielles (313) divisées dans la direction d'un axe.

10. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 4 à 9, comprenant en outre une unité d'affichage d'image pour convertir des données d'images en mouvement et des données d'images panoramiques en signaux d'affichage d'image et afficher les signaux sur l'écran (150).

11. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 10, dans lequel l'unité d'affichage d'image affiche une aire de traitement d'image qui est destinée à détecter au moins un parmi le taux de décalage (dx) et le taux de rotation (dθ) à titre de figure dans une aire d'affichage de l'image en mouvement (310) sur l'écran (150).

12. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 10, dans lequel l'unité d'affichage d'image a une unité de conception d'aire de traitement pour afficher une aire de traitement d'image qui est utilisée pour former l'image panoramique (151) à titre de figure dans une aire d'affichage de l'image en mouvement (310) sur l'écran.

13. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 10 à 12,
dans lequel l'unité d'affichage d'image a une unité de conception de la position (322) pour afficher l'information de position d'une image en mouvement qui est en train d'être traitée à titre de figure dans l'aire d'affichage de l'image panoramique (320) sur l'écran (150).

14. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 10 à 13,
dans lequel l'unité d'affichage d'image renvoie l'image panoramique (151) à un temps antérieur à l'état arbitraire en déplaçant l'information de position.

15. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 13 ou 14,
dans lequel l'unité d'entrée (210) des données de la pluralité d'images plans est raccordée à une sonde (200) pour obtenir des données ultrasonores, et l'unité de calcul (130), l'unité de synthèse et l'unité d'affichage de l'image sont conçues pour afficher au moins une parmi l'image en mouvement ou l'image panoramique (151) sur l'écran (150) simultanément avec l'opération de la sonde.

16. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 15, dans lequel l'écran (150) est formé en une pièce avec la sonde (200).

17. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 15 ou 16, dans lequel la sonde (200) est munie de l'unité (202) pour commander un paramétrage ou une remise à zéro de l'opération de la sonde.

18. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 4 à 17, comprenant en outre une unité de stockage de l'image amovible (190) pour stocker les données d'images panoramiques.

19. L'appareil pour synthétiser une image panoramique (151) à partir d'images ultrasonores selon la revendication 10 à 18,
dans lequel l'unité d'affichage d'image affiche une aire d'affichage des symboles de type opération d'image (330) ayant des aires de bouton de commande panoramique (331), de bouton de remise à zéro (334), de bouton de commande avant/arrière (335) prévues sur l'écran (150) et le démarrage de l'affichage, l'interruption, le redémarrage, ou l'inversion de l'image panoramique (151) sont réalisés à l'aide du bouton correspondant dans l'aire du bouton de commande (330).

20. Support d'enregistrement qui peut être lu par un ordinateur et sur lequel un programme pour l'obtention des données d'image panoramiques est enregistré,
dans lequel le programme comprend :

une première étape consistant à calculer une distribution projective (601, 602) de pixels dans la direction verticale dans une aire spécifiée (312) dans chacune des deux images planes présente et antérieure et obtenir un taux de décalage (dx) dans la direction horizontale entre les deux images planes présente et antérieure en faisant correspondre les distributions projectives présente et antérieure (601, 602) ;
une deuxième étape consistant à fournir une pluralité d'aires indiquées divisées (313) dans des positions correspondantes dans chacune des deux images planes présente et antérieure, calculer la distribution projective des pixels dans chacune de la pluralité des aires indiquées divisées, et faire correspondre les distributions projectives dans la pluralité d'aires indiquées divisées, ce qui permet d'obtenir un taux de décalage (dx) dans chacune de la pluralité d'aires indiquées divisées entre les deux images planes présente et antérieure ;
une troisième étape consistant à calculer un angle de rotation ($d\theta$) entre les deux images planes présente et antérieure en utilisant le taux de décalage (dx) de chacune des aires indiquées divisées obtenues dans la deuxième étape ; et
une quatrième étape consistant à décaler et faire tourner l'aire d'image à synthétiser dans le présent plan d'image par le taux de décalage (dx) obtenu dans la première étape et l'angle de rotation ($d\theta$) obtenu dans la troisième étape et à écrire le résultat dans une mémoire d'image panoramique (140),
les première à quatrième étapes étant exécutées de manière répétitive sur un plan d'image nouvellement entré comme plan d'image présent.

21. Le support d'enregistrement qui peut être lu par un ordinateur, selon la revendication 20,
dans lequel, dans la deuxième étape, le rapport des pixels efficaces sur tous les pixels dans chacune de la pluralité d'aires indiquées divisées (313) est vérifié et, quand le rapport des pixels efficaces est égal ou supérieur à une valeur prédéterminée, la distribution projective de l'aire indiquée divisée est calculée, et
la troisième étape comprend une étape consistant à choisir les taux de décalage (dx) entre deux aires indiquées divisées qui sont les plus éloignées les unes des autres (dx) de la pluralité des aires partielles divisées (313) et réaliser un calcul de l'angle de rotation ($d\theta$) en utilisant une différence entre deux taux de décalage sélectionnés (dx).

FIG. 1

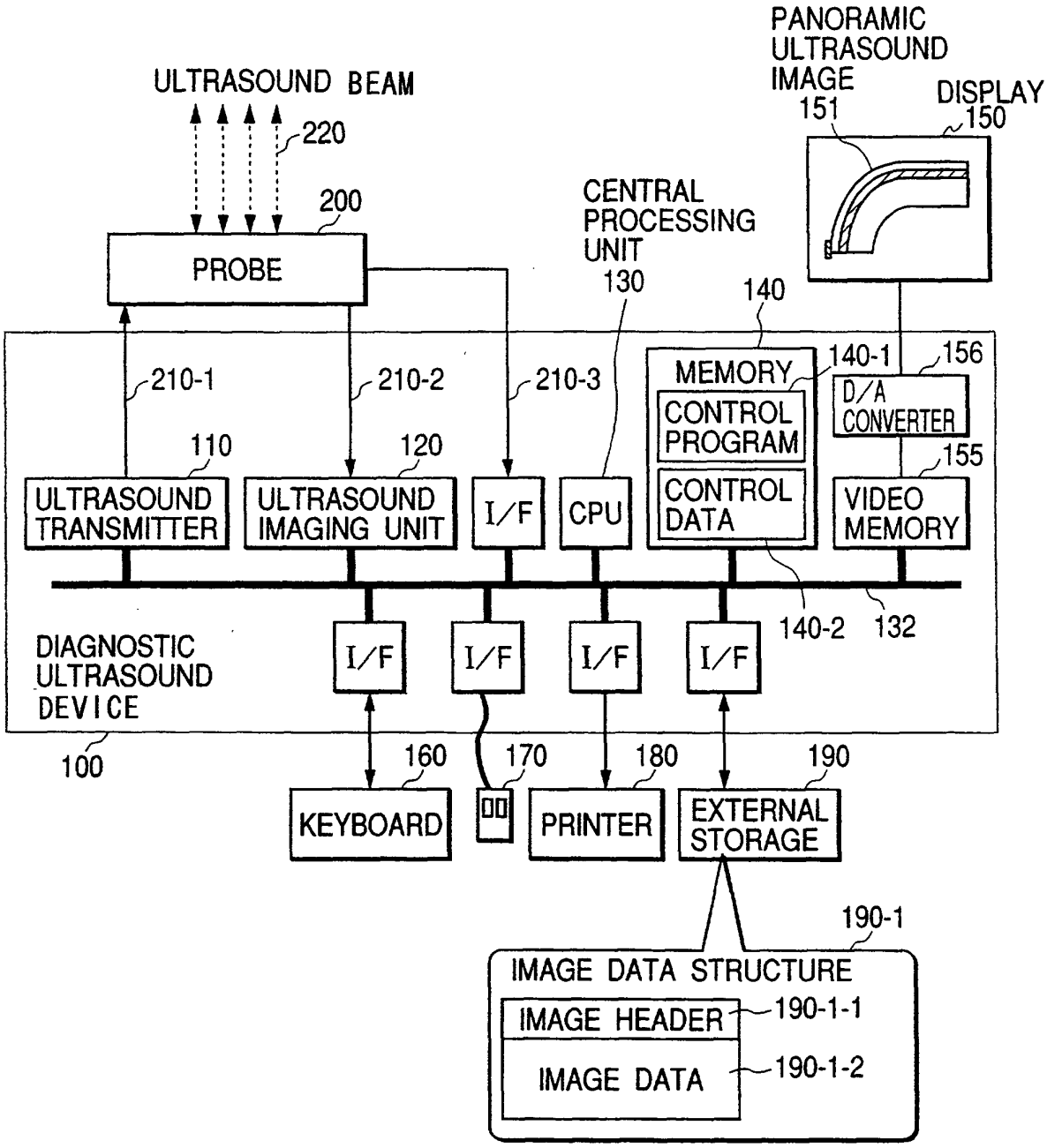

PANORAMIC ULTRASOUND IMAGE
151
DISPLAY
150
ULTRASOUND BEAM
220
200
PROBE
CENTRAL PROCESSING UNIT
130
140
MEMORY
CONTROL PROGRAM
CONTROL DATA
140-1
156
D/A CONVERTER
155
VIDEO MEMORY
210-1
210-2
210-3
110
120
ULTRASOUND TRANSMITTER
ULTRASOUND IMAGING UNIT
I/F
CPU
140-2
132
DIAGNOSTIC ULTRASOUND DEVICE
100
160
170
180
190
KEYBOARD
PRINTER
EXTERNAL STORAGE
190-1
IMAGE DATA STRUCTURE
IMAGE HEADER
190-1-1
IMAGE DATA
190-1-2

FIG. 2

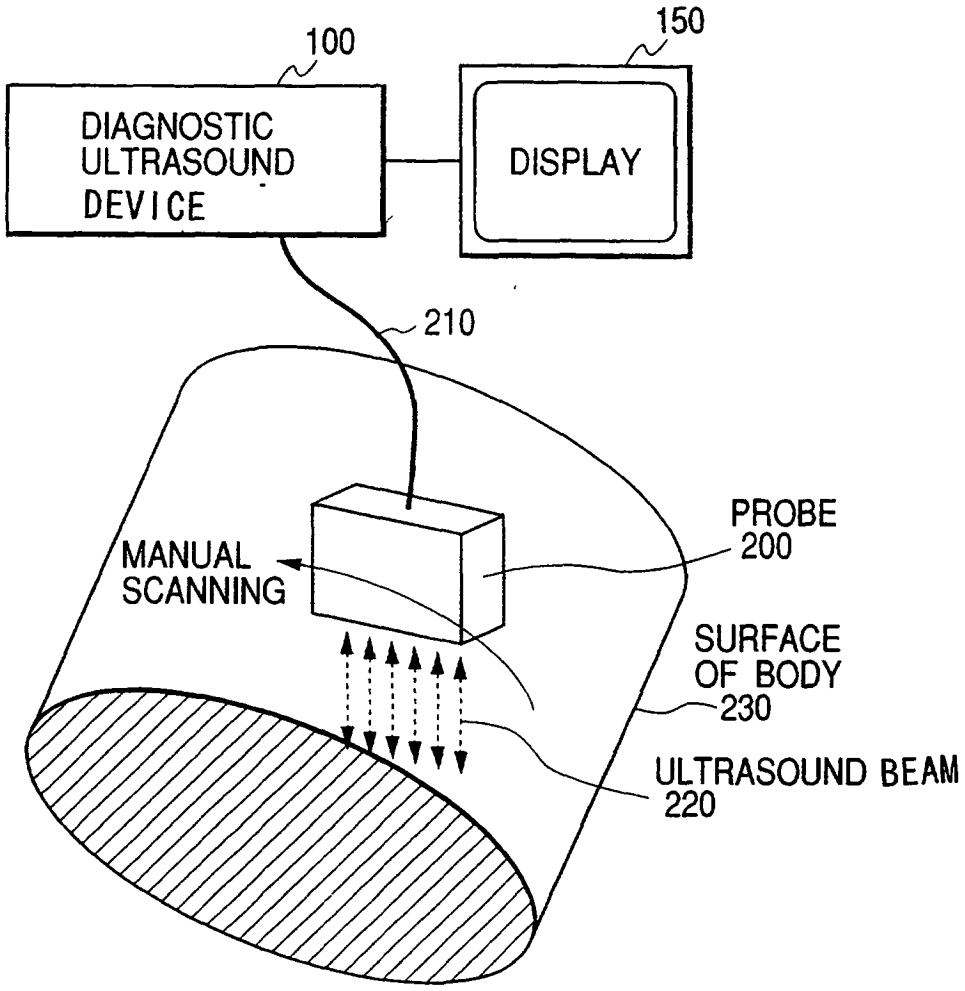

100
150
DIAGNOSTIC ULTRASOUND DEVICE
DISPLAY
210
PROBE 200
MANUAL SCANNING
SURFACE OF BODY 230
ULTRASOUND BEAM 220

FIG. 3

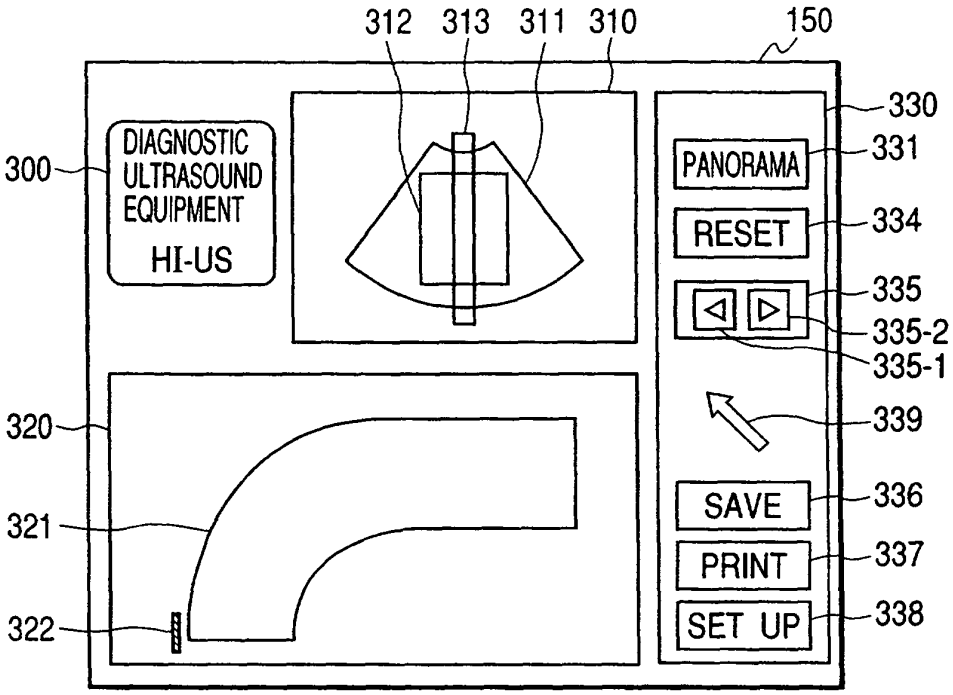


FIG. 4(a)

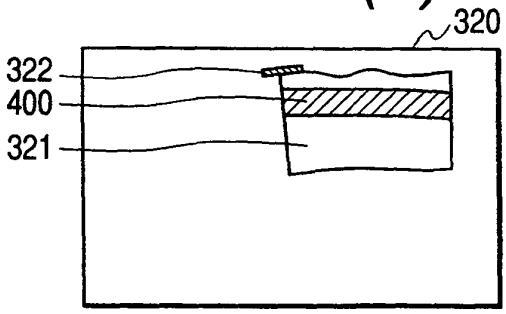


FIG. 4(b)

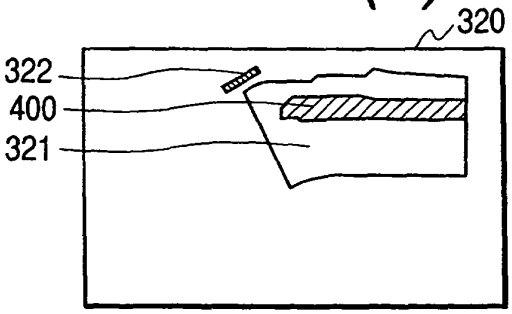


FIG. 4(c)

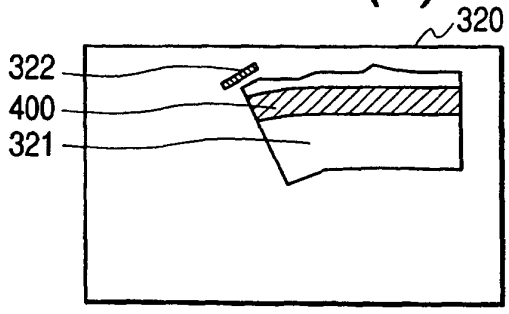


FIG. 4(d)

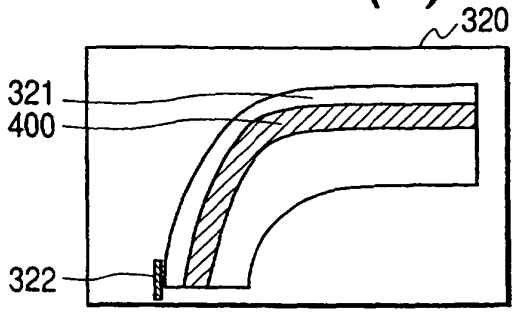


FIG. 5

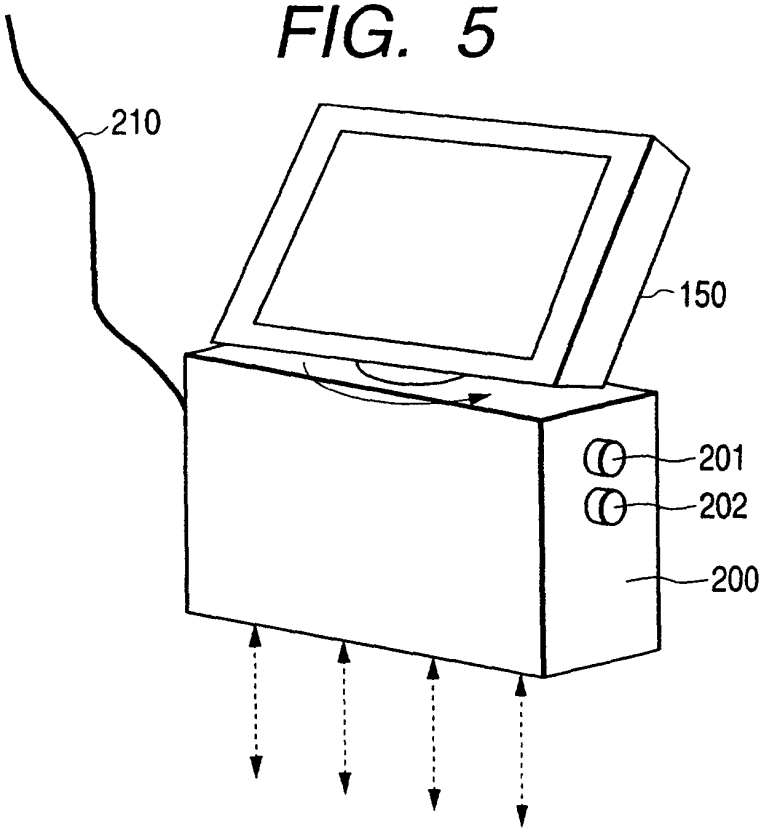

210
150
201
202
200

FIG. 6

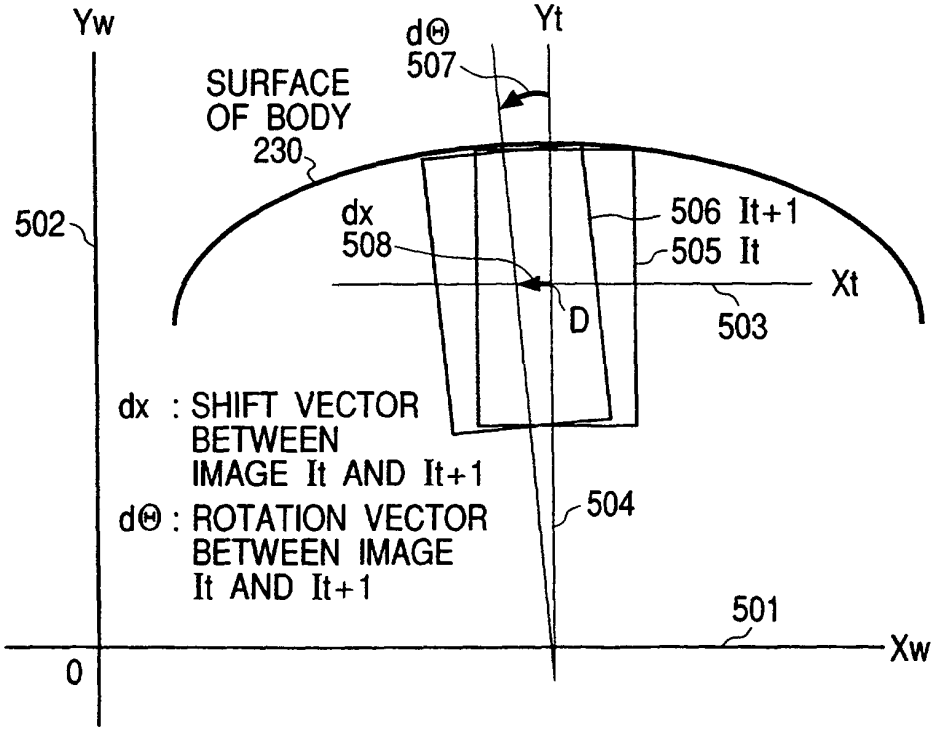

Yw
dΘ
507
Yt
SURFACE
OF BODY
230
502
dx
508
506 It+1
505 It
Xt
D
503
dx : SHIFT VECTOR
BETWEEN
IMAGE It AND It+1
dΘ : ROTATION VECTOR
BETWEEN IMAGE
It AND It+1
504
501
Xw
0

FIG. 7

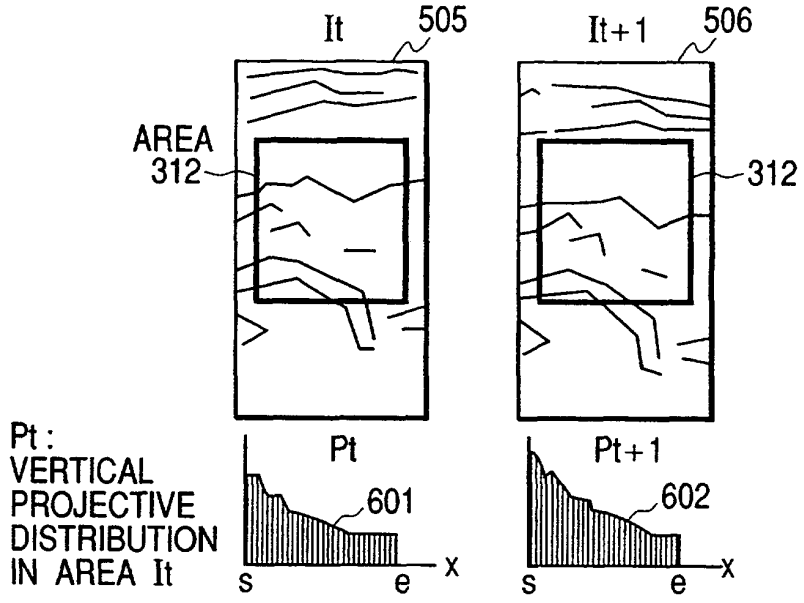

It
505
It+1
506
AREA
312
312
Pt :
VERTICAL
PROJECTIVE
DISTRIBUTION
IN AREA It
Pt
601
Pt+1
602
s
e
x
s
e
x

FIG. 8

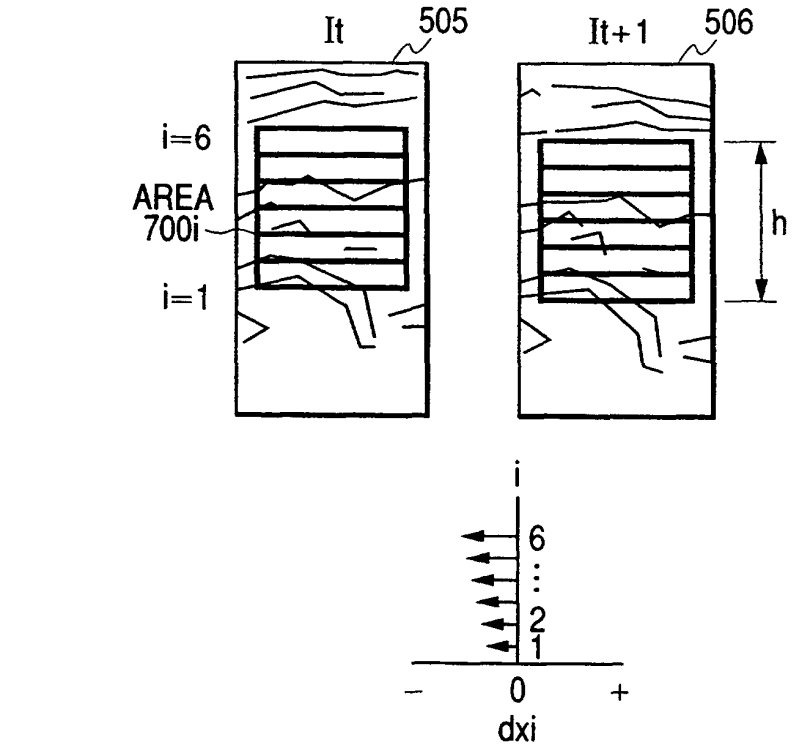

It
505
It+1
506
i=6
AREA
700i
i=1
h
i
6
2
1
–
0
+
dxi

FIG. 9

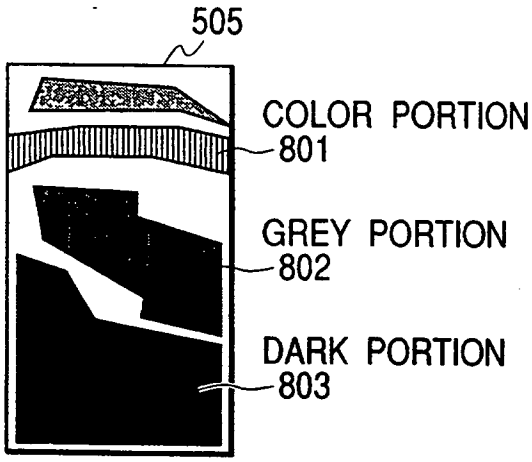


FIG. 10

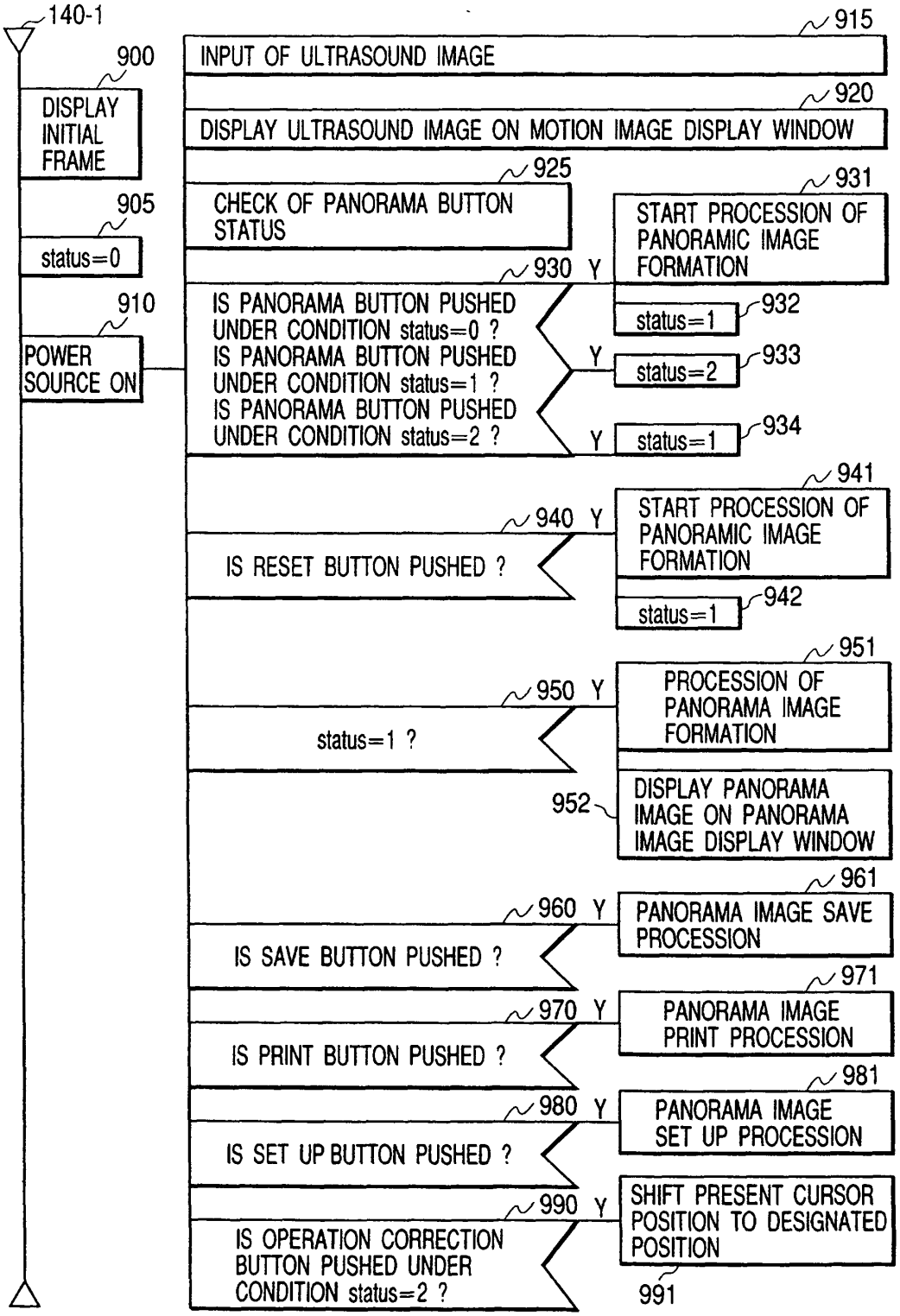

140-1
900
DISPLAY INITIAL FRAME
905
status=0
910
POWER SOURCE ON
915
INPUT OF ULTRASOUND IMAGE
920
DISPLAY ULTRASOUND IMAGE ON MOTION IMAGE DISPLAY WINDOW
925
CHECK OF PANORAMA BUTTON STATUS
930
IS PANORAMA BUTTON PUSHED UNDER CONDITION status=0 ?
IS PANORAMA BUTTON PUSHED UNDER CONDITION status=1 ?
IS PANORAMA BUTTON PUSHED UNDER CONDITION status=2 ?
Y
931
START PROCESSION OF PANORAMIC IMAGE FORMATION
status=1
932
status=2
933
status=1
934
940
IS RESET BUTTON PUSHED ?
941
START PROCESSION OF PANORAMIC IMAGE FORMATION
status=1
942
950
status=1 ?
951
PROCESSION OF PANORAMA IMAGE FORMATION
952
DISPLAY PANORAMA IMAGE ON PANORAMA IMAGE DISPLAY WINDOW
960
IS SAVE BUTTON PUSHED ?
961
PANORAMA IMAGE SAVE PROCESSION
970
IS PRINT BUTTON PUSHED ?
971
PANORAMA IMAGE PRINT PROCESSION
980
IS SET UP BUTTON PUSHED ?
981
PANORAMA IMAGE SET UP PROCESSION
990
IS OPERATION CORRECTION BUTTON PUSHED UNDER CONDITION status=2 ?
SHIFT PRESENT CURSOR POSITION TO DESIGNATED POSITION
991

FIG. 11

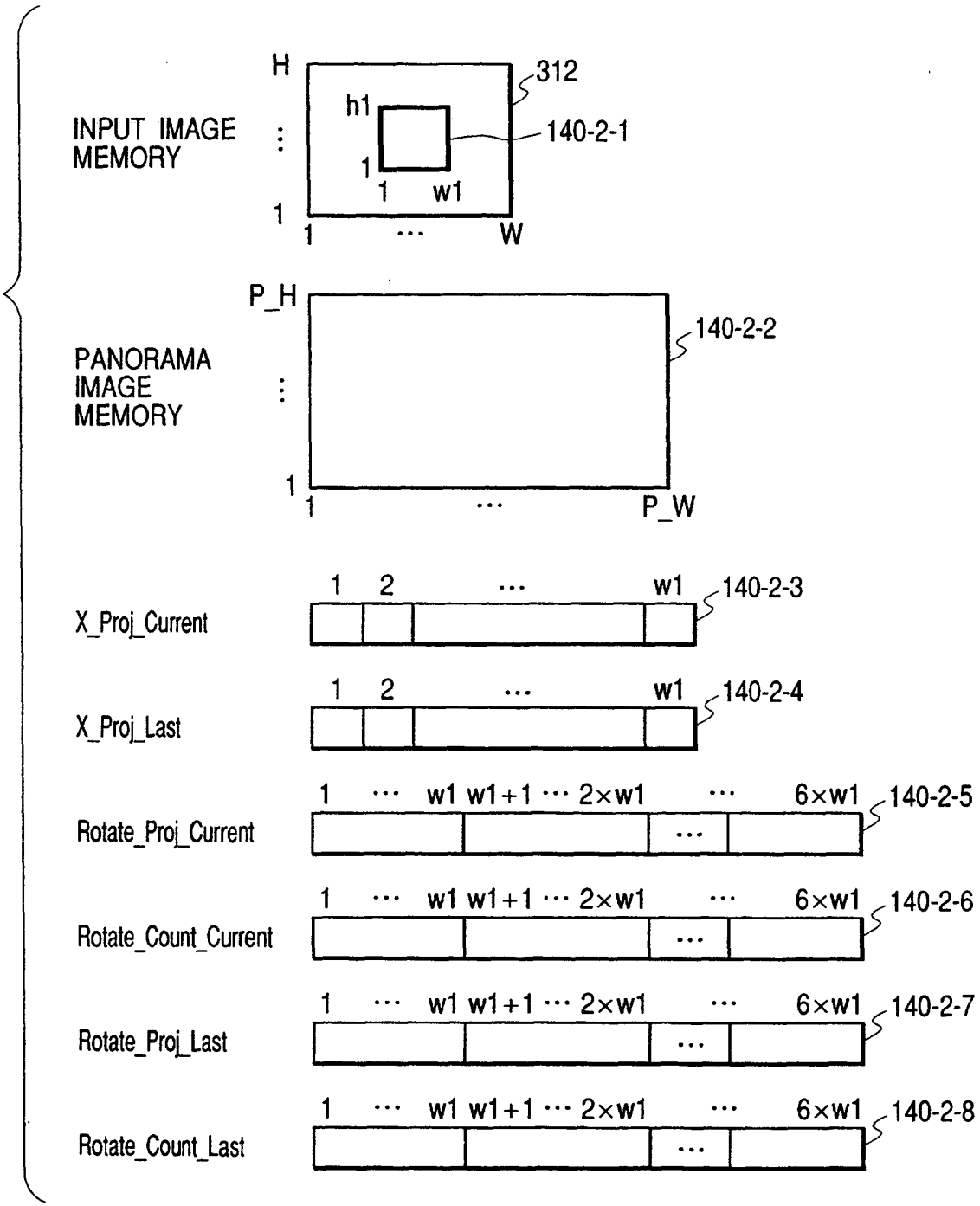

INPUT IMAGE MEMORY
H
h1
1
1
w1
1
1
W
312
140-2-1
PANORAMA IMAGE MEMORY
P_H
1
1
P_W
140-2-2
X_Proj_Current
1 2 ··· w1
140-2-3
X_Proj_Last
1 2 ··· w1
140-2-4
Rotate_Proj_Current
1 ··· w1 w1+1 ··· 2×w1 ··· 6×w1
140-2-5
Rotate_Count_Current
1 ··· w1 w1+1 ··· 2×w1 ··· 6×w1
140-2-6
Rotate_Proj_Last
1 ··· w1 w1+1 ··· 2×w1 ··· 6×w1
140-2-7
Rotate_Count_Last
1 ··· w1 w1+1 ··· 2×w1 ··· 6×w1
140-2-8

FIG. 12

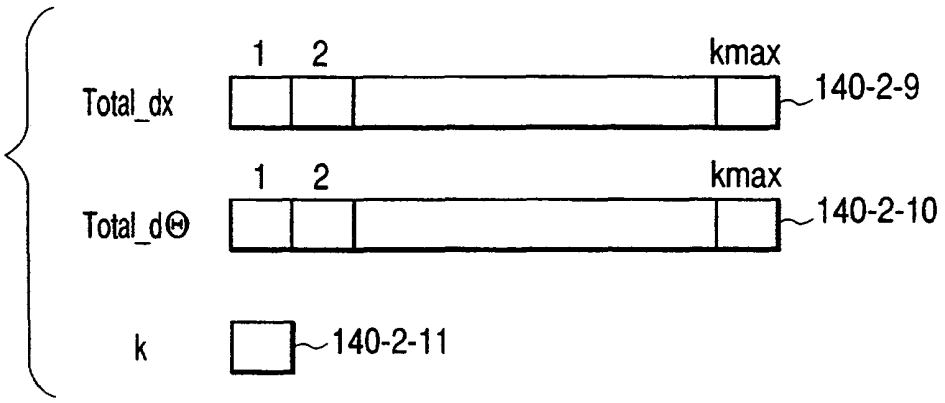

1
2
kmax
Total_dx
140-2-9
1
2
kmax
Total_dΘ
140-2-10
k
140-2-11

FIG. 13

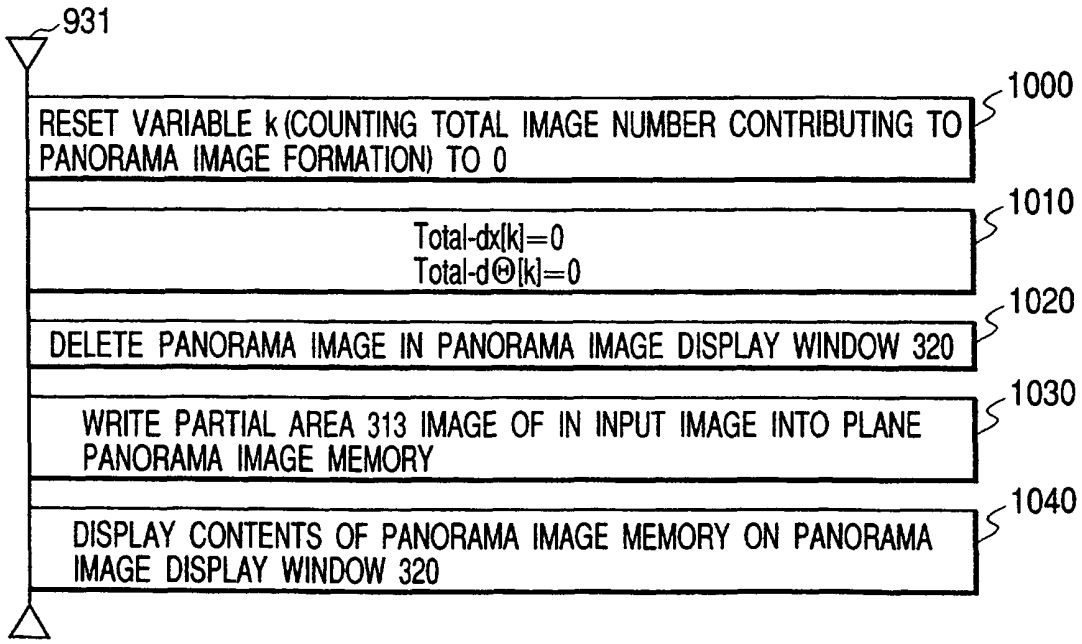
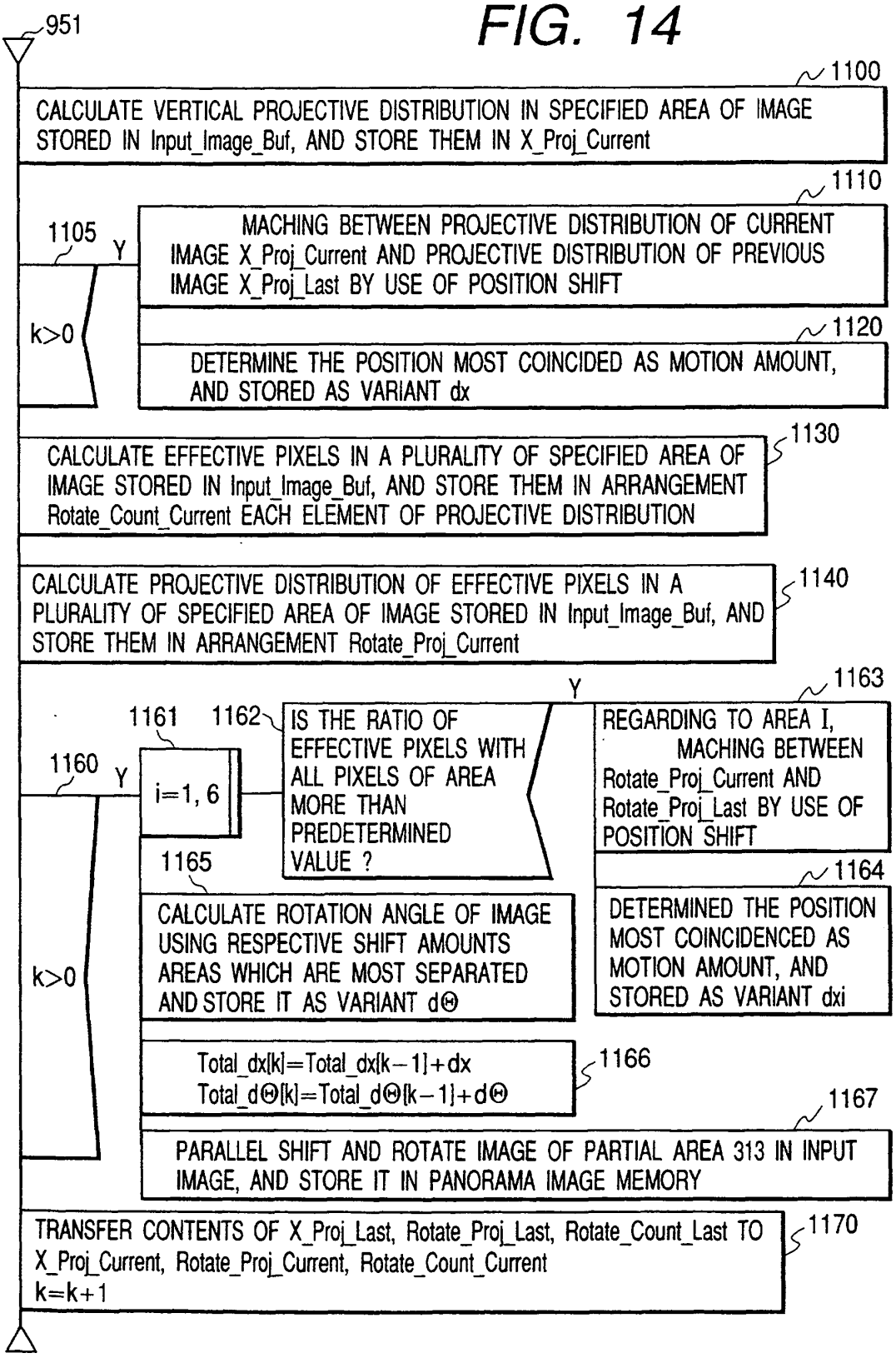

931
RESET VARIABLE k (COUNTING TOTAL IMAGE NUMBER CONTRIBUTING TO PANORAMA IMAGE FORMATION) TO 0
1000
Total-dx[k]=0
Total-dΘ[k]=0
1010
DELETE PANORAMA IMAGE IN PANORAMA IMAGE DISPLAY WINDOW 320
1020
WRITE PARTIAL AREA 313 IMAGE OF IN INPUT IMAGE INTO PLANE PANORAMA IMAGE MEMORY
1030
DISPLAY CONTENTS OF PANORAMA IMAGE MEMORY ON PANORAMA IMAGE DISPLAY WINDOW 320
1040

FIG. 14


951
1100
CALCULATE VERTICAL PROJECTIVE DISTRIBUTION IN SPECIFIED AREA OF IMAGE STORED IN Input_Image_Buf, AND STORE THEM IN X_Proj_Current
1110
1105
Y
MACHING BETWEEN PROJECTIVE DISTRIBUTION OF CURRENT IMAGE X_Proj_Current AND PROJECTIVE DISTRIBUTION OF PREVIOUS IMAGE X_Proj_Last BY USE OF POSITION SHIFT
k>0
1120
DETERMINE THE POSITION MOST COINCIDED AS MOTION AMOUNT, AND STORED AS VARIANT dx
1130
CALCULATE EFFECTIVE PIXELS IN A PLURALITY OF SPECIFIED AREA OF IMAGE STORED IN Input_Image_Buf, AND STORE THEM IN ARRANGEMENT Rotate_Count_Current EACH ELEMENT OF PROJECTIVE DISTRIBUTION
1140
CALCULATE PROJECTIVE DISTRIBUTION OF EFFECTIVE PIXELS IN A PLURALITY OF SPECIFIED AREA OF IMAGE STORED IN Input_Image_Buf, AND STORE THEM IN ARRANGEMENT Rotate_Proj_Current
Y
1163
1161
1162
IS THE RATIO OF EFFECTIVE PIXELS WITH ALL PIXELS OF AREA MORE THAN PREDETERMINED VALUE ?
REGARDING TO AREA I, MACHING BETWEEN Rotate_Proj_Current AND Rotate_Proj_Last BY USE OF POSITION SHIFT
1160
Y
i=1, 6
1164
DETERMINED THE POSITION MOST COINCIDENCED AS MOTION AMOUNT, AND STORED AS VARIANT dxi
1165
k>0
CALCULATE ROTATION ANGLE OF IMAGE USING RESPECTIVE SHIFT AMOUNTS AREAS WHICH ARE MOST SEPARATED AND STORE IT AS VARIANT dΘ
Total_dx[k]=Total_dx[k−1]+dx
Total_dΘ[k]=Total_dΘ[k−1]+dΘ
1166
1167
PARALLEL SHIFT AND ROTATE IMAGE OF PARTIAL AREA 313 IN INPUT IMAGE, AND STORE IT IN PANORAMA IMAGE MEMORY
TRANSFER CONTENTS OF X_Proj_Last, Rotate_Proj_Last, Rotate_Count_Last TO X_Proj_Current, Rotate_Proj_Current, Rotate_Count_Current
k=k+1
1170

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5782766 A1 **[0002]**
- US 5832110 A1 **[0002]**
- US 5575286 A **[0006]**

专利名称(译)	从超声图像合成全景图像的方法和装置		
公开(公告)号	EP1024455B1	公开(公告)日	2009-01-14
申请号	EP2000101264	申请日	2000-01-26
[标]申请(专利权)人(译)	株式会社日立制作所		
申请(专利权)人(译)	HITACHI，LTD.		
当前申请(专利权)人(译)	株式会社日立制作.		
[标]发明人	MIYATAKE TAKAFUMI NAGASAKA AKIO UMEMURA SHINICHIRO		
发明人	MIYATAKE, TAKAFUMI NAGASAKA, AKIO UMEMURA, SHINICHIRO		
IPC分类号	G06T7/00 A61B8/00 A61B8/14 G01S7/52 G06T1/00		
CPC分类号	A61B8/14 A61B8/463 A61B8/5238 G01S7/52065 G01S7/52074 G06T7/30 G06T2207/30004		
优先权	1999019462 1999-01-28 JP		
其他公开文献	EP1024455A3 EP1024455A2		
外部链接	Espacenet		

摘要(译)

实现了一种廉价，可操作的超声诊断装置，能够以实时方式形成全景切片图像。该装置包括：成像单元120，用于将从探头200获得的超声数据转换为图像;计算机（130,140）具有通过探头200的操作检测形成的图像之间的偏移量的偏移量检测功能和检测通过探头200的操作产生的切片图像之间的旋转量的旋转量检测功能;全景图像显示装置150用于显示全景图像151，该全景图像151是通过根据由计算机检测到的移动量和旋转量与运动图像显示并行地以平面方式连接在诊断期间捕获的切片图像序列而获得的。因此，可以从探针获得的切片图像序列以实时方式形成全景图像。可以在显示器上暂时识别全景图像形成状态，并且可以校正错误的探测操作。